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Abbreviations and Acronyms

-AARD - Agency for Agricultural Research and Development (Indonesia)
-ACCT - Agency for Cultural and Technical Cooperation
-ADRC - Agricultural Development Research Center in North-east Thailand
-a.i. - active ingredient
-AIT - American Institute in Taiwan
-AMV - alfalfa mosaic virus
-ARTT - advanced soybean rust tolerance trials
-ASET - AVRDC Soybean Evaluation Trials
-AVRDC - Asian Vegetable Research and Development Center
-AYT - advanced yield trials

-BARD - Bangladesh Academy of Rural Development
-BARI - Bangladesh Agricultural Research Institute
-BMZ - German Ministry for Economic Cooperation
-BW - bacterial wilt

-CAAS - Chinese Academy of Agricultural Sciences
-CARDI - Caribbean Agricultural Research and Development Institute
-CENARGEN - Centro Nacional de Recursos Genéticos (Brazil)
-CGIAR - Consultative Group on International Agricultural Research
-cfu - colony-forming units
-CIAT - Centro Internacional de Agricultura Tropical
-CIMMYT - Centro Internacional de Mejoramiento de Maiz y Trigo
-CINDE - Coalicion Costarricense de Iniciativas de Desarrollo (Costa Rica)
-CIP - Centro Internacional de la Papa
-CLS - Cercospora leaf spot
-CMS - cytoplasmic male sterility
-CMV - cucumber mosaic virus
-CRIFC - Central Research Institute for Food Crops (Indonesia)
-CTA - Technical Center for Agricultural and Rural Co-operation (EC)
-CUSO - Canadian University Service Overseas
-CV - coefficient of variation
-CVMV - chili veinal mottle virus
-DAIS - District Agricultural Improvement Station (Taiwan)
-DAS - days after sowing
-DAT - days after transplanting
-DBM - diamondback moth
-DOAE - Dept. of Agricultural Extension (Thailand)
-DPI - Dept. of Primary Industry (Australia)

-EC - European Community
-ELISA - enzyme-linked immunosorbent assay
-EMBRAPA - Empresa Brasileira de Pesquisa Agropecuaria (Brazil)

-FAO - Food and Agriculture Organization of the United Nations
-FCRC - Field Crop Research Centre (Thailand)
-FIRDI - Food Industry Research and Development Institute (Taiwan)
-FMV - feathery mottle virus

-GLA - green leaf area
-GRSU - Genetic Resources and Seed Unit (AVRDC)
-GTZ - German Agency for Technical Cooperation (Fed. Rep. of Germany)
-GYT - general yield trial

-HT - heat tolerant

-IARC - international agricultural research center

-IARI - Indian Agricultural Research Institute
-IBPGR - International Board for Plant Genetic Resources
-IBSRAM - International Board for Soil Research and Management
-ICAR - Indian Council of Agricultural Research
-ICARDA - International Center for Agricultural Research in the Dry Areas
-ICIMOD - International Centre for Integrated Mountain Development
-ICIPE - International Centre of Insect Physiology and Ecology
-ICLARM - International Center for Living Aquatic Resources Management
-ICRAF - International Council for Research in Agroforestry
-ICRISAT - International Crops Research Institute for the Semi-Arid Tropics
-IDIAP - Instituto de Investigación Agropecuaria de Panamá

-IFAD - International Fund for Agricultural Development
-IFDC - International Fertilizer Development Center
-IFPRI - International Food Policy Research Institute
-IITA - International Institute for Tropical Agriculture
-ILCA - International Livestock Center for Africa
-ILRAD - International Laboratory for Research on Animal Diseases
-IMMI - International Irrigation Management Institute
-IMN - International Mungbean Nursery (AVRDC)
-INERA - Institut National pour l'étude et la Recherche Agronomiques (Zaire)
-INIA - Instituto Nacional de Investigacao Agraria (Cape Verde Is.)
-INIAP - Instituto Nacional de Investigaciones Agropecuarias (Ecuador)
-INRA - Institut Nacional de la Recherche Agronomique (France)
-IPB - Bogor Agricultural University (Indonesia)
-IPB - Institute of Plant Breeding, UPLB (Philippines)
-IPM - integrated pest management
-IRAT - Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres (France)
-IRETA - Institute for Research, Extension, and Training in Agriculture
-IRRI - International Rice Research Institute
-ISABU - Institut des Sciences Agronomiques du Burundi
-ISNAR - International Service for National Agricultural Research
-ISRA - Institut Sénégalais de Recherches Agricoles (Senegal)
-IYT - intermediate yield trial

-LEHRI - Lembang Horticulture Research Institute (Indonesia)

-MARDI - Malaysian Agriculture Research and Development Institute
-MARIF - Malang Research Institute for Food Crops (Indonesia)
-MMSU - Mariano Marcos State University
-MMV - sweet potato mild mottle virus
-NAIR - National Institute of Agrobiological Resources (Japan)
-NARS - national agricultural research systems
-NIRS - near infrared reflectance spectroscopy
-OD - optical density
-OIS - Office of Information Services (AVRDC)
-OP - open-pollinated
-OYT - observation yield trial

-PARC - Pakistan Agricultural Research Council
-PDA - potato dextrose agar
-PE - polyethylene
-PeMV - pepper mottle virus
-PM - powdery mildew
-POP - Philippine Outreach Program (AVRDC)
-PVMV - pepper veinal mottle virus
-PVY - potato virus Y
-PYT - preliminary yield trial

-RCBD - randomized complete block design
-RDA - Rural Development Administration (Rep. of Korea)
-RTI - rust tolerance index
-RYT - regional yield trial

-SDI - selective dissemination of information
-SDP - selective dissemination of publications
-SP - stem and petiole
-SPFMV - sweet potato feathery mottle virus
-SPLC - sweet potato leafcurl
-SPVB - sweet potato vine borer
-SPYDV - sweet potato yellow dwarf virus

-TADCO - Tabuk Agricultural Development Co. (Saudi Arabia)
-TARI - Taiwan Agricultural Research Institute
-TVDF - Tropical Vegetable Data File (AVRDC)
-TEV - tobacco etch virus
-TMV - tobacco mosaic virus
-ToMV - tomato mosaic virus
-TOP - Thailand Outreach Program (AVRDC)
-TSWV - tomato spotted wilt virus
-TuMV - turnip mosaic virus
-TYLCV - tomato yellow leafcurl virus

-UPLB - University of the Philippines at Los Baños (Philippines)
USAID - United States Agency for International Development
-USDA - United States Department of Agriculture

-WARDA - West Africa Rice Development Association

Crop Improvement Program

Chinese Cabbage Breeding

Improvement of Open-pollinated Cultivars for Uniform Maturity

Summary

Previous four generations of maternal line selection of two Chinese cabbage open-pollinated cultivars, 77M(3)-27 and 77M(3)-35, were grown in summer. The coefficient of variation for days to maturity showed a clear but slow decrease in accordance with generation advancement. Maternal lines of MLS_3 generations were evaluated in late warm season, from which selections were made to create the next cycle.

Introduction

To attain uniform maturity in two selected open-pollinated cultivars, three cycles of maternal line selection (MLS) were completed in cool season 1987-1988. The effect of previous selection cycles was estimated by comparing the consecutive generations during summer 1988. Based on the performance in late warm season, lines and individual plants were selected to constitute the population for the next cycle.

Materials and Methods

ML_0 to ML_3 generations of two cultivars, 77M(3)-27 and 77M(3)-35 were sown on 16 June and transplanted on 6 July 1988. Each plot consisted of two 6-m-long double-row raised beds. Spacing was 150 cm between beds, 50 cm between rows on beds and 40 cm between hills in rows. In each cultivar, field layout followed a randomized complete block design with three replicates. The standard cultural practices were employed for seedling bed and field management. The optimum date for harvest was judged on heads' firmness when pressed. The number of days from transplanting to harvest was recorded for individual plants. For reference, each plant's top weight, head weight and head length were also measured at harvest. Ranges and the coefficients of variation were used as indicators of uniformity in comparing different generations.

Twenty-five and 19 maternal lines of ML_3 generation were produced in 77M(3)-27 and 77M(3)-35, respectively, in cool season 1987 to 1988. They were sown on 4 August and transplanted 30 August 1988. A randomized complete block design with three replicates was employed for each cultivar group. A plot consisted of two 8-m long, double-row beds. The spacing was 150 cm between two adjacent beds from center to center, 50 cm between rows on beds, and 40 cm between plants in rows. The seedling nursery and field management practices of AVRDC were followed. During the first and third weeks of October, selection was made for 77M(3)-27 and 77M(3)-35, respectively. In 77M(3)-27, line selection was done by a weighted index method, where degree of uniform maturity, average days to maturity, acceptability and uniformity of head shape, head size and disease incidence were considered. Promising individual plants of similar maturity, shape and size were then selected. In 77M(3)-35, individual plants of desired maturity, head shape and size were chosen regardless of the maternal line to which they belong. The count of these promising plants was used as a criterion in the selection of the superior lines.

Results and Discussion

Growth and development in the field trial was normal until harvest began on 12 August. The heavy rainfall (468 mm) on 13 and 14 August brought about soft rot incidence in 10% of the total plants and delayed the maturity of the survivors. It was assumed that rain damage was more or less the same all over the experimental field.

Ranges for days to maturity did not show a decreasing trend as the generation advanced in both cultivars; however, coefficient of variation showed a slow but clearly decreasing trend (Table 1). Decrease in coefficient of variation and narrowing of range were minimal, in top weight, head weight and head length of both cultivars. Plant appearance at maturity showed a distinct improvement from MLS_0 to MLS_1. These facts indicated poor selection in the previous generations. Increased selection intensity may have to be applied to achieve a more rapid advancement in the next generations. Utmost care in handling the experiment to reduce the environmental effects on maturity is an essential factor. Visual judgement of maturity, although practical probably reduces the efficiency of selection. Moving the planting date to a warmer season may allow a more intensive selection for maturity.

In cultivar 77M(3)-27, differences in maturity and other horticultural traits were clearly noticed among lines, while variation within maternal lines seemed to be greater than that among lines in 77M(3)-35. Table 2 summarizes the selections made in two cultivars. The final selection intensity was 2.31 and 2.63% in 77M(3)-27 and 77M(3)-35, respectively. The selected individual plants will constitute MLS_4 generation.

Table 1. Ranges and coefficients of variation for days to maturity in two Chinese cabbage cultivars at different generations of maternal line selection.

Cultivar	Generation	Range DAT	C.V. %
77M(3)-27	MLS_0	35-52	9.3
	MLS_1	35-52	9.2
	MLS_2	35-52	9.1
	MLS_3	37-56	8.3
77M(3)-35	MLS_0	37-53	9.1
	MLS_1	35-52	9.3
	MLS_2	37-56	8.8
	MLS_3	35-53	8.9

Table 2. Summary of selections made from MLS_3 generation of two open-pollinated Chinese cabbage cultivars to constitute the next cycle.

Cultivar	Planted		Selected		
	lines	plants	lines	paternal parents	maternal[z] parents
77M(3)-27	25	5840	6	102	33
77M(3)-35	19	4560	7	91	29

[z]Will be used as both maternal and paternal parents.

Heat-tolerant and Cylindrical Head Shape Varieties

Summary

Crosses were previously made between heat-tolerant, round-headed parents and heat-sensitive, cylindrical-headed parents. A total of 121 families belonging to BC_1F_3 and BC_2F_2 generations were evaluated in the later part of warm season 1988. Considerable recovery of heat-tolerance was observed

in BC_2F_2 families of two combinations, B61 × E-9 and B61 × R1-3, but with slightly reduced frequency of cylindrical head shape. A total of 66 plants were selected from 34 families for further generation advancement and backcrossing.

Introduction

Most heat-tolerant cultivars previously developed by AVRDC had round heads. In some countries, however, elongated head shape is strongly preferred. This prompted the initiation of combining heat tolerance and cylindrical or elongated head shape to meet their requirements. The plants of BC_1F_2 families selected from the evaluation in fall 1987 were advanced to BC_2F_2 and BC_1F_3 by artificial pollination during the cool season 1987 to 1988. Intercrosses among selected BC_1F_2 families were also done simultaneously. These advanced generations were planted at the later part of the warm season 1988 and evaluated for their heat tolerance, head shape and other horticultural traits. Promising families and plants were then selected for further generation advancement.

Materials and Methods

A total of 121 families of BC_1F_3, BC_2F_2, and BC_1F_2 × BC_1F_2 were sown on 9 August and transplanted on 12 September 1988. A randomized complete block design with three replicates was employed for every generation of each combination. A plot consisted of two 4-m long beds. Two adjacent beds were 150 cm apart from center to center. The spacing between rows was 50 cm and 40 cm between hills within rows. Parental lines, together with a heat-tolerant check Hybrid 62, were also planted beside each of the three combinations and intercross families for evaluation and selection. The field layout of these parents and the check also followed a randomized complete block design, but the plot consisted of double-row beds.

During the third and fourth week of October, family and individual plant selection was done when most lines and plants had attained maturity.

Results and Discussion

Although great variations were observed among plants within families, and among families within a given generation of a given combination, a higher level of heat tolerance and a shortened head length were clearly observed in BC_2F_2 generation than in BC_1F_3 (Table 3). Intercrossed families appeared

Table 3. Summary of heat tolerance level and performance of BC_1F_3's and BC_2F_2's of three heat-tolerance × cylindrical head combinations in late warm season 1988.

Combination[z]	Generation	HT level	Head shape	Head top posture	Tipburn/ internal rot	Bolting	Remarks
B61 × E-9	BC_1F_3	medium	short cylindrical	mostly overlapping	rare		wavy, dark green leaves
	BC_2F_2	medium-high	short elongated	mostly overlapping	rare		wavy, dark green, thin but tough leaves
B61 × R1-3	BC_1F_3	medium	elongated	mostly overlapping	often		
	BC_2F_2	medium-high	round-short cylindrical	overlapping	common		
B61 × B152	BC_1F_3	low	highly varying	michili type	often	susceptible	
	BC_2F_2	low-high	round	overlapping	rare	very susceptible	
Intercross	(BC_1F_2 × BC_1F_2)	low-high	mostly elongated	overlapping -michili type	rare		generally shows very high vigor

[z]B61 is a heat-sensitive donor parent with cylindrical head, while the others are heat-tolerant recipients with round heads.

to be more vigorous than other families, possibly due to the heterotic effect. The combination, B61 × B152 had a high frequency of premature bolting especially in the BC_2F_2 generation. This bolting sensitivity was attributed to the characteristics of the heat-tolerant recurrent parent, B152. This combination was also observed to be less heat-tolerant in both backcross generations than the other two combinations. In families that belong to the combination, B61 × R1-3, either tipburn or internal rot was observed frequently. This was also more frequent in BC_2F_2 than in BC_1F_3, implying that tipburn or internal rot may be genetically attributed to the recurrent parent, R1-3.

A total of 66 plants with cylindrical or elongated heads and highly heat tolerant were selected from 34 families (Table 4). Diseases, tipburn, premature bolting and other horticultural traits were also considered in family and individual selection. The selections from the intercrosses and BC_1F_3's need backcrossing again to increase the heat tolerance level, while those from BC_2F_1 will be both selfed and backcrossed to the heat-tolerant parent.

Table 4. Selections from BC_1F_2 and BC_2F_1 families in three heat-tolerant × cylindrical head combinations.

Combination	Generation	Evaluated		Selected	
		families	plants	families	plants
B61 × E-9	BC_1F_3	13	1,510	6	15
〃	BC_2F_2	24	2,880	11	19
B61 × R1-3	BC_1F_3	12	1,440	0	0
〃	BC_2F_2	18	2,160	9	18
B61 × B152	BC_1F_3	19	2,280	0	0
〃	BC_2F_2	19	2,280	0	0
Intercrosses	(BC_1F_2 × BC_1F_2)	16	1,920	8	14
Total		121	14,520	34	66

Inheritance of Resistance to Turnip Mosaic Virus

Summary

To determine the inheritance of TuMV resistance, P_1, P_2, F_1, F_2 and BC_1F_1 generations (of the crosses between a resistant line, O-2, and each of three susceptible lines, E-7, E-9 and FL-9) were inoculated with two strains of the virus. Segregation ratios obtained through visual reading and ELISA test indicated that two recessive genes confer the resistance to TuMV-C_4 and TuMV-C_5.

Introduction

Previously, inbred O-2 and two sister lines of Chinese cabbage were found to be immune to five known strains of turnip mosaic virus (TuMV). Inheritance of resistance of O-2 to TuMV-C_4 and TuMV-C_5 was studied through artificial inoculation to parent, F_1, F_2 and BC generations of the crosses with three susceptible parents.

Materials and Methods

The resistant line, O-2 was crossed in cool season 1985-1986 with E-7, E-9, and FL-9 which are susceptible to both TuMV-C_4 and TuMV-C_5. The F_1's were selfed and crossed to either parents to produce F_2 and backcross generations in cool season 1986/87. Parental lines and F_1's were also reproduced during this season. Due to poor pollen production of O-2, the line was mostly used as female parent in developing the segregating families.

Of the five TuMV strains, TuMVC_4 and TuMVC_5 were chosen partly because some lines were found susceptible to these particular strains. Besides, these strains were observed to be more virulent than the other three in previous studies. It was suspected that TC_5-resistant lines somehow may have a high resistance to the four other strains.

Seeds of O-2 × E-7, O-2 × E-9 and O-2 × FL-9 combinations, were sown 8 and 22 October, and 5 November 1987, respectively, in petri dishes lined with moistened filter paper to allow germination at room temperature. Three days later, seedlings were pricked to plastic pots of 9 cm in both diameter and height containing a sterile mixture of soil, sand, sugarcane compost and rice hulls at a ratio of 3:1:1:1. The pots were arranged in plastic flats with drainage holes at the bottom. The flats were first placed in an insect-proof screenhouse. During the experiment, outside air temperature ranged from 11 to 26°C. In the later part of the experiment, plants were moved to a plastic film house and then to a glasshouse where higher temperature was maintained than in the screenhouse. To maintain the plants in the small pots for four months, old outer leaves were continuously removed. A small quantity of N, P and K fertilizers was applied to soil mixture at two-week intervals. In addition, 0.3% urea was applied three times.

For inoculum preparation, one part of infected fresh mustard leaves was homogenized in four parts of 0.1 M potassium phosphate buffer (pH 7.5) containing 0.001 M NaEDTA, 0.1 % TA, and filtered in double layer cheese cloth. Two to three young leaves were dusted with carborundum (600 mesh) and inoculated by rubbing gently with a wet cotton. The inoculated leaves were immediately rinsed.

Symptoms were first visually observed three weeks after inoculation. All symptomless plants were tested by enzyme-linked immunosorbent assay (ELISA). ELISA-negative plants were inoculated again. This step was repeated three times until the experiment was terminated on 10 February 1988.

Results and Discussion

Symptoms generally began appearing three to four weeks from inoculation, whereas the susceptible mustard check showed clear symptoms within three weeks. Mosaic symptom was most commonly observed, followed by vein clearing, necrotic spots and discoloration.

Tables 5, 6 and 7 summarize the results obtained from the O-2 × E-7, O-2 × E-9, and O-2 × FL-9 combinations, respectively. All O-2 plants showed negative response in ELISA and remained symptomless until the experiment ended. The other three parental lines were 100% susceptible to both TuMV-C_4 and TuMV-C_5. All plants of F_1's and backcrosses to susceptible parents showed susceptible response to both strains in three combinations. F_2's in all three combinations showed a resistance ratio of 1:15 in both strains. These results suggested that two recessive genes control resistance to TuMV-C_4 and TuMV-C_5 is inherited in a double recessive mode.

The O-2 × FL-9 combination was inoculated with a mixture of TuMV-C_4 and TuMV-C_5 in addition to the single-strain inoculations. The segregation pattern after mixed inoculation was not different from that with single-strain inoculation (Table 7). This indicated that resistance to these two strains is governed by the same set of genes.

Table 5. Segregation of resistance to TuMV in different generations of O-2 × E-7 combination.

Strain	Generation[z]	Total plants	Observed ratio		Theoretical ratio	X^2	Probability
			res.	sus.			
TuMV-C_4	Pr (0-2)	30	30	–			
	Ps (E-7)	30	–	30			
	F_1 (Pr × Ps)	42	–	42	0 : 1		
	F_2 (Pr × Ps) selfed	121	9	112	1 : 15	0.296	0.50 - 0.75
	BC_1F_1 (Pr × Ps) × Pr	25	5	20	1 : 3	0.333	0.50 - 0.75
	BC_1F_1 (Pr × Ps) × Ps	55	0	55	0 : 1		
	BC_1F_1 Ps × (Pr × Ps)	55	0	55	0 : 1		
TuMV-C_5	Pr (0-2)	30	30	–			
	Ps (E-7)	30	–	30			
	F_1 (Pr × Ps)	42	–	42	0 : 1		
	F_2 (Pr × Ps) selfed	123	10	113	1 : 15	0.742	0.25 - 0.50
	BC_1F_1 (Pr × Ps) × Pr	25	5	20	1 : 3	0.333	0.50 - 0.75
	BC_1F_1 (Pr × Ps) × Ps	55	0	55	0 : 1		
	BC_1F_1 Ps × (Pr × Ps)	55	0	55	0 : 1		

[z]Pr = resistant parent; Ps = susceptible parent.

Table 6. Segregation of resistance to TuMV in different generations of O-2 × E-9 combination.

Strain	Generation[z]	Total plants	Observed ratio		Theoretical ratio	X^2	Probability
			res.	sus.			
TuMV-C4	Pr (O-2)	32	32	–			
	Ps (E-9)	34	–	34			
	F_1 (Pr × Ps)	43	0	43	0 : 1		
	F_2 (Pr × Ps) selfed	140	10	130	1 : 15	0.191	0.5 - 0.75
	BC_1F_1 (Pr × Ps) × Pr	20	5	15	1 : 3	0.000	> 0.90
	BC_1F_1 (Pr × Ps) × Ps	55	0	55	0 : 1		
	BC_1F_1 Ps × (Pr × Ps)	55	0	55	0 : 1		
TuMV-C5	Pr (O-2)	32	32	–			
	Ps (E-9)	36	–	36			
	F_1 (Pr × Ps)	43		43	0 : 1		
	F_2 (Pr × Ps) selfed	128	8	120	1 : 15	0.000	> 0.90
	BC_1F_1 (Pr × Ps) × Pr	19	5	14	1 : 3	0.017	> 0.90
	BC_1F_1 (Pr × Ps) × Ps	41	0	41	0 : 1		
	BC_1F_1 Ps × (Pr × Ps)	55	0	55	0 : 1		

[z]Pr = resistant parent; Ps = susceptible parent.

Table 7. Segregation of resistance to TuMV in different generations of O-2 × FL-9 combination.

Strain	Generation[z]	Total plants	Observed ratio		Theoretical ratio	X^2	Probability
			res.	sus.			
TuMV-C4	Pr (O-2)	30	30	–			
	Ps (FL-9)	30	–	30			
	F_1 (Pr × Ps)	30	0	30	0 : 1		
	F_2 (Pr × Ps) selfed	100	6	94	1 : 15	0.011	> 0.90
	BC_1F_1 (Pr × Ps) × Pr	30	6	24	1 : 3	0.4	0.50 - 0.75
	BC_1F_1 (Pr × Ps) × Ps	55	0	55	0 : 1		
	BC_1F_1 Ps × (Pr × Ps)	55	0	55	0 : 1		
TuMV-C5	Pr (O-2)	30	30	–			
	Ps (FL-9)	30	–	30			
	F_1 (Pr × Ps)	30	–	30	0 : 1		
	F_2 (Pr × Ps) selfed	100	7	93	1 : 15	0.096	0.75 - 0.90
	BC_1F_1 (Pr × Ps) × Pr	29	6	23	1 : 3	0.298	0.50 - 0.75
	BC_1F_1 (Pr × Ps) × Ps	55	0	55	0 : 1		
	BC_1F_1 Ps × (Pr × Ps)	53	0	53	0 : 1		
C4 & C5[y]	Pr (O-2)	30	30	–			
	Ps (FL-9)	30	–	30			
	F_1 (Pr × Ps)	30	0	30	0 : 1		
	F_2 (Pr × Ps) selfed	100	6	94	1 : 15	0.011	> 0.90
	BC_1F_1 (Pr × Ps) × Pr	30	5	25	1 : 3	1.111	0.25 - 0.50
	BC_1F_1 (Pr × Ps) × Ps	55	0	55	0 : 1		
	BC_1F_1 Ps × (Pr × Ps)	55	0	55	0 : 1		

[z]Pr = resistant parent; Ps = susceptible parent. [y]Inoculated with the mixed inoculum of two strains, TuMV-C^4 and TuMV-C^5.

International Cooperation

In 1988, 744 seed packets were distributed to 67 cooperators in 32 countries. Most packets consisted of open-pollinated and/or F_1 hybrid cultivars developed by AVRDC. These materials were intended for trials in different growing environments. A limited number of shipments of the parental lines of the F_1 hybrids were made to national programs for in-country seed production studies. Below are some reports from AVRDC's international cooperators.

China

Dr. Charles Y. Yang of the Thailand Outreach Program compiled the results of the Chinese cabbage trials conducted in different provinces of China during summer 1987. Figure 1 highlights the performance of hybrids 58 and 62 in the trials. Both hybrids performed well in all central and southern provinces except Shanxi, but not in provinces of high latitude due to premature bolting induced by low night temperatures.

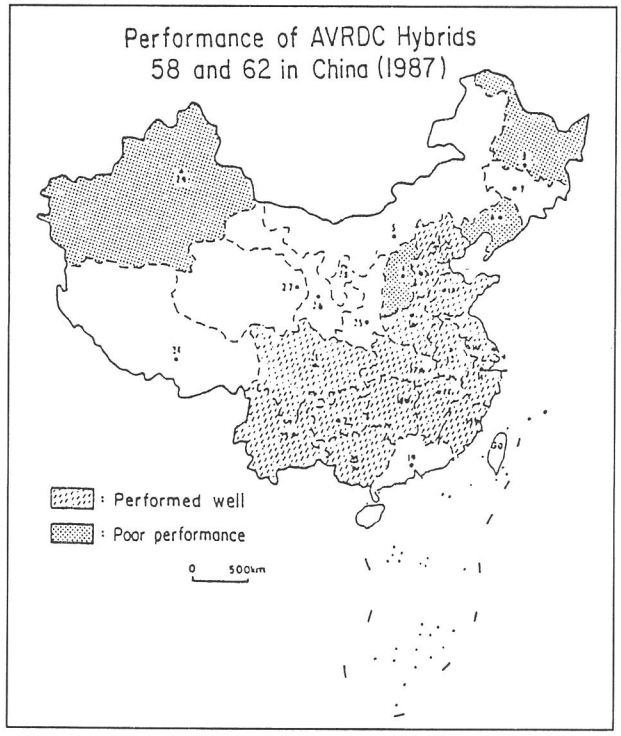

Fig. 1.
Performance of AVRDC hybrids 58 and 62.

El Salvador

In a winter trial conducted by Mr. Daniel Chen, AVRDC hybrids 85202 and 85216 produced big and cylindrical heads. Both entries remained free of diseases until harvest. Among AVRDC entries, Hybrid 85216 was the most preferred. The heat-sensitive check, B40 and the local check, Pin-Lu from Sakata Seed Co., also formed marketable compact heads.

Indonesia

Four AVRDC introduced Chinese cabbage hybrids were tested under lowland conditions at Bodag, Kecemantan Kare, East Java by Mr. F. Palembang and Dr. Brian Hilton of Merdeca University at Madiun, Indonesia. An infestation of an unknown yellow disease and Alternaria leaf spot greatly reduced the yield. Although varietal difference was not statistically significant, Hybrid 82-157 was the highest yielder among entries (Table 8). A separate experiment was conducted to study the effect of five different fertilizer treatments on tipburn/internal rot incidence in Hybrid 62. They, however, failed to induce the symptoms in any treatment.

Table 8. Yield and other traits of four AVRDC Chinese cabbage hybrids in a trial[z] at Kare Madiun, East Java, 1988.

Entry	Head weight (kg)	Soft rot (%)	Harvest rate (%)	Yield (t/ha)
77M(2/3)-46	0.4	17	45	9.8
Hybrid 82-157	0.4	10	70	15.5
Hybrid 82-156	0.4	20	43	8.4
Hybrid 62	0.3	33	56	12.1
LSD .05	NS	14	NS	NS

[z]Sown on 28 December 1987 and transplanted 22 January 1988.

Malaysia

At the Agricultural Research Center, Tuaran, Sabah, Malaysia, four heat-tolerant AVRDC Chinese cabbage cultivars were tested together with a local cultivar and a heat-sensitive check under straw-mulched and nonmulched conditions. Hybrid 58 gave the highest yield under both conditions, followed by 77M(2/3)-46 (Table 9). B189 showed heading rate similar to that of the former two entries, but yield was lower due to smaller heads. Mulching significantly increased head yield, especially in Hybrid 59 and Pei Choi China. Such increase was, however, not found in any of the yield components.

Mr. Yong Lee Ming of the Agricultural Research Station at Tenom, Sabah evaluated 11 entries from various sources in July to August 1987. Among five highest yielders, four were AVRDC cultivars (Table 10); they also exhibited a satisfactory level of heat tolerance.

Table 9. Performance[z] of AVRDC Chinese cabbage cultivars in a trial[y] at the Agriculture Research Center, Tuaran, Sabah, Malaysia.

Entry	Heading rate (%)	Head weight (kg)	Yield (t/ha)
77M(2/3)-46	61 a[x]	0.9 c	26 b
Hybrid 58	34 b	1.4 a	25 b
Hybrid 59	68 a	1.2 ab	41 a
B 189	63 a	0.5 d	17 bc
B 40 (HS check)	24 b	1.0 bc	13 c
Pei Choi China (local check)	26 b	1.3 a	17 bc

[z]Mean of straw-mulched and nonmulched treatments. [y]Direct-seeded on 15 September 1987. [x]Mean separation within columns at 5% probability level by DMRT.

Table 10. Performance of some selected entries in a trial[z] at the Agricultural Research Station at Tenom, Sabah, Malaysia.

Entry (source)	Head weight (kg)	Yield (t/ha)
77M(2/3)-43 (AVRDC)	0.80 b[y]	24.7 a
77M(2/3)-46 (AVRDC)	0.76 b	22.7 ab
Hybrid 58 (AVRDC)	0.79 b	22.5 ab
Hybrid 62 (AVRDC)	0.70 b	21.8 ab
Summer Bright (Known You)	0.76 b	22.6 ab

[z]Conducted during the period of July to August 1987. [y]Mean separation within columns by DMRT at 5% probability level.

Nepal

Mr. Laxman Pun of Vegetable Development Division, Department of Agriculture tried seed production of Hybrid 62, which had been recommended for prerelease in 1987 and multiplication of parental lines. Mr. Pun sent samples of the produced parents and hybrid to test their purity at AVRDC. Table 11 summarizes the results. Purity was within an acceptable range in all seeds except for the hybrid produced from B-18.

Philippines

At POP, eight AVRDC cultivars were tested in two trials in dry season 1987 and wet season 1988. Between the two seasons, maturity was later, soft rot incidence was lower, harvest rate was higher and head weight and yield were lower in the dry season (Table 12). Coefficient of variation was greater in most variables in the dry than in the wet season.

Among entries, Hybrid 82-156 had the highest harvest rate. Hybrids 85202 and 85216 were the highest yielders in both trials.

Mr. E.I. Castro and his colleagues at MMSU conducted trials at Batac, Ilocos Norte in two seasons. One trial was done in February to April 1987 and the other from November 1987 to February 1988. In the first trial with seven entries, AVRDC Hybrids 58 and 62, and a commercial variety, Soro 127, exhibited the highest yield. In the second trial, all 12 heat-tolerant entries, of which 11 were from AVRDC, exhibited big heads of over 1 kg and high yields of over 40 t/ha in 40 days after transplanting. Even the heat-sensitive check, B 40 produced marketable heads although it matured later by more than 10 days than the other entries.

Dr. J.O. Narciso of University of the Philippines at Los Baños evaluated six AVRDC Chinese cabbage cultivars in the wet season 1987 and identified heat tolerance sources to be used in his own breeding program.

Sri Lanka

Thirteen AVRDC Chinese cabbage cultivars were tested in wet season 1987 to 1988 at the Agricultural Research Station, Maha Illuppallama, Sri Lanka. Four hybrids and three open-pollinated

Table 11. Seed purity test of F_1 Hybrid 62 and its parents produced in Nepal.

Index	Code[z]	Origin[y]	No. of plants					Purity (%)
			Total	F_1	Sib/Selfing	Off-type		
1	E-7	AVRDC	40	–	40	0		100
2	Np E-7	Nepal	451	–	443	8	(Non-heading type)	98.2
3	62D	AVRDC	51	50	1	0		98
4	Np 62D	Nepal	595	592	2	1	(Sib-like)	99.5
5	B-18	AVRDC	44	–	44	0		100
6	Np B-18	Nepal	357	–	357	0		100
7	62R	AVRDC	48	46	2	0		95.8
8	Np 62R	Nepal	537	382	15	140	(Much variation among these off types)	71.1

[z]D and R refer direct (E-7 × B-18) and reciprocal (B-18 × E-7) crosses, respectively. [y]Seeds of AVRDC origin were used as the check.

Table 12. Performance of four selected Chinese cabbage cultivars in two trials at POP.

Season[z]	Entry	Maturity (DAT)[y]	HSI[x]	Head weight (kg)	Soft rot (%)	Harvest rate (%)	Yield (t/ha)
Dry season, 1987	Hybrid 82-156	50 a[w]	1.4	0.5 b	5	91	15.7
	Hybrid 85202	44 ab	1.6	0.6 a	1	96	20.2
	Hybrid 85216	48 ab	1.5	0.6 ab	1	95	20.2
	Hybrid 62	44 ab	1.4	0.7 a	5	81	17.8
	LSD .05	5.4	NS	0.0	NS	NS	NS
Wet season, 1988	Hybrid 82-156	39 bc	1.4 cd	0.6 c	9 c	86 a	14.8 ab
	Hybrid 85202	42 ab	1.7 a	0.7 ab	19 bc	65 ab	15.1 ab
	Hybrid 85216	40 abc	1.7 a	0.8 a	19 bc	66 ab	15.9 a
	Hybrid 62	37 c	1.4 cd	0.7 abc	34 ab	50 bc	10.8 b
	LSD .05	3.8	0.13	0.1	–	–	4.7

[z]The dry season trial was sown on 25 November 1987 and harvested during 1-19 January 1988, while the wet season trial was sown on 31 May 1988 and harvested during 4-13 July 1988. [y]Days after transplanting. [x]Head shape index = head length/head width. [w]Mean separation within columns within season by DMRT at 5% probability level.

varieties yielded over 30 t/ha (Table 13). Soft rot incidence was below 15% in all entries. The head quality was rated good and uniform in every entry.

Mr. P. Tharmalingam of the Tropical Green Isle Seeds at Jaffna, Sri Lanka tested five AVRDC Chinese cabbage cultivars sown on 5 February 1988. Only two hybrids, 85202 and 85216, produced marketable heads, whereas Hybrid 62, 77M(3)-40 and 77M(2/3)-46 failed to form marketable heads.

Thailand

Eight AVRDC entries were evaluated together with a commercial check in a trial sown on 17 December 1987 at the Institute of Technology and Vocational Education, Chonburi, Thailand. Dr. Chanai Yodpetch of the Institute reported that Hybrid 85216 was the highest yielder, followed by Hybrids 83-20 and 62. Yield data of some selected entries are presented in Table 14.

Table 13. Yield of selected Chinese cabbage cultivars[z] in a trial at the Agricultural Research Station, Maha Illuppallama, Sri Lanka, 1987-1988.

Entry	Yield[y] (t/ha)	Entry	Yield (t/ha)
Hybrid 83-20	32.3	77M(3)-26	26.0
82-46	29.2	77M(3)-27	34.4
58	31.7	77M(2/3)-41	30.2
59	31.9	77M(2/3)-43	34.8

[z]Sown on 19 October, transplanted 20 November 1987 and harvested in January 1988. [y]Data from single replication.

Table 14. Yield, head weight and heading rate of some selected AVRDC entries in a trial[z] at the Institute of Technology and Vocational Education, Sriracha, Chonburi, Thailand.

Entry	Yield (t/ha)	Head weight (kg)	Heading rate (%)
Hybrid 85202	47.6 bc[y]	1.0 bc	92 ab
Hybrid 83-20	52.9 b	1.2 ab	89 bc
Hybrid 85216	62.6 a	1.3 a	99 a
Hybrid 62	48.4 bc	1.0 bc	93 ab

[z]Conducted from 17 December 1987 to 5 February 1988. [y]Mean separation within columns by DMRT at 1% probability level.

Chinese Cabbage Entomology

Establishment of DBM Parasite in Taiwan Highlands

Summary

Diadegma eucerophaga, a larval parasite of diamondback moth (DBM), was imported from Indonesia and introduced in crucifer growing areas in the highlands of central Taiwan in 1986. Surveys in 1988 revealed that this parasite is now established and has spread up to 60 km from the site of release. Parasitism of up to 50% by *D. eucerophaga* alone was found at certain locations. The DBM population was reduced considerably and farmers reported very little use of insecticides.

Introduction

The DBM, *Plutella xylostella* L. (Lepidoptera: Yponomeutidae) is a pest of economically important crucifers, such as common cabbage, cauliflower, Chinese cabbage and radish. The insect larva feeds on the foliage and seriously reduces crop yield and quality. This pest is most serious in the tropics where it breeds throughout the year. At present, farmers use a large quantity of insecticides to combat this pest. As a result of frequent and indiscriminate use of insecticides, the DBM has developed resistance to practically all insecticides used. Hence, it has become almost impossible to control.

To lessen the use of expensive and hazardous insecticides, AVRDC imported from Indonesia, a larval parasite of DBM, *Diadegma eucerophaga* Horstm (Hymenoptera: Ichneumonidae), and introduced it in lowland and highland crucifer growing areas in Taiwan to control DBM. In 1988, AVRDC made surveys in highlands for the presence of the parasite and extent of parasitism.

Materials and Methods

In summer of 1986, a mixed population of 45,000 *D. eucerophaga* and another larval parasite native to lowland areas of Taiwan, *Apanteles plutellae* Kurdj (Hymenoptera: Braconidae), were released on a 17-ha farm in the highland area of Wuling (elevation 1700 m) in central Taiwan. In 1987, the area was not surveyed but in August-September 1988, an extensive survey of DBM parasitism at Wuling and in other crucifer growing areas within a radius of 70 km was conducted. At each location, the number of DBM larvae and pupae and parasitized DBM larvae and pupae per unit number of plants were recorded, usually 50 to 200. DBM parasitism was judged by the presence of parasite pupae and larvae within DBM larvae when the latter were cut open. Parasitism rate was calculated by dividing the number of DBM larvae + pupae parasitized by total number of DBM larvae + pupae and multiplying the product by 100.

Results and Discussion

At Wuling (Fig. 1), where parasites were released, 56.9% of the DBM population was parasitized by both insects. At Chingchin (an elevation of 1600 to 2000 m) 60 km to the south, 68.3% of DBM population was parasitized. *D. eucerophaga* contributed 46.8% of the parasitism and *A. plutellae*, 21.5%. Both parasites were also found at Lishan (elevation 1600-2100 m), 20 km to the south; Tienhsiang (elevation 1000 m), 30 km to the east; and Nanshan (elevation 1100 m), 50 km to the north. However, DBM population was too low to reliably judge the extent of parasitism.

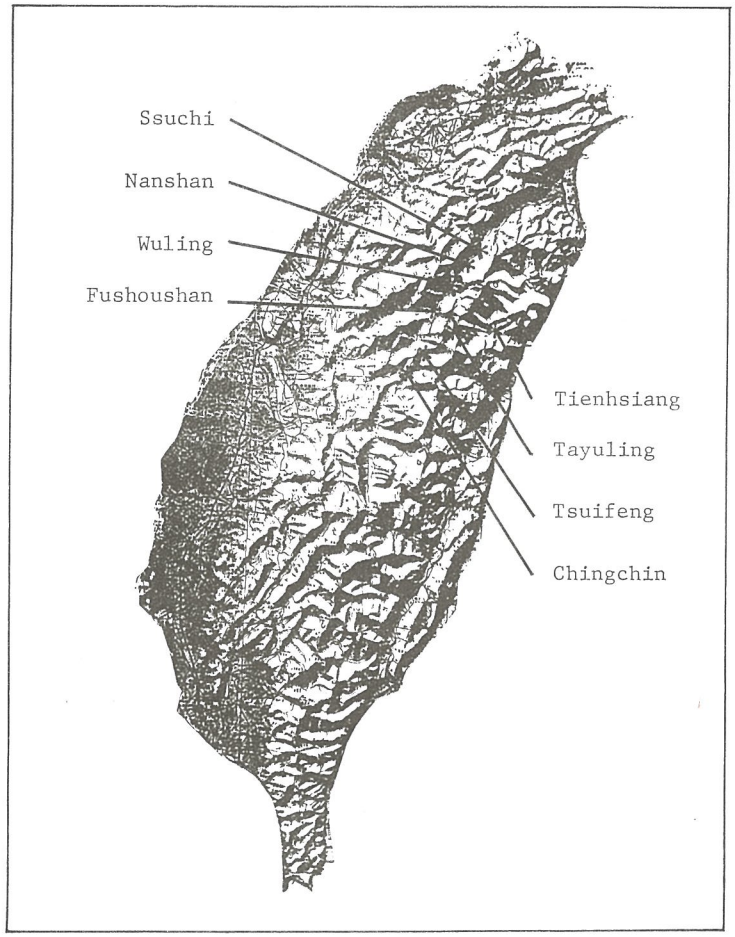

Fig 1.
Map of Taiwan showing the sites where parasites were released and established.

Today, the parasite is established in crucifer growing areas in the highlands of central Taiwan. Farmers in these areas report considerably less DBM damage and consequently less use of insecticides. *A. plutellae* occurred occasionally in this area before but from the time *D. eucerophaga* was introduced by AVRDC, it has been well established and is spreading. The parasite can overwinter and seems to have alternate hosts, possibly some forest insects.

Reliable data on the cost of insecticides for DBM control were not taken before the introduction of parasites. However, in a similar highland area, Yangminshan near Taipei, farmers spend NT$5500 for DBM control per hectare per crop. Based on this, the introduction of parasite represents savings of over NT$10 million (US$350,000) per year. Moreover, the reduction in insecticide use also decreases the toxicant being washed off from the highlands into the streams, which eventually pollutes the rivers and coastal areas around Taiwan.

When crucifers are grown in lowlands, and temperature during winter is similar to summer in the highlands, this parasite may likely spread in the lowlands and reduce DBM damage. This aspect is now under study.

Technology transfer. A collaborative research project to transfer this technology to Thailand, Malaysia, Indonesia and the Philippines was proposed. Tentative pilot project areas were identified in consultation with national program scientists in these countries.

Biological Control of DBM

Summary

An attempt on the biological control of DBM in Yangmingshan, Taiwan was made by releasing the larval parasite, *Apanteles plutellae* in crucifer growing areas in the mountains. A total of 44,400 parasites were released at intervals in one season. Parasitism ranged from 12 to 55%. A cyclic pattern of parasite and host pest emergence was observed. Farmers' use of nonselective chemicals resulted in parasite mortality which reduced parasitism and increased DBM population. More intensive efforts are needed to curb the unnecessary use of broad-spectrum insecticides by farmers to achieve DBM control through parasite introduction.

Introduction

Common cabbage and Chinese cabbage are important crucifers cultivated in Yangmingshan mountain areas during hot-rainy summer when they fetch a high price in the market. As elsewhere in Taiwan, the DBM, *Plutella xylostella* is the most destructive insect pest in this area. In cooperation with Taoyuan District Agricultural Improvement Station (DAIS), two larval parasites *Diadegma eucerophaga* and *Apanteles plutellae* were released in 1987 and in 1988, respectively.

Materials and Methods

In early April, when farmers started transplanting, AVRDC established 10 parasite-release stations in a 5-ha area owned by 14 farmers. Each station consisted of a quadrangular wooden box with slanted top and a door on one side which can be opened and closed. Except for the top and bottom, all sides were perforated with three to four 1.5 cm diameter holes to allow the escape of the parasite adults emerging from the pupae inside the release station. The box was mounted on a 1 m high wooden pole. *A. plutellae* was reared on DBM larvae in the laboratory and a large number of pupae was released in each station.

Starting on the last week of May until mid August, parasites in the stations were released once every two weeks. Observations on the parasitism were recorded once every week. The total number of DBM larvae + pupae and number of *A. plutellae* pupae on 100 randomly selected plants were also recorded.

Farmers were requested to use, if necessary, only *Bacillus thuringiensis*, and two insect growth regulators, teflubenzuron and chlorfluazuron, which are nontoxic to the parasite. Several water trough traps baited with sex pheromone of *Spodoptera litura* were placed throughout the area to ensnare *S. litura*, an occasional pest of crucifers.

Results and Discussion

A. plutellae was released seven times at biweekly intervals starting 24 May, the date of first release. A total of 44,400 pupae were released. Adult emergence was usually in excess of 90%. Results of DBM infestation on cabbage and parasitism of DBM by *A. plutellae* are summarized in Figure 2.

Parasitism ranged from 12 to 55%. Initially during the first six weeks, parasitism averaged 35% and DBM population was low. After six weeks, DBM population rose sharply and parasitism decreased. This could be due to the farmers' use of such nonselective chemicals such as chlorpyrifos, methamidophos, carbofuran, acephate and Karate, a newly developed synthetic pyrethroid, which they were not supposed to use. Such insecticides are not only useless against DBM, since it has developed resistance, but they also kill the parasites which tend to reduce DBM populations. Farmers used insecticides amounting to NT$5520 (US$196) per hectare. This accounted for 14.2% of the total production cost.

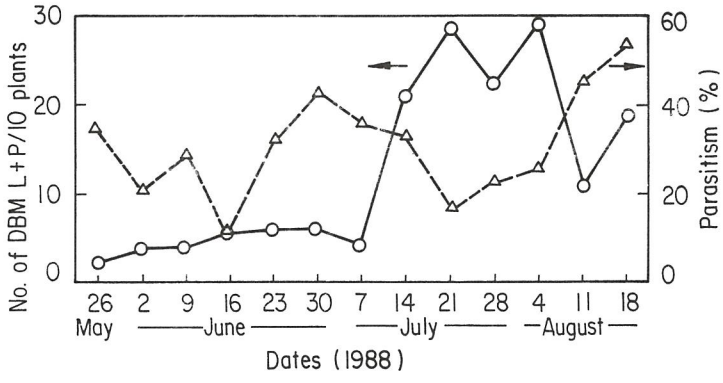

Fig. 2.
Population of DBM larvae and pupae and DBM parasitism by *A. plutellae* at Yangminshan.

DBM Egg Parasite

Summary

An egg parasite, *Trichogrammatoidea bactrae*, was imported from Thailand for introduction in Taiwan and elsewhere in Southeast Asia to combat DBM on crucifers. Preliminary laboratory and field studies were conducted in 1988 to assess the potential of this parasite. The ideal temperature for parasitism was 20 to 30°C. Parasitism occurred only at day time. Selective insecticides such as a bacterial formulation, *Bacillus thuringiensis*, and teflubenzuron, an insect growth regulator, were nontoxic but broad-spectrum chemicals such as deltamethrin were extremely toxic to *T. bactrae*. In the field, parasitism of DBM eggs ranged from 36.8 to 66.7%, indicating the potential of this parasite to control DBM.

Introduction

In the tropics and subtropics where crucifers can be grown throughout the year, DBM, *Plutella xylostella*, is a serious pest. The insect lays eggs on the leaves and the larvae feed on the foliage. As a result of insect feeding, the quantity and quality of the produce are adversely affected. At present farmers use insecticides to combat the pest. Their indiscriminate use of insecticides has made DBM resistant to practically all chemical insecticides presently used. No suitable alternative control measures which are practical on farmers' fields, are yet available to control the pest.

In late 1987, an egg parasite, *Trichogrammatoidea bactrae* was imported from Thailand. After developing a mass rearing technique, AVRDC conducted some laboratory and field tests to assess the suitability of this insect for biological control of DBM.

Materials and Methods

Effect of temperature. The eggs of *Corcyra cephalonica* Staint (Lepidoptera: Galleriidae), used routinely for mass rearing of the parasite, were utilized in the study. About 1,200 eggs were pasted on paper (5 cm × 2 cm) and irradiated by UV light to kill the embryo. A similar number of already parasitized eggs were placed in a 15 cm long glass tube with 3 cm diameter, just before the adult parasites were about to emerge. Fresh irradiated *Corcyra* eggs pasted on paper were put in the same tube. Four tubes were placed each at 15, 20, 25, 30, and 35°C for 24 hours after which the freshly parasitized eggs were removed and placed at 26 ± 1°C until egg parasitism could be observed. Parasitized eggs turned black whereas unparasitised ones remained transparent to milky white for one week. The percentage of parasitized eggs was computed.

Effect of light/darkness on parasitism. Newly emerged *T. bactrae* adults were held in eight tubes (15 cm long and 3 cm wide). Four tubes each were placed in lighted and dark chambers for 12 hours to acclimatize the insect. Fresh and irradiated *Corcyra* eggs pasted on paper were then placed into each tube; tubes were returned to the lighted or dark chambers as before for another 24 hours. This time, freshly parasitized eggs were removed and placed at 26 ± 1°C and 12h:12h, light:dark condition. The percentage of parasitized eggs was determined a week later when parasitized eggs turned dark.

Effect of age of DBM eggs on parasitism. Every day for four consecutive days, freshly laid eggs of DBM were collected from cabbage leaves. The collection each day was pasted on four pieces of paper; each paper having 20 eggs. They were irradiated soon after pasting on the paper. When the first day's collection reached four days, each day's collection was transferred into four tubes (15 cm long, 3 cm diameter.) containing an equal number of *T. bactrae* adults. After two-hour exposure, the eggs were removed and placed at 26 ± 1°C until parasitized eggs turned dark. The percentage of parasitized eggs for each age group was calculated.

Effect of insecticides on parasitism. Formulations of one insect growth regulator (IGR), teflubenzuron, one *Bacillus thuringiensis* product, Dipel and one synthetic pyrethroid, deltamethrin, were dispensed in water to allow concentrations twice the recommended rates for field use. Teflubenzuron was diluted to 0.0075% AI (=75 g AI/ha), Dipel to 0.1% product (=1 kg product/ha) and deltamethrin, 0.01% AI (=100 g AI/ha). Irradiated *Corcyra* eggs pasted on paper were dipped in each solution or water only (as one check) for 30 seconds. When the eggs dried, treated as well as untreated eggs were placed in glass tubes (15 cm long with 3 cm dia) containing equal numbers of eggs already parasitized and *T. bactrae* adults which were about to emerge. The tubes were maintained at 26 ± 1°C for one week. The percentage of parasitized eggs was recorded.

Parasitism of DBM eggs in the field. A parcel of land was rototilled and applied with basal fertilizers, after which, it was worked into 1.5-m wide beds. One-month old seedlings of common cabbage were transplanted in two parallel rows along the length of each bed. Soon after transplanting, the entire land was divided into five 7.5 m × 20 m blocks and each block was partitioned by 2-m high fine mesh nylon net. A 1-m high plastic sheet was also wrapped around the partition net. The top of each block was covered with the same nylon net to prevent the movement of insects from room to room. From three weeks after transplanting, an equal number of freshly emerged DBM adults in each room were released. Simultaneously, an equal number of three species of egg parasites: *T. bactrae*, *Trichogramma ostriniae* and *Trichogramma chilonis* were released, one species per room. In another room, teflubenzuron 15EC at the rate of 37.5 g AI/ha once every two weeks was sprayed but one room was left untreated. Within a week of parasite release, 20 cabbage leaves from each room were taken as samples to detect and record total DBM and parasitized eggs.

Results and Discussion

Effect of temperature. Figure 3 illustrates the effect of temperature on parasitism by *T. bactrae*. Parasitism increased from 24.4% to 77.7% with an increase in temperature between 15 to 25°C, and a proportionate decrease thereafter from 25 to 35°C. At 35°C, only 5% of the eggs were parasitized by *T. bactrae*. The ideal temperature range for parasitism was 20 to 30°C. This parasite is therefore suitable for lowland and midlevel highlands.

Effect of light/darkness on parasitism. The effect of light and darkness on parasitism by *T. bactrae* is summarized in Table 1. Parasitism occurred mainly when there was light; it was practically absent in the dark. It must be noted that both tests were conducted simultaneously and the difference in parasitism was not due to diurnal variation but rather due to the parasite's ability to find hosts when there was light rather than when it was dark.

Effect of age of DBM eggs on parasitism. Effect of age on parasitism of DBM eggs is summarized in Figure 4. Parasitism increased gradually when eggs reached one to three days, then

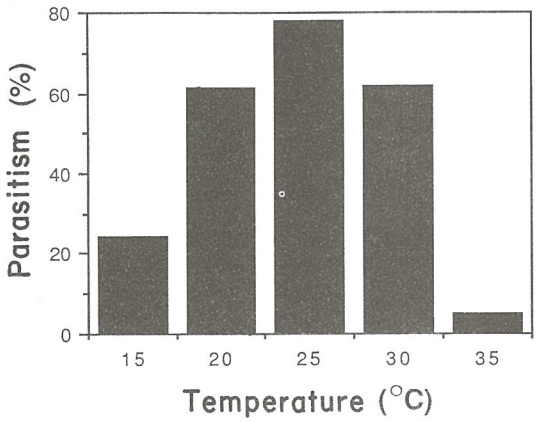

Fig. 3. Effect of temperature on *T. bactrae* parasitism.

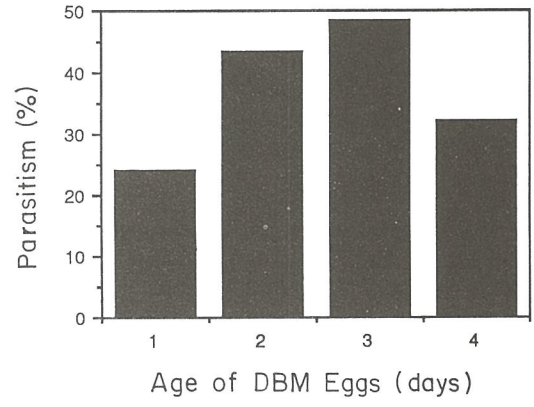

Fig. 4. Effect of age of DBM eggs on parasitism by *T. bactrae*.

Table 1. Effect of light and darkness on parasitism of *T. bactrae*.

Condition	Parasitism (%)[z]
Light	65.1 a
Dark	7.0 b

[z]Data are means of four replicates. Mean separation by DMRT at 5% probability level.

declined slightly thereafter. The age of DBM eggs, therefore, does not seem to play a part in the selection of DBM eggs. DBM eggs hatched in five to six days at 26°C. Whether the four-day old DBM embryo could interfere in the development of parasite needs investigation since the eggs were irradiated and the embryos died in the present study.

Effect of insecticides on parasitism. The effect of selected insecticides on parasitism by *T. bactrae* is summarized in Table 2. Neither teflubenzuron nor *B. thuringiensis* adversely affected parasitism. However, deltamethrin was extremely harmful. The possible residues of teflubenzuron and *B. thuringiensis* on egg surface did not affect the parasite which came in contact with the eggs for oviposition. On the other hand, deltamethrin was poisonous and when the parasite came in contact with the treated surface, apparently died before it could lay eggs. It was, however, not clear whether deltamethrin killed the parasite before oviposition or the embryo. In any case, for practical purposes, deltamethrin and similar contact insecticides are considered not compatible with *T. bactrae* parasitism.

Parasitism of DBM eggs in the field. Neither *T. ostrinae* nor *T. chiloni* parasitized DBM eggs. Parasitism was not observed in check or teflubenzuron-treated plots where no parasite was released. Parasitism by *T. bactrae* was found in all three observation intervals. It ranged from 36.8% to 66.7%. This experiment aimed to confirm laboratory findings of substantial DBM parasitism by *T. bactrae*. This parasite, therefore, is suitable for release in the field.

Table 2. Effect of selected insecticides on parasitism by *T. bactrae*.

Insecticide	AI (%) spray	Parasitism[z] (%)
Teflubenzuron 15EC	0.0075	70.9 a
B. thuringiensis	0.01	58.2 c
Deltamethrin 2.8EC	0.01	4.6 d
Water		65.3 b
Control		73.6 a

[z]Data are means of four replicates. Mean separation by DMRT at 5% probability level.

Testing of *Bacillus thuringiensis* Formulations and Insect Growth Regulators

Summary

Insect growth regulators such as teflubenzuron, chlorfluazuron, PH70-23 and WL 115110 gave good DBM control. These treatments increased the yield. There was no indication of DBM showing resistance to any of these chemicals. All *Bacillus thuringiensis* formulations controlled DBM but SAN 415 was the most effective. Methanolic extract of neem (*Azadirachta indica*) seed failed to control DBM in the field. The insect growth regulator and *B. thuringiensis* formulations were selectively toxic to DBM and other caterpillar pests and were not harmful to beneficial parasites. Thus, they are suitable for integrated pest management.

Introduction

Insecticides play an important role in crop protection, especially on vegetables wherein besides quantity, the quality of the produce determines the net income. Insecticides are widely used by vegetable farmers in Asia, especially in the control of DBM, *Plutella xylostella*. As a result of indiscriminate insecticide use, DBM has become resistant to practically all classes of insecticides presently used. Apart from killing the DBM, the insecticides also kill its parasites and predators as well as those of other crucifer pests. The parasites tend to be more sensitive to these chemicals than the host insects. This has made DBM even more serious than it was before the wide use of chemical insecticides. Recently, a new class of chemicals called insect growth regulators (IGR), which are specifically toxic to caterpillar pests and safer to natural enemies, have been synthesized and are registered in different countries. These chemicals have potential in the integrated control of various caterpillar pests. In 1988, two experiments on these chemicals, along with formulations of a well-known bacterial insecticide *Bacillus thuringiensis*, were conducted.

Materials and Methods

The procedures were identical to those described in the AVRDC publication 'Vegetable Pest Control: Insecticide Evaluation Tests'. In brief, each test included nine insecticide treatments and one untreated check. Using an air-pressurized sprayer, each chemical was applied once a week to designated plots of 4.5 m × 3.3 m size. Each treatment had four replicates arranged in a randomized complete block design. Insecticide spraying was initiated from about two weeks after transplanting and discontinued a week before harvesting.

Insecticide efficacy was evaluated at intervals, usually a day before the next weekly insecticide application. At each interval, the number of DBM larvae and pupae found in randomly selected 10 plants in each plot was recorded. At harvest, heads of cabbage were weighed and marketable heads in each plot were recorded. From these data, head weights in every plot were also computed. Insect count and yield data were analyzed by ANOVA and means were separated by DMRT.

Results and Discussion

All IGRs except BAS 206SC gave excellent DBM control (Table 3). BAS 206 in EC formulation gave distinctly better control than the same chemical in SC formulation. However, EC formulation caused phytotoxicity. As a result, the yield was lower in EC treatments despite good DBM control. The older IGRs, teflubenzuron and chlorfluazuron, still exhibited good control and there was no indication of DBM-developed resistance to these chemicals.

All *B. thuringiensis* formulations reduced DBM infestation but Dipel 2X was less effective than the rest (Table 4). SAN 415 formulation was superior over the others. Neem, a methanol extract of seeds from *Azadirachta indica*, was not effective in DBM control. The extracts showed insecticidal activity against a large number of insect pest species in India and elsewhere. None of the *B. thuringiensis* formulations gave as good DBM control as teflubenzuron.

Table 3. Screening of insect growth regulators for DBM control on common cabbage.[a-f]

Insecticides	Rate g AI/ha	DBM Larvae + Pupae/10 plant					Marketable yield t/ha	Marketable heads /plot	Marketable heads kg/head
		88/2/4	2/25	3/3	3/10	3/17			
PH70-23 25 liq.	50	0.5 c	0.7 c	12.7 c	9.2 c	11.0 c	86.6 ab	47.7 a	2.7 a
PH70-23 25 liq.	75	0.7 c	2.5 c	9.7 c	7.2 c	5.5 c	87.9 a	46.7 ab	2.8 a
PH70-23 25 liq.	100	1.5 c	2.2 c	4.2 c	9.0 c	6.0 c	86.1 ab	47.2 a	2.7 a
BAS206 10SC	60	5.2 ab	32.2 a	89.5 b	119.0 a	119.0 b	77.5 bcd	47.2 a	2.5 b
BAS206 5EC[g]	60	0.5 c	1.5 c	0.7 c	0.2 c	2.5 c	75.9 cd	46.5 ab	2.4 b
WL115110 10WDC	40	0.2 c	1.0 c	1.7 c	1.0 c	1.2 c	84.8 ab	47.5 a	2.7 a
WL115110 5WDC	40	1.7 c	2.2 c	1.5 c	1.2 c	1.5 c	83.9 abc	46.7 ab	2.7 a
Chlorfluazuron 5EC	50	0.2 c	0.5 c	0.2 c	0.5 c	0.5 c	85.4 ab	47.2 a	2.7 a
Teflubenzuron 15SC	37.5	1.5 c	0.5 c	0.2 c	0.7 c	0.7 c	89.5 a	47.0 ab	2.8 a
Control		7.5 a	26.2 ab	120.7 a	116.0 ab	186.2 a	73.7 d	44.7 b	2.4 b

[z]Cultivar: K.Y. Cross. [y]Transplanting date: 88/1/4. [x]Insecticides applied: 88/1/22, 1/29, 2/5, 2/12, 2/19, 2/26, 3/4, 3/11. [w]Harvest date: 88/3/25. [v]Means separation within columns by DMRT at 5% probability level. [u]Plot size: 15 m^2. [t]Phototoxicity observed.

Table 4. Screening of *Bacillus thuringiensis* for DBM control on common cabbage.[a-f]

Insecticides	Rate kg product /ha	DBM Larvae + Pupae/10 plant					Marketable yield t/ha	Marketable heads /plot	Marketable heads kg/head
		88/2/4	2/25	3/3	3/10	3/17			
H3A3B g	0.7	6.7 b	4.7 c	16.7 c	30.5 c	77.0 cd	56.3 ab	46.7 a	1.8 abc
H3A3B	1.0	3.2 bcd	2.2 c	10.2 c	15.0 d	59.5 de	57.9 a	47.5 a	1.8 abc
H7g	0.7	2.5 bcd	6.2 c	9.0 c	10.5 d	45.2 e	57.1 ab	47.0 a	1.8 abc
H7	1.0	1.7 cd	6.0 c	12.2 c	19.5 d	44.5 e	57.7 a	46.5 a	1.9 ab
SAN415g	0.5	2.0 cd	1.2 c	7.7 c	9.7 e	31.2 e	57.6 a	46.5 a	1.9 ab
ABG6162g	0.5	4.5 bc	6.2 c	19.5 bc	31.2 c	93.0 c	50.6 bc	45.0 a	1.7 cd
Dipel 2X	0.5	5.7 b	20.5 ab	37.3 b	51.7 c	130.2 b	54.2 ab	46.2 a	1.8 bcd
Neem 2.5%h	25.0	6.5 b	12.0 bc	60.2 a	104.0 b	146.0 b	41.5 d	45.2 a	1.4 e
Teflubenzuron 15SC	0.0 i	0.5 d	1.7 c	0.7 c	0.2 e	2.2 f	60.7 a	46.5 a	2.0 a
Control		16.0 a	26.7 a	77.0 a	128.2 a	177.7 a	47.0 cd	45.7 a	1.6 d

[z]Cultivar: K.Y. Cross. [y]Transplanting date: 88/1/5. [x]Insecticides applied: 88/1/22, 1/29, 2/5, 2/12, 2/19, 2/26, 3/4, 3/11. [w]Harvest date: 88/3/25. [v]Means separation on within columns by DMRT at 5% probability level. [u]Plot size: 15 m^2. [t]*Bacillus thuringiensis* formulations. [s]Methanol extract of *Azadirachta indica* seeds. The dose represents 25 kg seed/ha. [r]AI/ha.

Chinese Cabbage Pathology

Resistance to TuMV

Summary

Turnip mosaic virus (TuMV) is one of the most important viruses of Chinese cabbage in Southeast Asia. Five strains of the virus have been detected in Taiwan. All new Brassica accessions are routinely screened for resistance to strains C_4 and C_5 for which resistance is not commonly found. None of the 35 accessions screened this year by artificial inoculation were found resistant to these strains.

Introduction

TuMV is in the form of black spots commonly found on *Brassica* sp. in Southeast Asia including Chinese cabbage. Infection by this virus often results in low quality heads. It also makes the heads more vulnerable to fungal and bacterial diseases during storage. Five strains of this virus have been detected in Taiwan. Resistance to strains 1, 2 and 3 is readily found in the germplasm collection. Resistance to C_4 and C_5 is however rare. All new germplasm is routinely screened for resistance to C_4 and C_5.

Materials and Methods

Thirty-five new *Brassica* sp. accessions (B 801 to 803, 805, 807 to 813, 816 to 818, 821 to 836, 842 to 846) were screened by artificial inoculation. The plants were inoculated twice in the greenhouse and symptomless plants were checked by DAS ELISA for latent infection.

Results

All accessions were found susceptible to TuMV C_4 and C_5.

Mungbean Breeding

New Germplasm Evaluation

Summary

Six breeding lines with potential for bruchid resistance were introduced from Tamil Nadu Agricultural University, Coimbatore, India. One line, NARP-4 was found resistant to bruchid under AVRDC conditions.

Introduction

Bruchids are serious storage pests in mungbean. During a visit to Tamil Nadu Agricultural University (TNAU), Coimbatore, India, the AVRDC plant breeder came across a report that some breeding lines are resistant to *Callosobruchus chinensis*. At the request of the plant breeder, Dr. S.R. Sree Rangaswamy provided seeds of six promising breeding lines, a portion of which was given to AVRDC entomologist to examine bruchid resistance.

Materials and Methods

On August 2, three pots each of NARP-2 and NARP-3 and 2 pots of NARP-4 were planted in the greenhouse. Each pot had two plants. Days to flowering, days to maturity, node number and seed weight per plant were recorded.

On August 25, seeds of X_1, X_2 and X_3 were each planted to five pots in the greenhouse. Each pot had two plants.

NARP-1 is a selection from TMV blackgram. NARP-2 is a selection from 79 (blackgram) with hairy pods and bold seeds. NARP-3 is a selection from CO_2 blackgram. NARP-4 is a selection from LM66 mungbean $\times$ CO_3 blackgram. The above information and seeds were provided by V. Muralidharan, R. Rathnasamy and S.R. Sree Rangaswamy of TNAU. X_1, X_2 and X_3 were collected from the TNAU fields and their origin is unknown.

Results and Discussion

The characteristics of the six entries are given in Table 1. The promising entry for bruchid resistance, NARP-4 will be evaluated in the field.

Table 1. Evaluation of newly introduced *Vigna* sp.

Entry name	Days to		Nodes/ plant	Pods/ plant	Seed weight/ plant (g)
	flowering	maturity			
NARP-2	48	70	15	–	74
NARP-3	48	71	18	–	96
NARP-4	50	72	12	–	36
X-1	29	51	12	12	–
X-2	30	49	10	11	–
X-3	30	39	9	10	–

Line NARP-4 was found resistant to bruchids for five months, after which time, the level of resistance declined. Further research on harvest conditions, seed moisture content, seed storage conditions are being examined in relation to bruchid resistance at TNAU.

Hybridization

Summary

The population improvement program initiated in 1986 was continued. Single plants selected from the Cycle 3 first segregating generation were advanced by selfing and crossing with VC2991, VC4080A, VC4066A, VC3737A and VC3764A to combine the desirable alleles into the gene pool. The performance of each population will be further evaluated in the advanced generation for desirable traits. Crosses were made between NARP-4 (bruchid resistant) and five promising V and VC lines.

Status of Selective Mating

To combine high yield, early and uniform maturity, and disease resistance, 20 breeding lines and accessions were selected and crossed systematically based on a factorial design II in 1986. Seventeen F_5 pedigrees were evaluated in a preliminary yield trial in spring and summer. From Cycle 1 and Cycle 2 intermating, 55 F_3 bulks and 94 F_4 bulks were advanced to F_4 and F_5, respectively. Cycle 3 F_1s were intermated with five promising cultivars, namely VC2991, VC4080A, VC4066A, VC3737A and VC3764A and, 1024 Cycle 4 F_1s were produced. From Cycle 3, 324 pedigrees were advanced to F_2.

The progress of intermating and selfing done since 1986 is shown in Figure 1. The total number of lines or single plants selected and bulk population retained along with the characteristics of the selected female parents used in intermating during Cycle 2 and Cycle 3 are given in Table 2.

Table 2. Number of lines or single plants selected and bulk population retained in different cycles of intermating or inbreeding generation.

Source	Cycle of intermating and generation								
	HC_0M (F_3)	HC_0MM (F_4)	HC_1 (F_1)	HC_1P (F_2)	HC_1PM (F_3)	HC_2 (F_1)	HC_2M (F_2)	HC_3 (F_1)	HC_4 (F_1)
Total planted lines	99	17	99	263	55	96	94	210	1024
Selected lines	17	17	99	55	27	94	54	208	806
Total single plants	–	–	263	–	41	–	82	324	1073
Selected bulk	17	17	–	55	–	–	–	–	–

87-Fall	Remarks
VC 3890A × HC_2	EM, UM, PM, (CLS)
VC 2755A (F_2)	HY, (CLS), (PM)
VC 2768A	HY, (CLS), EM, GR, (PM)
V 3726	EM, UM, NS
88-Spring	
VC 2991A × HC_3	HY, (CLS, PM), UM, YS
VC 4080A (F_1)	(HY), SS, UM, EM, (CLS, PM)
VC 4066A	HY, SS
VC 3737A	HY, (CLS, PM), NS
VC 3746A	(HY), CLS

Characteristics of mungbean materials:

CLS: Resistant to *Cercospora* leaf spot	EM: Early maturity;
GR: Good general rating;	HY: High grain yields;
LD: Resistant to lodging;	NS: Photoperiod insensitivity;
PM: Resistant to powdery mildew;	SS: Large seeded;
UM: Uniform maturity;	YS: Yellow seeded;
(): Moderately resistant.	

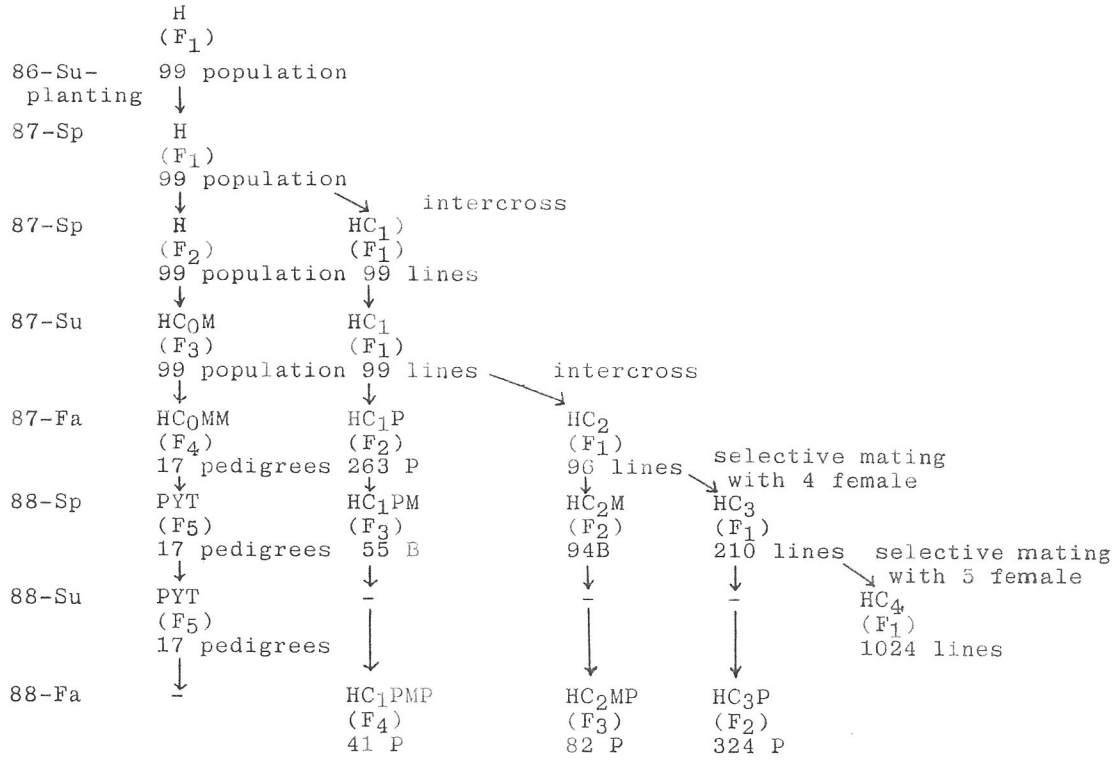

Fig. 1. The progress of intermating and inbreeding since 1986.

The selection of single plants was based on vigorous vegetative growth, disease resistance, large pod size, synchronized maturity, early maturity and nonlodging.

Crossing for Bruchid Resistance

NARP-4 was identified as resistant to bruchids. On October 3, 1988 NARP-4 was planted along with VC1178A, VC1973A, VC2778A, VC3890A, and V3476. Reciprocal crosses between NARP-4 and all other V and VC lines shown above were made. The genetics of resistance to bruchids will be further evaluated.

Yield Trials

Summary

Promising selections had been advanced from preliminary to intermediate yield trials. A number of advanced yield trial selections had high yield, higher percent of first harvest yield and better CLS and PM resistance than checks V3726 and V2768A. New improved selections will be made available to the cooperators through IMN. Moreover, preliminary results from thinning and no thinning treatments in the advanced yield trials suggested that although there were significant differences between the two treatments, there was no interaction between genotypes and thinning treatment. Therefore, this observation will be further evaluated during different seasons to determine whether thinning can be dropped as a recommended practice in the conduct of IMN trials.

Introduction

Breeding lines in the past and a number of selections from the inbreeding generation of intermated were included in the preliminary yield trial. Selected entries from intermediate yield trials were included to form the advanced yield trial (AYT). An experiment was conducted to determine the differences between genotypes with and without thinning.

Materials and Methods

Details of the experiment (number of entries, design, planting dates and plot sizes) are given in Table 3. AVRDC's recommended cultural practices were followed in the trials. Observations were recorded on seed yield adjusted to 12% moisture, first harvest percentage (first harvest yield/total yield × 100), days to 50% maturity and 1000-seed weight.

Powdery mildew disease was rated, highly resistant to highly susceptible, on a 1 ± 0.5 scale. Data from each season were analyzed. Data from spring and summer seasons were pooled and analyzed.

Table 3. Planting dates and experimental design for PYT and AYT in spring and summer 1988.

Experiment	No. of entries plus (checks)	Design (replication)	Planting date	Plot size
PYT	69 (2)	RCBD (2)	March 3, 1988	5 m × 1 m
	69 (2)	RCBD (2)	July 5, 1988	5 m × 1 m
AYT	33 (2)	Split plot (4)	March 3, 1988	5 m × 2 m
	33 (2)	RCBD (4)	July 5, 1988	5 m × 2 m

Results and Discussion

PYT. In spring, the yield of 71 entries varied from 0.5 t/ha to 1.8 t/ha. The yields of two check varieties were 1.2 t/ha (V3726) and 1.6 t/ha (VC2768A). None of the entries yielded higher than VC2768A. However, compared to 52% and 28% first harvest yield for VC2768A and V3726, respectively, there were selections which yielded 85% during first harvest. Most of the entries yielded high (Fig. 2). Invariably, all entries with good powdery mildew resistance attained low yield and vice versa. Some promising selections for specific characters are listed in Table 4.

In summer, the differences in yield between VC2768A (check) and the selections were insignificant. However, there were selections which were high yielding and more resistant to *Cercospora* leaf spot (CLS) than VC2768A and V3726. The yield in summer varied from 0.8 t/ha to 2.8 t/ha. Distribution of the 71 entries in different yield categories is given in Figure 3. Twenty one entries had a CLS score of 2.0 (a score of 5 was highly susceptible). Of the 20 highest yielding entries, eight had a CLS score of 2.0 (Table 5). Selected entries from PYT will be advanced to IYT in 1989.

Table 4. Promising entries from PYT in spring 1988.

Entry no.	Yield (t/ha)	% First yield	1000-seed weight (g)	Powdery mildew
VC 4533-1-2B	1.8	67	52	4.0
VC 4195-B-5-3B	1.8	83	58	4.3
VC 4541-2-2B	1.6	85	46	4.3
VC 4152-2-B-1-3B	1.4	40	67	4.0
VC 4503-3B	1.4	84	63	4.3
KM 83019-4-4B	1.3	42	65	1.8
VC 4532-2-2B	1.1	32	54	1.3
VC 4403-B-6-2B	1.1	43	56	1.8
VC 4433-B-4-2B	1.1	31	68	3.0
VC 4038-37	0.9	61	32	1.5
VC 4041-47	0.6	52	35	1.0
V 3726 (check)	1.2	28	62	4.0
VC 2768A (check)	1.6	52	61	3.8
LSD 0.05	0.4	3	4.6	1.4

Table 5. Promising entries from PYT in summer 1988.

Entry no.	Yield (t/ha)	% First harvest yield	1000-seed weight (g)
VC 4304-4B	2.8	63	52
VC 4133-2-B-1-3B	2.4	56	65
VC 4192-B-2-9-3B	2.3	62	56
VC 4366-B-4-2B	2.2	60	56
VC 4183-B-2-2B	2.2	60	63
VC 4417-B-2-2B	2.2	58	70
VC 2768A (check)[z]	2.6	53	65
V 3476 (check)[y]	0.9	74	64

Note: All selections had CLS score of 2.0. [z]CLS score = 3.0. [y]CLS score = 5.0.

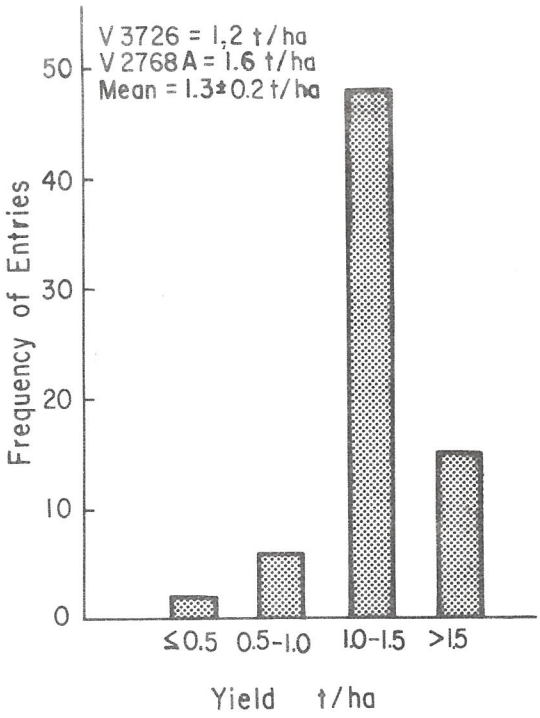

Fig. 2. Frequency of PYT entries in various yield categories in spring 1988.

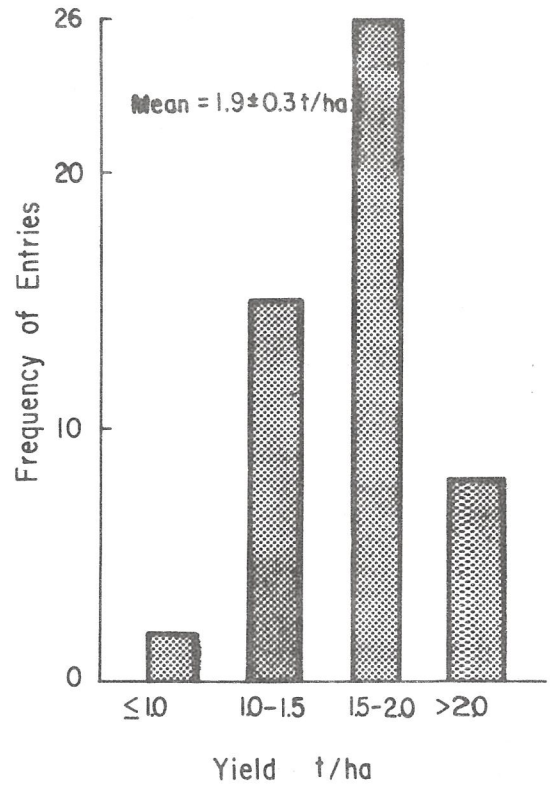

Fig. 3. Frequency of PYT entries in various yield categories in summer 1988.

AYT. There were significant differences in yield between genotypes in spring and in summer. There was also a significant difference in seed yield between thinning and no thinning. Higher yield was observed with no thinning than with thinning and there were no genotype × thinning treatment interactions suggesting that it is not necessary to thin the plants. Thinning and no thinning will be evaluated again in spring and summer next year to determine the interaction of such treatment with genotypes. In spring, VC3944- 2B-2-1-1-B and VC3945-2B-1-2-2-B gave a yield of 1.9 t/ha with 78 to 80% first harvest. VC4119-B-3-1-1-1-B gave 1.6 t/ha with 87% first harvest in spring. VC3890-B-2-1-1-B had 1.6 t/ha with 79% first harvest and 65 g for 1000 seeds.

In summer, VC4152-2B-1-3B, attained the highest yield of 2.8 t/ha, 51% first harvest and 64 g for 1000-seed weight. Of the 35 entries evaluated, 30 yielded 2 t/ha or more. The maximum first harvest yield with high yield potential in summer was 79%. However, only five entries had a CLS score of 2.0 or less. Those entries with an average yield of 2t/ha or more in spring and summer are given in Table 6.

Table 6. Promising selections from AYT in spring and summer 1988.

Cross no.	Yield (t/ha)	% first harvest	1000-seeds weight (g)
VC 4152-2B-1-3B	2.1	62	63
VC 4143-B-2-3B	2.1	68	55
VC 3907A	2.1	64	67
VC 4176-1-B-1-3B	2.0	61	53
VC 3901A	2.0	67	61
VC 2768A (check)	1.9	71	60
V 3726 (check)	1.0	79	61

Evaluation of V and VC Lines

Summary

One hundred and seventy three improved mungbean VC lines developed over the past 15 years were compared against 20 promising germplasm which were the parents of VC lines. A steady progress in yield improvement occurred over the years. Compared to V lines, mean yield of VC lines increased by 55%, 11% and 16% between 1973-1977, 1978-1982 and 1983-1987, respectively in summer. Similarly in spring, the increases in yield of VC lines were 26%, 20% and 16% respectively during the same periods. The level of CLS resistance and 1000-seed weight was also improved. However, percent first harvest and PM resistance did not show improvement at all. There is a strong seasonal influence on percent first harvest. Future research should emphasize on percent first harvest and powdery mildew resistance.

Introduction

Twenty selected breeding lines were assessed with multiple breeding objectives. In an effort to prepare a catalog of lines used in the breeding program, developed and distributed to the cooperators, promising V lines were evaluated in spring, summer and autumn. Furthermore, since the breeding lines can be grouped according to period during which they were developed, the steady progress made to improve the mungbean through breeding could be evaluated.

Materials and Methods

A total of 193 lines comprising 20 V lines and 173 VC lines were planted in a randomized complete block design in two replicates. The plot size was 2m × 1m. The spacing between rows was 50 cm between rows and 10 cm between hills with two plants per hill. The AVRDC's cultural practices were followed. Observations were made at 50% flowering stage, days to maturity, total yield, percent first harvest yield, 1000-seed weight, plant height at maturity, number of plants harvested, seed quality, *Cercospora* leaf spot (CLS) resistance score (in summer), and powdery mildew (PM) resistant score in spring and autumn. Pod harvesting was done twice. Moisture content of the seed was determined and the yield was expressed on a 12% moisture basis. This report discusses data on total yield, percent first harvest yield, 1000-seed weight, CLS and PM rating, obtained in spring and summer. Collection of data in autumn is in progress.

Results and Discussion

The powdery mildew resistance score (evaluated in spring with 1 = highly resistant to 5 = highly susceptible scale) for V lines showed that the mean of 20 lines was 4.8 and of the entries were in between 4.5 and 5 category (Figure 4). The mean for all the VC lines was 4.5. Although most of the lines were in between 3.5 and 5.0 category there were at least some in the range of 2.25 to 3.00 (Figure 5).

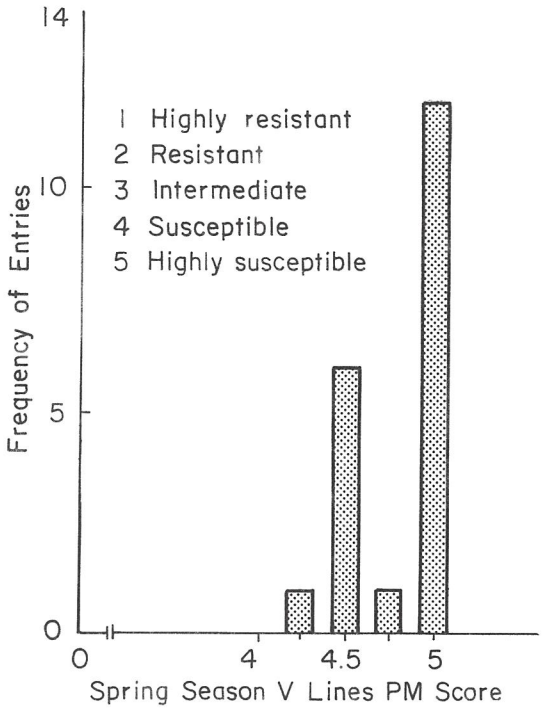

Fig. 4. Frequency distribution of V lines evaluated in spring 1988, in different PM score categories.

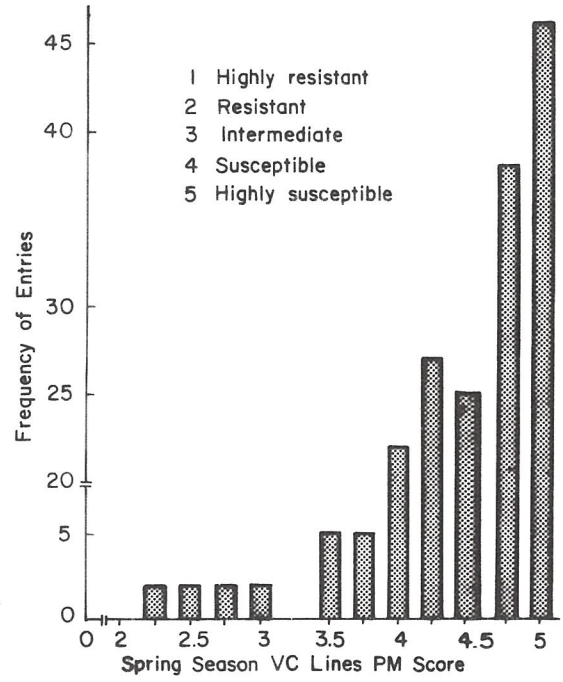

Fig. 5. Frequency distribution of VC lines, evaluated in spring 1988, in different PM score categories.

The status of CLS resistance in the V lines is shown in Figure 6. An evaluation for CLS in summer showed that significant progress has been made in improving the level of resistance in the new breeding lines (Fig. 7).

In spring, the VC lines developed from 1973 to 1977 had an increased yield of 26% compared to V lines. An additional 20% increase in yield was noted among the VC lines developed during 1978 to 1982 (Fig. 8). A 16% increase in yield was noted in those four VC lines developed from 1983 to 1987. There was a 10 to 15% increase in 1000-seed weight of VC lines over the V lines in the first two phases (Fig. 9).

There was no significant improvement observed on the percent first harvest (Fig. 10) and powdery mildew resistance (Fig. 11) In fact, the highest percent first harvest was only 70% which is similar to V lines.

During summer, an improvement in yield from 1973 to 1977 and 1978 to 1982 was 55% and 11%, respectively (Fig. 12). Compared to the V lines the mean yield of the new improved VC lines had doubled. Similarly, compared to V lines the 1000-seed weight increased by about 19%, 23% in 1973-1982, respectively (Fig. 13).

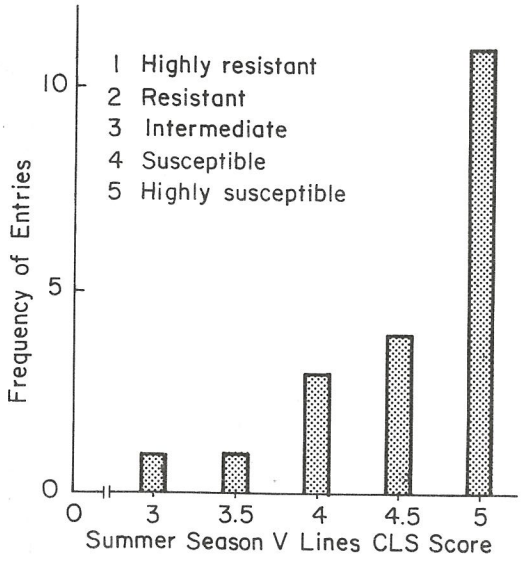

Fig. 6. Frequency distribution of V lines for CLS score evaluated in summer, 1988.

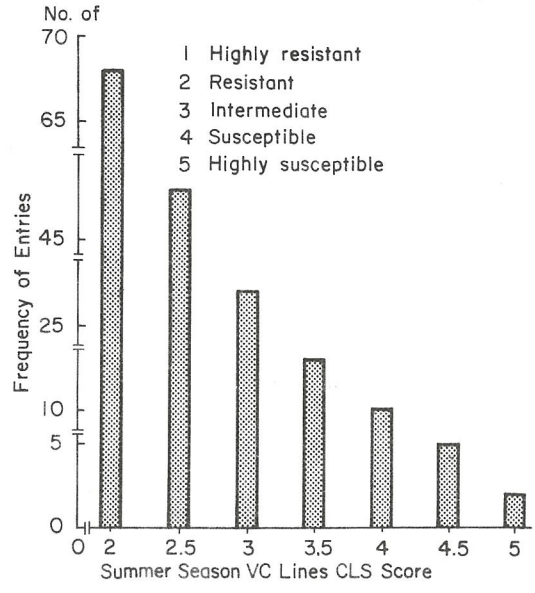

Fig. 7. Frequency distribution of VC lines for CLS score evaluated in summer, 1988.

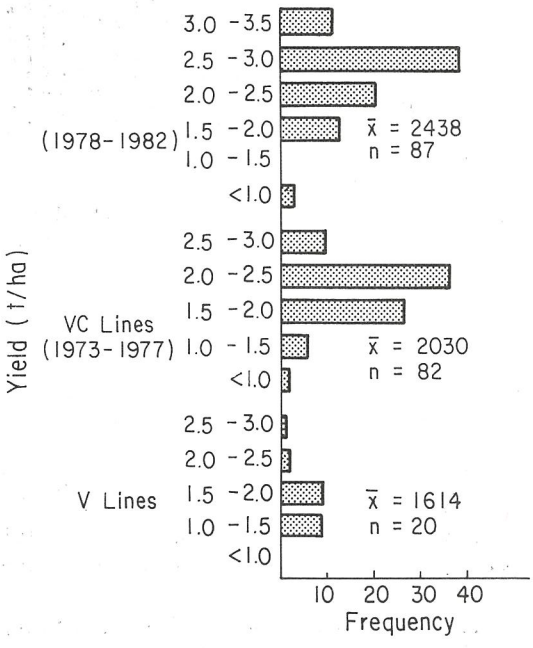

Fig. 8. Progress in improving yield at five-year intervals (spring 1986).

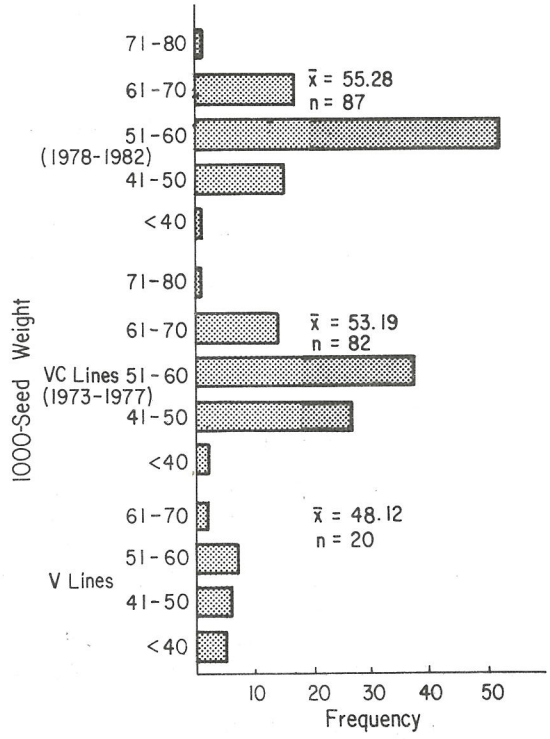

Fig. 9. Progress in improving 1000-seed weight at five-year intervals (spring 1988).

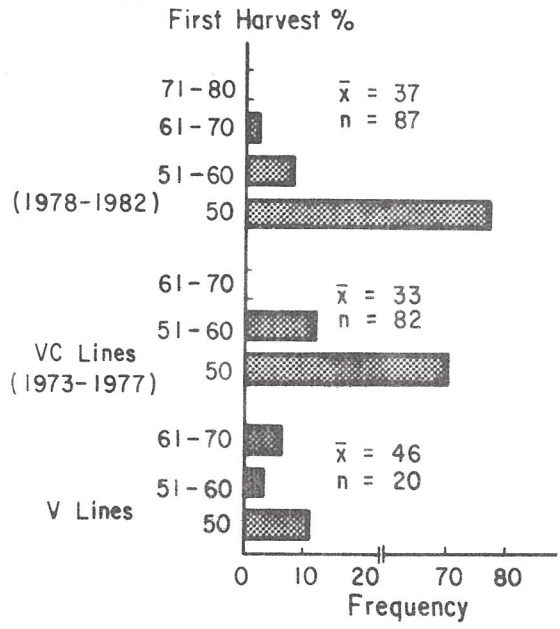

Fig. 10. Progress in improving first harvest percent at five-year intervals (spring 1988).

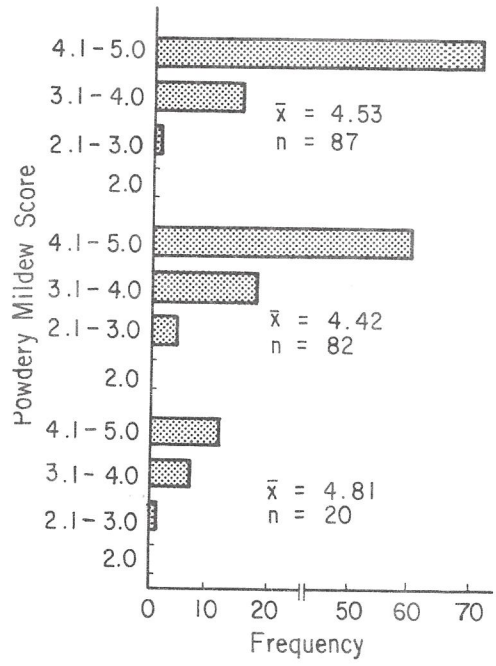

Fig. 11. Progress in PM resistance improvement at five-year intervals (spring 1988).

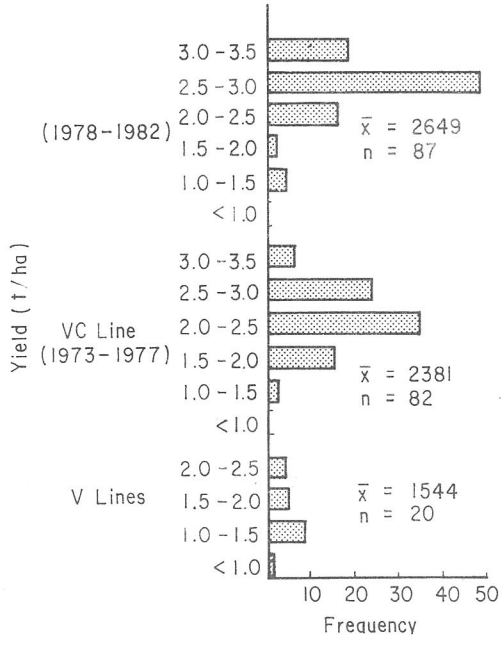

Fig. 12. Progress in yield improvement at five-year intervals (summer 1988).

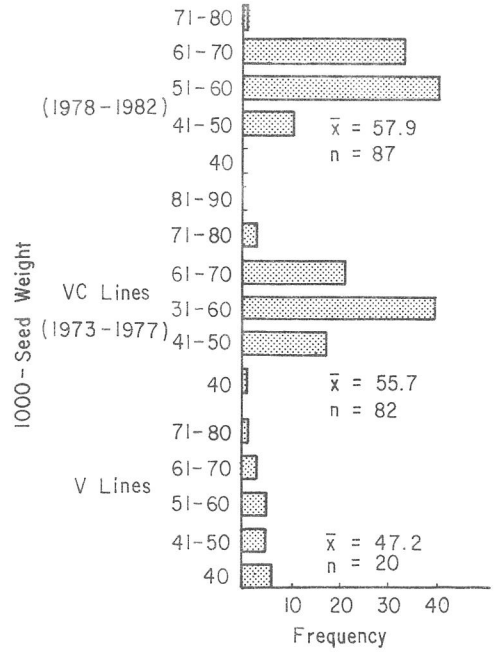

Fig. 13. Progress in 1000-seed weight improvement at five-year intervals (summer 1988).

Unlike powdery mildew, CLS resistance was achieved in 1972-77 and it improved slightly in 1977-1982 (Fig. 14). During 1982-87 such high level of resistance was maintained.

However, the mean percent of first harvest for the VC lines decreased by 22% in 1972-77 compared to V lines and further declined during 1977-1982 (Fig. 15). In 1983-1987, it improved slightly.

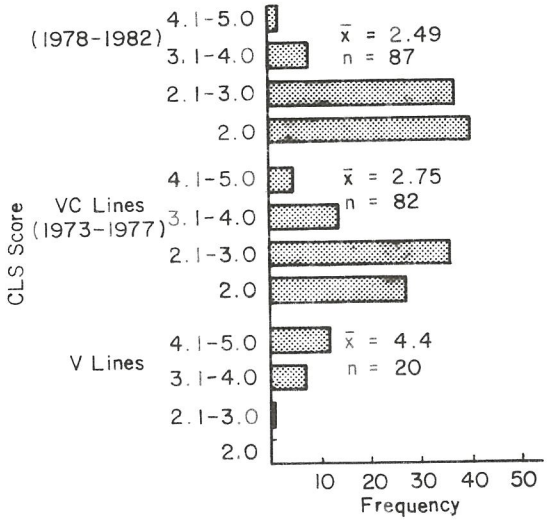

Fig. 14. Progress in improving CLS resistance at five-year intervals (summer 1988).

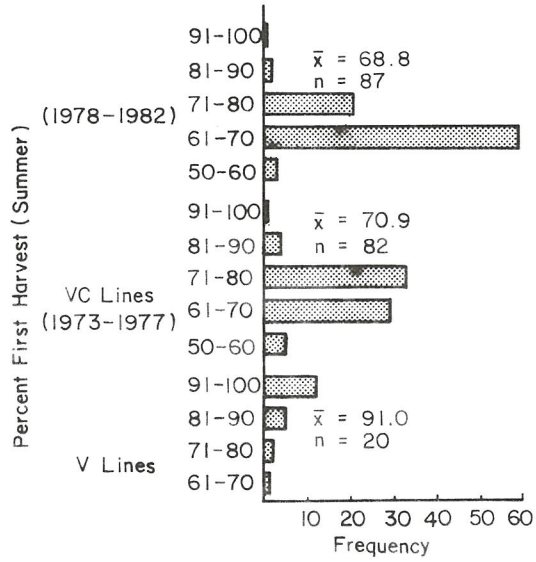

Fig. 15. Progress in the improvement of percent first harvest yield (summer season) at five-year intervals since 1973.

Although the entries were evaluated in only two seasons, results showed that there were significant differences in terms of yield, percent first harvest, days to maturity and 1000-seed weight. Considerable variation was noted especially for percent first harvest (Table 7).

The data from seasons were pooled and analyzed. Variance components were calculated by equating appropriate mean squares to their expectations and solving the components. The genotypic variance was the largest source of phenotypic variance for total yield and 1000-seed weight (Table 8). The variance due to G × S for yield is more than five times as much as seasonal variance and about one third of genotypic variance. Therefore, the genotypes should be carefully selected for specific seasons.

Seasonal variance predominated for percent first harvest (Table 8). Therefore, it appears that temperature, photoperiod and/or temperature × photoperiod interaction influence the percent first harvest.

In early years, mungbean breeding concentrated on high stable yield and photoperiod insensitivity. From 1978 onwards, efforts were made to combine disease resistance and synchronize maturity (high percent of first harvest). Significant improvement in yield and CLS resistance was attained. Incidentally, gains were also made for large seed size.

Finally, it appeared that problems on percent first harvest and host, pathogen, environment, and interaction for powdery mildew disease resistance require future research consideration.

Table 7. Variation in yield and other characters in V and VC lines between spring and summer.

Season	Yield (t/ha)	% First harvest	Days to maturity	1000-seed weight (g)
Spring	2.4 A	72 A	75 A	56 A
Summer	2.2 B	37 B	60 B	54 B
Mean (both seasons)	2.3 ± 351	54 ± 9	67 ± 3	55 ± 3

Table 8. Variance components for total yield, percent first harvest and 1000-seed weight of V and VC mungbean lines in spring and summer, 1988.

Variance[z]	Total yield (kg/ha)^2	1000-seed weight (g^2)	% First harvest ($\%^2$)
σ^2s	10262	617	2.50
σ^2g	193952	25	54.36
σ^2sg	59653	78	4.11
σ^2e	123374	85	7.04

[z]Variance components (σ^2) are for seasons (s), genotype (g), season by genotype (sg) and error (e).

The 15th and 16th International Mungbean Nursery

Summary

A total of 16 (15th and 16th) IMN sets were distributed to 16 cooperators in 12 countries. Results reported here are only for the AVRDC test and for Lubbock Texas.

Introduction

A total of nine 15th IMN and seven 16th IMN were distributed to 16 cooperators in 12 countries (Table 9). So far, only one cooperator from the U.S.A. returned the data.

Table 9. Distribution of 15th and 16th International Mungbean Nurseries.

Country	No. of cooperators	15th nursery	16th nursery
Brazil	2	–	2
Gambia	1	–	1
India	1	1	–
Indonesia	1	1	–
Nigeria	1	–	1
Philippines	2	1	1
Spain	1	–	1
Sri Lanka	–	1	–
Suriname	1	1	–
Swaziland	1	1	–
Thailand	2	2	–
U.S.A.	2	1	1
Total	16	9	7

Materials and Methods

The experiment followed a randomized complete block design in three replicates, 5 m × 2 m plot size; four rows per plot with a row spacing of 50 cm and two seeds per hill. Observations were made and data were collected.

Results and Discussion

AVRDC. VC4066A, VC3301A, VC4111A and VC3300A significantly outyielded VC2768A (Table 10).

Among promising lines in spring, only VC3301A gave high yield with low CLS rating and a high percent of first harvest yield (Table 11). Analysis of data in spring and summer showed that VC3301A, VC4066A, VC3300A, VC3117A and VC4111A yielded almost 1.9 t/ha. Entries VC4066A and VC2991A had the lowest CLS score of 2.0.

Table 10. Promising selections from 16th IMN in spring 1988.

Entry	Yield (t/ha)	% First yield	1000-seed weight (g)	PM
VC 4066A	1.7	72	53	2.8
VC 3301A	1.7	74	47	3.8
VC 4111A	1.7	75	47	2.3
VC 3300A	1.7	74	59	4.3
VC 3902A	1.3	71	69	3.3
VC 3890A	1.3	75	54	1.4
VC 2768A (check)	1.4	82	57	3.3
V 3726 (check)	1.3	67	57	4.1
LSD (0.05)	0.22	14	3.6	1.2

Table 11. Promising selections from 16th IMN in summer 1988.

Entry	Yield (t/ha)	% First yield	1000 seed weight (g)	CLS
VC 2768A (check)	2.3	47	69	3.3
VC 3301A	2.2	68	50	2.3
VC 3117A	2.2	63	61	2.3
VC 3737A	2.2	57	62	3.3
VC 3738A	2.1	79	55	4.3
VC 4066A	2.1	72	56	2.0
VC 2991A	2.0	52	57	2.0
V 3726	1.1	75	63	4.8
LSD (0.05)	0.1	9	4.02	0.8

U.S.A. Dr. J.C. Miller, Jr. conducted two 16th IMN trials, one in College Station and another at Lubbock, Texas. At College Station, the yield varied from 0.4 t/ha for VC3890A to 0.6 t/ha for VC3902A but the differences between the genotypes were significant only at 0.07 probability level. One thousand-seed weight varied from 61 g for V3476 to 91 g for VC1973A. VC1973A tended to shatter. Yields of VC3902A and VC3737A did not differ significantly from VC1973A and the seed size is not as big as VC1973A.

At Lubbock, Texas variation in yield was almost similar to College Station (0.3 t/ha for VC2991A to 0.6 t/ha for VC3300A). Mean yield and mean 1000-seed weight (0.5 t/ha and 74 g, respectively) at College Station were higher than at Lubbock (0.4 t/ha and 68 g, respectively).

International Cooperation

Summary

A total of 434 seed packets were distributed to 40 cooperators in 21 countries. In Thailand, AVRDC line VC1168A was officially released as Chainat 60. AVRDC selections were found promising in Argentina, Brazil, Laos PDR, Malaysia and the Philippines. VC2763A is widely grown in Mekong Delta in Vietnam with a production of about 10,000 t.

Seed Distribution

The distribution of breeding lines and improved germplasm to national programs is one major goal of the mungbean breeding program. A total of 311 breeding lines, 18 accessions and 105 F_1s, back-crosses or segregating populations were distributed to 40 cooperators in 21 countries (Table 12).

Table 12. Distribution of mungbean breeding lines and accessions to cooperators around the world.

Country	No. of cooperators	Breeding lines	Accessions	Others
Australia	2	7	–	–
Burma	1	3	–	–
Ethiopia	2	7	–	–
Gambia	1	6	1	–
India	5	101	3	–
Indonesia	1	5	–	–
Israel	1	1	1	–
Japan	1	15	–	–
Korea	2	3	1	–
Lesotho	1	3	1	–
Liberia	1	9	–	–
Malaysia	1	3	–	–
Nigeria	1	7	–	–
Philippines	1	1	–	–
Solomon Islands	1	6	–	–
Switzerland	1	1	1	–
Taiwan	4	29	–	–
Thailand	8	198	4	10
U.S.A.	2	2	1	95
U.K.	2	2	5	–
Yemen	1	2	–	–
Total	40	311	18	105

Results from Cooperators

Argentina (Cooperator: Ing. Agr. Julio Enrique Luna) VC1973A, VC2754A and VC2764A yielded 1.1, 0.9 and 0.9 t/ha, respectively. As mungbean is a new crop, there was no local check in the trial. The cooperator expressed interest in large scale testing of the three lines and requested one kilogram of seeds for each of the lines.

Brazil (Cooperator: Rogerio Faria Vigiva) Of the 25 entries evaluated, 10 entries gave 1.5 t/ha to 2.1 t/ha (Table 13). The top three entries were found promising and will be reevaluated.

Laos PDR The trial of 12 selections from different sources conducted in December 1985 under the FAO RAS 82/002 project included four entries from AVRDC. VC1168B, VC2750A, VC1560D yielded about 0.4 t/ha whereas VC1482 yielded 0.3 t/ha in 102 days compared to Uthong 1 (0.2 t/ha). All AVRDC lines were reported resistant to powdery mildew and required three harvests. The low yield was due to late planting and low plant population density.

Malaysia (Cooperators: Tan Teo Soon and Yeong Chin Sheong) Among four entries evaluated, VC1973A produced a yield 1.6 t/ha in 50 days compared to a local clone A which yielded 1.3 t/ha. VC3890A gave 1.6 t/ha while VC2768 A gave 1.5 t/ha. VC1973A and VC3890A lodged

Table 13. Promising entries from yield trial in Brazil, 1987.

Entry no.	Yield (t/ha)	1000 seeds weight (g)	Lodging score
KY 1954	2.1	44	2
VC 3061A	1.9	52	1
VC 3828-1-1-1-1-B	1.8	61	1
VC 4049-B-3-1-1-1-B	1.7	57	1
VC 3984-B-2-B-4-1-B	1.7	56	1
KY 2013	1.7	41	2
VC 2768A	1.4	60	1
LSD (0.05)	0.5	5.5	0.95

while VC2768A was nonlodging. The 1000-seed weight of all AVRDC lines was 69 g while the local check was 61 g. It appears that AVRDC entries have potential in Malaysia. The cooperators concluded that all AVRDC varieties are very productive and suitable for growing in sandy loam soil.

Philippines (Cooperator: Ms. Rosabella C. Repollo) The cooperator from Pangasinan State University reported that from 200 g seed each of VC1973A and VC2768A, they multiplied the seeds to 1,350 g and 1,400 g respectively for large scale testing.

Thailand Last year, Chainat FCRC released a new mungbean variety, named Chainat 60, derived from a cross between MG50-10A(Y) and ML6 made at AVRDC in 1977. It has higher yield potential, early maturity, short and erect plant type, synchronized maturity and good grain quality.

The average yield in research and farmer's field is 1.4 t/ha and 1.1 t/ha, respectively compared to 1.1 and 0.9 t/ha for Uthong 1. Chainat 60 produced 63% of its total yield in the first harvest at 55 days after planting. Chainat 60 is high yielding and suitable for late planting in rainy season.

Vietnam (Cooperator: Mr. Dueng Minh, University of Cantho) VC2763A (DX113), VC2768A (DX102A) and VC1560D (DX91) were evaluated in 1987. From 50 g seed of VC2763A received by Vietnam, nearly 10,000 t are now produced in Mekong Delta. The farmers expressed their need for new lines with mosaic virus tolerance, aluminum tolerance, glossy large seed, high yield and uniform maturity.

Mungbean Entomology

Yield of Beanfly Resistant Breeding Lines

Summary

Six lines selected for insect resistance and good agronomic characters from crosses between high yielding mungbean breeding line and beanfly (*Ophiomyia phaseoli*) resistant mungbean accessions were evaluated with 65 other entries. None of the beanfly resistant lines outyielded the check cultivar. Selection VC 4035-17 gave the best yield of 1.75 t/ha. Its yield potential was two to three times greater than the resistant parent, V 4281, and its level of resistance was similar to V 4281. It exhibited moderate level of resistance to *Cercospora* leaf spot and it matured in 69 days in summer. This breeding line is a better source of resistance for breeding beanfly resistant mungbean.

Introduction

In tropical to subtropical Asia and Africa and Oceania, agromyzids, mainly *Ophiomyia phaseoli* (Tryon) (Diptera: Agromyzidae), commonly called beanfly, is a serious pest in legumes. The insect larvae bore into stems of young seedlings which at times, results in plant mortality. In surviving plants, the growth is affected and yield is significantly reduced. In 1980, sources of resistance to beanfly in mungbean germplasm were identified in AVRDC. Since 1981 AVRDC had been incorporating this into agronomic breeding lines. Five breeding lines with good agronomic characters and beanfly resistance were selected. In 1988, these entries were included in a yield trial to compare their yield potential and other agronomic characters.

Materials and Methods

Preliminary yield trials of 71 breeding lines were conducted in spring and summer. In spring, each entry was planted in 9 m^2 plots and in summer, 5 m^2. Routine cultural practices were followed to grow the crop. During the growth stage and harvest, observations on various agronomic characters such as days to flowering, days to maturity, seed yield, and 1000-seed weight, in addition to powdery mildew resistance rating in spring and *Cercospora* resistance rating in summer, were recorded. Yield and seed weight data were analyzed by ANOVA and means were compared by DMRT. Each entry was ranked according to yield and seed size.

Results and Discussion

All six beanfly resistant breeding lines yielded significantly less than the standard agronomic line, VC 2768A in both seasons (Table 1). Their seeds were considerably smaller than those of VC 2768A's in both seasons. In terms of yield and seed size, all six breeding lines were ranked far below the standard agronomic line. Among beanfly resistant breeding lines, VC 4035-17 yielded higher than the rest, both in spring and summer. Its seed size is similar to other beanfly resistant lines, although it is distinctly smaller than the standard breeding line. The yield potential of VC 4035-17 is two to three times greater than that of the resistant parent. V 4281. VC 4035-17 matures in 69 days, which is

Table 1. Yield performance of beanfly resistant breeding lines.

Breeding line	Spring 1988[z]				Summer 1988[y]			
	Yield		1000-seed wt.		Yield		1000-seed wt.	
	t/ha	rank[x]	grams	rank[x]	t/ha	rank[x]	grams	rank[x]
VC 4035-17	1.2 f-n	55	37.0 cd	68	1.7 i-v	40	40.0 q-t	65
VC 4038-37	0.9 m-p	67	32.0 f	70	1.0 y-a	69	29.5 tu	70
VC 4039-38	0.5 p	70	27.5 ef	71	1.1 x-a	68	25.0 u	71
VC 4041-47	0.5 op	69	34.5 de	69	0.8 z-a	71	30.0 tu	69
VC 4041-48	0.9 l-o	66	44.0 z-b	63	1.2 w-a	67	43.0 o-s	64
VC 4041-49	0.5 p	71	43.5 ab	66	1.3 s-z	63	39.0 st	66
VC 2768A[w]	1.6 a-h	11	60.5 c-j	15	2.6 a-c	3	65.0 a-d	8

[z]Planting date: 4 March 1988; Plot size: 9 m^2. [y]Planting date: 5 July 1988; Plot size: 5 m^2. Replicates: 2; design RCBD; Mean separation by DMRT, P = 0.05. [x]Rank among the total of 71 entries. [w]Standard agronomic breeding line.

10 days later than the standard check in summer. It matures in 72 days in spring. VC 4035-17 has moderate level of resistance to *Cercospora* leaf spot disease but is susceptible to powdery mildew. However, one of its poorer yielding sister lines, VC 4039-38, is resistant to powdery mildew.

Although VC 4035-17 is not high yielding, and thus may not be preferred by national programs, its yield potential is much higher than that of the beanfly resistant parent. It should be a better source of beanfly resistance than the parent line, V 4281, for breeding beanfly-resistant agronomic cultivars.

Germplasm Screening for Bruchid Resistance

Summary

Seeds of 500 mungbean accessions were screened for resistance to *Callosobruchus chinensis*. Ten accessions were classified highly resistant. Two entries, V 2802B-G and V 1128B-BL, were found free from bruchid infestation. V 2802BG is a selection from a resistant accession, V 2802.

Introduction

A bruchid species, *Callosobruchus chinensis* L. (Coleoptera: Bruchidae), is a serious pest of mungbean and several other legumes especially during storage. The primary infestation begins in the field where adults lay eggs on green pods and the newly emerged larvae bore through the pod cover then into the developing seeds. The larva feeds inside the seed. When such seeds are harvested and stored, the bruchid adults emerge and lay eggs on other seeds and infestation spreads during storage.

Since stored mungbean seeds are frequently used for food, the use of insecticides to protect the seeds is not practical. To effectively control this pest without using insecticides, therefore, AVRDC has attempted to develop a bruchid resistant mungbean cultivar. Since the resistance in the previously identified blackgram accession, VM 2164, could not be transferred into agronomic mungbean lines, the screening of 500 new accessions in the laboratory for resistance to *C. chinensis* was initiated.

Materials and Methods

About 10-20 g seeds of each accession were placed in 125 ml Erlenmeyer flasks and 15 pairs of 1- to 3- day old adult *C. chinensis* were confined with the seeds. After a week, insects were removed and seeds were incubated at 30°C and 70 ± 5% RH for four to six weeks, after which the number of emerging first generation adults was recorded. Five screenings, each consisting of 100 accessions and one susceptible check (VC 1973A), were performed.

A statistical analysis procedure based on the mean number of insects emerged and standard deviation (SD) of the mean was used to classify the resistance of each accession into highly resistant (HR),

moderately resistant (MR), low resistance (LR), susceptible (S) and highly susceptible (HS). The accessions with insect count less than mean−2SD were considered HR; between mean−2SD and mean−1SD, MR; between mean−1SD and mean, LR; between mean and mean+2SD, S; and more than mean+2SD, HS.

Results and Discussion

The distribution of 500 accessions into various resistance categories is presented in Figure 1. Among 10 accessions classified as highly resistant, only V 2802B-G and V 1128B-BL were free from insect infestation. Both accessions were selected from original V 2802 and V 1128 on the basis of variation in seed coat color. Last year, the original V 2802 was found moderately resistant to *C. chinensis*. Accessions V 2802, V 2802B-G and V 1128B-BL are distinctly small-seeded. Seeds of these accessions will be multiplied. After further confirmation and study of their mechanism of resistance to bruchids, these will be used in breeding bruchid resistant mungbean cultivars.

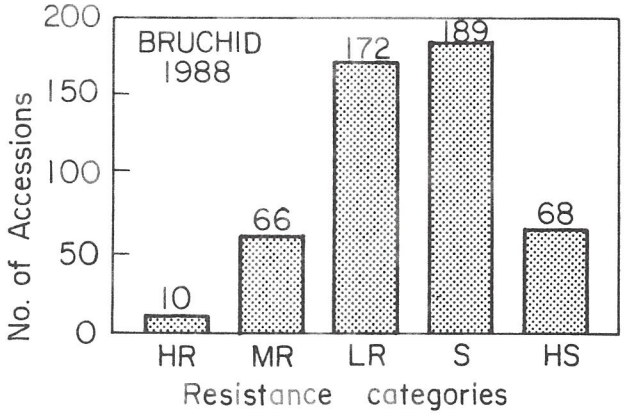

Fig 1.
Distribution of mungbean germplasm in various bruchid resistance categories.

Germplasm Screening for Resistance to Asiatic Corn Borer

Summary

Mungbean accession V 4701 was significantly less damaged by Asiatic corn borer, *Ostrinia furnacalis* than the susceptible check VC 1973A. The larval damage was confined in stems only. In a related test, three *Vigna sublobata* entries TC 221129, TC 221167 and TC 221034 were significantly less damaged than the susceptible mungbean VC 1973A. All *V. sublobata* accessions had distinctly thinner stems and viny growth habit, the characteristics that are associated with insect resistance.

Introduction

In recent years, Asiatic corn borer, *Ostrinia furnacalis* (Gn) (Lepidoptera: Pyralidae), a serious pest in corn, has become an important pest of mungbean in Taiwan and certain areas of Southeast Asia. In Taiwan, the insect attacks mungbean in summer but not from mid autumn through late spring. The insect larva bores into stems and green pods. As a consequence of larval feeding, the plant is weakened which, at times, results in wilting of entire shoot above the insect feeding point. AVRDC is screening *Vigna* germplasm with the aim of breeding Asiatic corn borer resistant mungbean cultivar which has acceptable agronomic characters. Screening of three sets of mungbean germplasm for resistance to Asiatic corn borer (ACB) was undertaken in 1988.

Materials and Methods

The planting area was rototilled and worked into 0.75 m wide beds. After every 10 rows, two rows were planted to corn. When corn plants were one month old, laboratory reared Asiatic corn borer pupae were placed on each corn plant to allow uniform and heavy infestation. These rows served as the source of ACB for the infestation of mungbean test accessions.

The seeds of test materials were planted in 10 rows between the two rows of corn. Each entry was planted as a single row on top of 5 m long and 0.75 m wide beds. Three groups of *Vigna* accessions were screened.

In the first group 84 mungbean accessions which were least damaged by ACD in 1986 trials but were not screened in 1987 were included. In the second test, 13 similar mungbean accessions were used. In the third, 24 least damaged (in 1987 test) *V. sublobata* accessions were tested with three *V. radiata* susceptible checks.

About 6 to 8 weeks after planting when ACB population was high, stems of each plant in every entry were examined and percentage of plants damaged was calculated. In the latter two screenings, data on insect damage were analyzed by ANOVA and means were separated by DMRT. In the first test, percentage of stems damaged by Asiatic corn borer was statistically analyzed based on mean damage and standard deviation. This procedure enabled the classification of the accessions into highly resistant (HR), moderately resistant (MR), low resistance (LR), susceptible (S) and highly susceptible (HS).

Results and Discussion

In the first test of 85 accessions, plant damage ranged from 0 to 7.14% with a mean of 2.49 ± 2.29. Thirty-five accessions were classified as MR, 37 S and 13 HS. In general, damage was low. About 35 MR accessions will be tested further in summer 1989 to confirm their resistance.

In the second test, ACB damage to mungbean plants ranged from 3.08 to 8.32%. Only one accession had significantly less damage than the susceptible check (Table 2). This accession will be investigated further in 1989.

In the third test, three selected *V. sublobata* entries: TC 221129, TC 221167 and TC 221034 were significantly less damaged than the susceptible check VC 1973A (Table 3). All *V. sublobata* accessions had distinctly smaller stem diameters and viny growth habit. In past studies, ACB resistance was found to be greater in mungbean plants with smaller stem diameter. A thin stem is an undesirable characteristic as plants lodge rather easily. In view of this, the need to develop ACB resistant cultivars will be examined before embarking on a resistance breeding program.

In all tests in 1988, ACB damage was less than in earlier years. This year, pods were not all damaged.

Table 2. Asiatic corn borer infestation of selected mungbean accessions.

Accession number	Plant damage (%)	Accession number	Plant damage (%)
V 3301	8.3 a	V 4669	6.4 ab
VC 1973A[y]	8.2 a	V 4391	5.7 ab
V 3855	7.8 a	V 4632	5.3 ab
V 4705	7.7 a	V 4513	4.7 ab
V 3968	7.6 a	V 5102	4.4 ab
V 4316	6.8 ab	V 4701	3.1 b
V 4499	6.8 ab		

[z]Data are means of three replicates. Mean separation by DMRT, P = 0.05. [y]Susceptible check.

Table 3. Asiatic corn borer infestation of selected *V. sublobata* accessions.[z]

Accession number	Plant damage (%)
TC 221129	0.8 d
TC 221167	0.8 d
TC 221034	0.8 d
VC 1973A	5.0 c

[z]Data are means of three replicates. Mean separation by DMRT, P = 0.05.

Characteristics of Asiatic Corn Borer Infestation

Summary

ACB (*Ostrinia furnacalis*) infestation in mungbean was studied in relation to distance of mungbean plants from the primary host. There was a significant linear decrease in insect infestation with increase in the distance of mungbean plants from the ACB infested corn. To avoid infestation of mungbean, the crop should be planted at least 50 m away from corn fields.

Introduction

The Asiatic corn borer, *Ostrinia furnacalis* (Gn) (Lepidoptera: Pyralidae) has caused increasing damage to mungbean in recent years. ACB larvae bore into mungbean stems and pods and feed concealed in these plant parts until pupation. The feeding weakens the plant, which at times causes lodging and consequently, yield losses. Since the area planted to corn has been increasing in Taiwan, ACB damage to mungbean has also become more frequent. Past studies in AVRDC revealed that ACB prefers corn over mungbean and insect damage to mungbean increases steadily after most of the corn are infested. Since both crops are grown, on occasions, in close proximity, it is essential to understand the influence of such cropping on ACB infestation in mungbean. This experiment is aimed at studying the influence of planting distance between two crops on the infestation of mungbean by ACB.

Material and Methods

A local corn was planted in a 60 m × 9 m parcel of land. Three weeks after germination, a large number of ACB pupae reared in the laboratory was released to allow infestation of the crop. At this time, in an empty area adjacent to the corn, the field was rototilled and prepared into 0.75 m wide beds parallel to corn planting. Mungbean line VC 1973A was then planted in 60 m long beds. About 66 beds were planted to this crop following the AVRDC standard cultural practices except that no insecticide was used. Starting three weeks after mungbean germination, the total number of plants and ACB damaged plants in rows was recorded. Observation was done once weekly for five consecutive weeks.

Results and Discussion

Results of ACB infestation in mungbean planted near the corn are shown in Figure 2. There was a significant linear decrease in insect infestation as distance between corn and mungbean increases. The

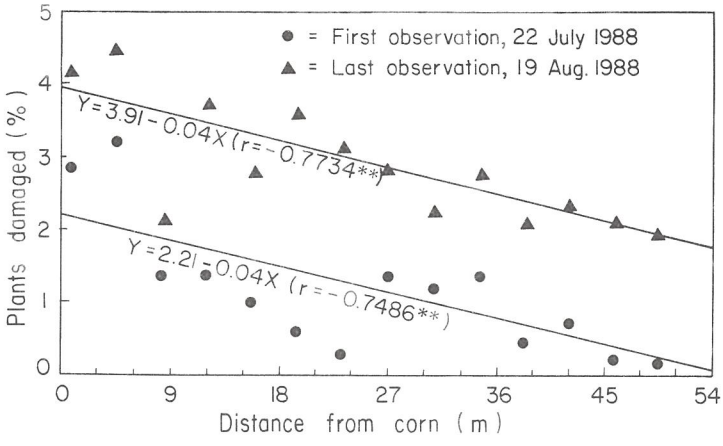

Fig 2.
Infestation of Asiatic corn borer on mungbean planted at different distances from source corn plantings.

farther the mungbean plants from corn, the lesser was the ACB damage. There was no other corn planted in the vicinity of mungbean. It appeared that the inability of the insect to fly longer distances reduces the ACB damage in mungbean planted away from the ACB source. So, if planting of mungbean near the corn is avoided, the risk of ACB infestation in mungbean is reduced.

Pepper Breeding

Germplasm Observation Trials

Summary

Two plantings of 368 accessions intended for seed multiplication and characterization were evaluated to identify promising genotypes. Forty-one accessions were preselected for high yield potential, dense fruit set, early maturity, high pungency and other promising characteristics to be further evaluated under different environmental conditions.

Introduction

To date, AVRDC's pepper germplasm collection comprises more than 5,000 accessions. Trials were conducted to preselect the accessions from nonreplicated trials for further evaluation in terms of yield potential and overall performance under tropical conditions.

Materials and Methods

A total of 113 and 255 accessions were included in the germplasm observation trials (GOT) in 1987 (warm) and 1987-1988 (cool) season, respectively. The first GOT was planted in April 1987 and the second, in November 1987 in screenhouses. Thirty plants of each accession were planted in a double-row bed. Spacing was 50 cm apart between rows and 45 cm between plants in a row. The screenhouses were divided into compartments. In each compartment, 20 to 30 accessions were grown with a single replication. The AVRDC cultural practices were followed without mulching. Extreme care was taken for insect and weed control. Starting the early fruiting stage, various traits related to plant growth and development, flower and fruit development and yield were observed.

Results and Discussion

The promising accessions for various traits are listed in Table 1. Those entries preselected for dense fruit set and high yield potential need to be reexamined for the respective traits in replicated trials. Pungency contents are yet to be analyzed, because preselection was based on organoleptic judgement of one or a few fresh fruit samples. Identity and aroma of the responsible compound(s) of the entries also need to be defined. Two accessions, C00693 and C00704, seemed pungent at green fruit stage, but not pungent at red fruit stage. Fruit wall of C01476 was observed to be not pungent, while pungency was detected in pungency plancenta tissues. Early maturity is regarded as a premium trait for pepper's incorporation in various cropping systems. It is, however, important to balance early maturity and plant vigor.

Table 1. Pepper accessions preselected for their important traits from germplasm observation trials.

Trait	GOT1	GOT2
Early maturity	C00200B, C00269 C00299, C00489	C00694, C00704, C00714, C00724, C00732, C00787B, C00918, C00964, C01315, C01475, C02180 (?)
Clustered fruit set	C00490	C00920, C00971, C01299
Heat-adaption (?) (Sweet pepper)		C00260, C00770, C00919
High yield potential (?)	C00200B, C00299 C00633	C01315, C01355
Dense fruit set	C00702, C00948,	C00971, C01355, C01379, C01540
Aroma		C00776A, C01379, C00776
High pungency		C00758, C00765, C00776, C00776A C00787B, C01379

Germplasm Evaluation Trials

Summary

Preselected genotypes from previous observation trials and advanced commercial cultivars were evaluated in replicated trials in the cool season 1987 to 1988 and summer 1988. Summer plantings were destroyed by flooding at the middle of the experiment. Two sweet and four hot pepper entries were, however, selected for their high yield. Eight hot pepper entries showed above 50% survival rates after flooding, whereas no sweet pepper achieved high survival rate.

Introduction

The genotypes preselected from observation trials were entered into replicated advanced evaluation trials in both cool and hot seasons for further examination in terms of yield and other horticultural traits. Some entries were accessions identified possessing useful genes for pest resistance or stress tolerance. Private firms and public institutes participated in the exhibition at the International Symposium on Integrated Management Practices for Tomato and Pepper in the Tropics (22-25 March 1988) contributed the advanced commercial cultivars. The exhibition field served the purpose of evaluation and the entries were again included with the plantings in summer which were destroyed by flood.

Materials and Methods

Twenty entries from 11 organizations in six countries and 32 entries from 14 organizations in eight countries were included in the cool season hot and sweet pepper trials, respectively. There were 40 entries for hot pepper and 51 for sweet pepper in the warm season. Planting and harvest schedules of the trials are given below:

	Date			Remarks
	Sown	Planted	Harvest	
Hot pepper	10 Nov. '87	4 Jan. '88	27 Apr. ~ 13 June	
	25 Apr. '88	3 June '88	1 Aug. ~ 23 Aug.	Field was destroyed by flood.
Sweet pepper	10 Nov. '87	4 Jan. '88	1 Apr. ~ 11 May	
	25 Apr. '88	6 June '88	1 Aug. ~ 19 Aug.	Field was destroyed by flood.

Seedlings were grown in plastic pots (9 cm, both in height and diameter) filled with sterilized mixture of soil, compost, sand and rice hull, and arranged in plastic flats. A field plot in the cool season consisted of a 5.4-m-long double-row bed and of a 6.75-m-long bed in the warm season both for hot and sweet pepper. Two adjacent beds were 150 cm apart, from center to center. Spacing between two rows in a bed was 50 cm and 45 cm between plants in a row. A randomized complete block design was followed in both crops with two and three replicates in the cool and warm seasons, respectively. Beds were mulched with polyethylene film with the black side underneath and the grayish silver on top. The plants were staked with bamboo poles. In sweet pepper, flowers were removed during early stage of fruit growth to encourage vegetative growth. On pest management, irrigation and other cultural practices, AVRDC techniques were followed. Both hot and sweet pepper fruits were harvested four times in the cool season, while only two harvests were made in the warm season. In addition to yield data, ratings were done on the traits relevant to productivity and fruit quality at the end of the spring crop. Ten days after flooding, plants were graded into three levels of damage and counted accordingly.

Results and Discussion

In the warm season, sweet pepper growth in east rows was clearly retarded compared to the west rows in the same bed. The trend was also observed in hot pepper, but to a lesser extent. The inferior growth of the east rows is attributed to the direct sun exposure. Soil temperature at 10 cm depth measured at 11:00 AM on a clear day ranged from 32 to 36°C and the difference between east and west rows was about 3°C. The effect on fruit size and yield-related traits was also clear in sweet pepper, while the difference was not statistically significant in any of the traits evaluated in hot pepper (Table 2). Nevertheless, the data taken from east and west rows were handled separately.

Since the primary target of the pepper program is the lowland tropics, performance data in the warm season were considered more valid than that in other trials. Trials were, however, destroyed by flood after two harvests. The yield in summer was studied for relationship to the yield in the cool season and some other traits (Tables 3 and 4). In hot pepper, the yield in summer from the east rows showed a significant positive correlation with first and second harvest yields, and with the total yield in the cool season. Yield in summer from the west rows showed a significant correlation with the yield from the first harvest in the cool season. Yield in summer from the east row also was highly correlated with that from the other row. In sweet pepper, summer yield was not correlated to yield and other traits of the cool season, but correlation with virus severity score at the end of the cool season was statistically significant.

The above results indicated that hot pepper is more adapted to various environmental stresses such as high temperature and excessive soil moisture than sweet pepper.

In the cool season, plants became aged and infected, and the ambient temperature became higher, as the harvest sequence advanced. All these factors may have affected size and number of fruits in relation to the harvest sequence. Sweet pepper showed a rapid decrease in both size and number as the harvest sequence was advanced while hot pepper showed no decrease in fruit number and a slower decrease in size until the fourth harvest (Fig. 1). These attest to the poor adaptation of sweet pepper.

Table 2. Means and t values between east[z] and west[z] rows for different traits in the plastic film-mulched plantings of hot and sweet pepper in summer.

Variable	Sweet pepper			Hot pepper		
	East	West	t value[y]	East	West	t value[y]
Total number of fruits harvested	4.9	7.3	-3.2**	18.6	25.3	-1.7^{NS}
Fruit weight (g/plant) harvested	95.0	179.7	-5.1***	81.0	103.7	-1.4^{NS}
Unit fruit weight (g)	19.1	27.9	-5.9***	4.8	4.7	0.1^{NS}
Fruit length (cm)	4.7	5.6	-3.6***	5.8	6.2	-1.1^{NS}
Fruit width (cm)	4.0	4.7	-5.9***	1.3	1.4	-0.4^{NS}
Fruit thickness (m/m)	2.8	3.3	-5.7***	1.7	1.7	0.5^{NS}

[z]Soil temperature of the east side was 3°C higher than that of the west side of the bed, when measured on a clear day at 10 cm depth from the surface. [y]** and *** designate the significance of the difference between east and west rows at 1 and 0.1% probability levels, respectively.

Table 3. Correlation coefficients[z] between yield from different harvest sequences of spring, yield of summer and flood survival rate in hot pepper.

	Spring yield (SPY)					Summer yield (SUY)		Flood survival rate (FSR)
	1st	2nd	3rd	4th	Total	East	West	
SPY1	–	0.239	-0.525*	-0.639**	0.263	0.567*	0.587*	0.155
SPY2		–	0.332	-0.353	0.799***	0.675**	0.447	0.218
SPY3			–	0.532**	0.572*	-0.021	-0.227	-0.153
SPY4				–	0.084	-0.612**	-0.662**	-0.455
SPYT					–	0.504*	0.249	-0.050
SUYE						–	0.840***	0.016
SUYW							–	0.059
FSR								–

[z]Calculated from means of 18 entries common to both plantings. *, ** and *** indicate that r is different from 0 at 5, 1 and 0.1% probability levels, respectively.

Table 4. Correlation coefficients[z] between spring[y] yield from different harvest sequences, summer[x] yield, virus severity and flood survival rate in sweet pepper.

	Spring yield (SPY)					Spring virus severity (SPVS)	Flood survival rate (FSR)	Summer yield (SUY)
	1st	2nd	3rd	4th	Total			
SPY1		-0.005	0.324	0.046	0.869***	-0.536**	0.043	-0.263
SPY2		–	0.598***	0.264	0.428*	-0.079	0.023	0.094
SPY3			–	0.460**	0.678***	-0.465**	-0.205	0.043
SPY4				–	0.336	-0.381*	-0.121	0.076
SPYT						-0.580***	0.000	-0.141
SPVS						–	-0.040	0.484**
FSR							–	-0.198
SUY								–

[z]Computed from means of 32 entries common to both plantings. *, **, *** indicate that r is different from 0 at 5, 1 and 0.1% probability levels, respectively. [y]Sown on 10 Nov. 1987 and transplanted on 4 Jan. 1988. [x]Sown on 25 Apr. and transplanted on 6 June 1988.

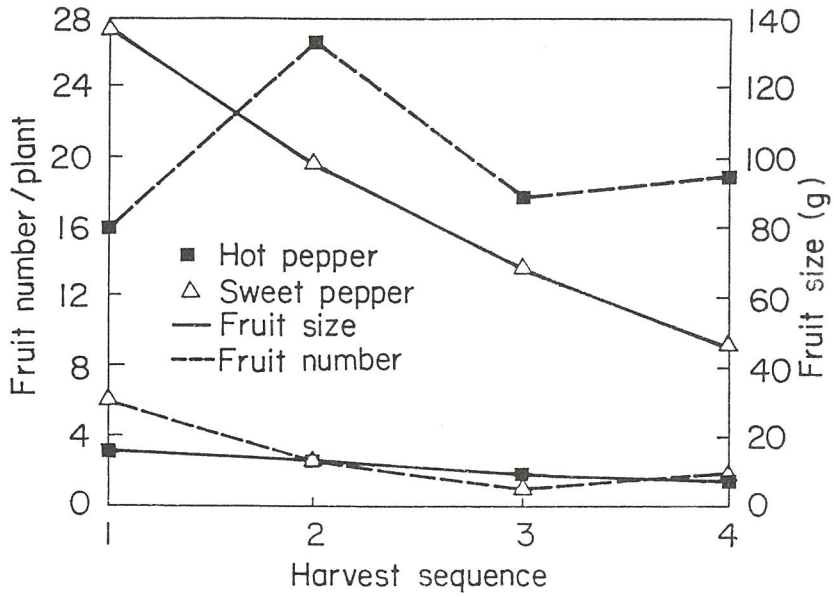

Fig. 1. Number of fruits harvested and fruit size of sweet and hot pepper as affected by harvest sequence. Means taken from 32 and 20 cultivars are presented for sweet and hot pepper, respectively.

Fruit weight and length showed generally good correlation between two seasons and between east:west beds in summer in both hot and sweet pepper (Tables 5 and 6). Fruit width also showed high correlation among the three sets of data in hot pepper, but less in sweet pepper. Fruit thickness of sweet pepper revealed significant correlation with fruit weight and width within environments. The environmental effect on fruit size, especially weight and length, seems to be rather parallel over different genotypes and therefore, selection for these traits could be applicable to different seasons and locations.

Table 7 lists the sweet pepper entries deemed promising in terms of yield or other traits. Gypsy was found stable and high yielding and attained good fruit-setting. Small and yellowish fruit were the defects of this entry. Annabell had stable and high yield. Despite varietal differences revealed in these trials, the performance of the entries needs careful evaluation in replicated trials in higher-temperature environments before they can be intensively used in the breeding program.

Table 8 presents the yield in two seasons of some selected hot pepper entries. HP621 and two other entries showed a stable, high yield. PP841 and seven other entries showed over 50% survival rates after flooding. The entry, 88P40 had high flood survival rate and stable high yield. This could be an important genetic source for these traits.

New Crosses and Generation Advancement

Summary

Crosses made in 1986 were advanced to F_2 generation in 1987-1988. A total of 34 accessions identified as resistant to important diseases were selfed under field conditions. Development of new crosses lagged because of technical problems on major plantings in summer 1988.

Introduction

Towards the end of 1987, priority objectives of the breeding program had been defined for hot and sweet pepper. The strategies to achieve the goals were likewise established. Part of the 1986 crosses were advanced to F_2 generation in 1988. The genotype identified to be resistant to CMV, CVMV, AMV and Phytophthora rot was multiplied by self-pollination.

Evaluation and Advancement of Previous Crosses

Of the previous 88 crosses, 20 were evaluated in the field in 1988. Many crosses were discarded because the characteristics which the parents should possess were found nonexistent. Inadequate resources also limited the number of entries which could be included. Ten crosses of sweet pepper were discarded during the field evaluation because of low chloroplast content in one parent, Gypsy; and the thin fruit wall of the other parent, Cubanelle. Five crosses, between early high yield and field tolerance to virus complex were finally selected to be advanced to F_2 generation. Individual selection was done on four F_1s, because of considerable variation among plants within F_1 families, probably resulting from genetic heterogeneity of either or both parents. Twenty-eight families are now grown in the field and these F_2s will be subjected to individual plant selection.

Crossing Program

The germplasm evaluation in summer 1988 aimed to identify the sweet pepper entries with best general performance under hot and wet climatic conditions to be utilized as recurrent parents in our backcross breeding programs. The planting also aimed to serve our need for making crosses. The field was, however, totally destroyed by heavy rains and water logging in mid-August. The situation also delayed the development of new crosses in 1988.

Extensive crossing will be conducted in cool season 1988 to 1989.

Table 5. Correlation coefficients[z] among fruit characters of sweet pepper grown in spring[y] and summer[x], 1987-1988.

	Fruit weight			Fruit length			Fruit width			Fruit wall thickness		
	Sp.	Su. (e)	Su. (w)	Sp.	Su. (e)	Su. (w)	Sp.	Su. (e)	Su. (w)	Sp.	Su. (e)	Su. (w)
UFW spring	–	0.7***	0.6***	0.1	0.0	-0.1	0.9***	0.3	0.0	0.7***	0.3	-0.1
UFW summer (e)[w]		–	0.7***	0.1	0.3	0.1	0.6**	0.6**	0.3	0.5*	0.6**	0.1
UFW summer (w)[w]			–	0.2	0.3	0.4	0.4*	0.6**	0.5**	0.3	0.6**	0.3
FL spring				–	0.8***	0.8***	-0.3	0.4*	0.5**	-0.2	0.1	-0.1
FL summer (e)					–	0.9***	-0.4*	-0.1	-0.3	-0.2	0.4	0.0
FL summer (w)						–	-0.4*	-0.3	-0.2	-0.4*	0.2	0.1
FW spring							–	0.5**	0.2	0.9***	0.3	-0.0
FW summer (e)								–	0.7***	0.5**	0.7***	0.3
FW summer (w)									–	0.0	0.3	0.5**
FTH spring										–	0.5**	0.0
FTH summer (e)											–	0.5*
FTH summer (w)												–

[z]Calculated between means of 32 entries common to both plantings. *, **, *** indicate that r is different from 0 at 5, 1 and 0.1% probability levels, respectively. [y]Sown on 10 Nov. 1987 and transplanted on 4 Jan. 1988. [x]Sown on 25 Apr. and transplanted on 6 June 1988. [w](e) and (w) pertain to east and west rows, respectively, of the double beds in the summer planting mulched with plastic film.

Table 6. Correlation coefficients[z] between fruit characters of hot pepper grown in spring[y] and summer[x], 1987-1988.

	Unit fruit weight			Fruit length			Fruit width		
	Sp.	Su. (e)	Su. (w)	Sp.	Su. (e)	Su. (w)	Sp.	Su. (e)	Su. (w)
UFW spring		0.9***	0.9***	-0.7**	0.4	0.4	0.9***	0.9***	0.9***
UFW summer (e)[w]		–	0.9***	0.7**	0.6*	0.5*	0.8***	0.9***	0.9***
UFW summer (w)[w]			–	0.7**	0.5*	0.5*	0.9***	0.9***	0.9***
FL spring				–	0.8***	0.8***	0.6*	0.5	0.5*
FL summer (e)					–	0.9***	0.3	0.3	0.2
FL summer (w)						–	0.3	0.3	0.2
FW spring							–	0.9***	0.9***
FW summer (e)								–	0.9***
FW summer (w)									–

[z]Computed from mean values of 18 entries common to both plantings. [y]Sown on 10 Nov. 1987 and transplanted on 4 Jan. 1988. [x]Sown on 25 Apr. and transplanted on 3 June 1988.

Table 7. Performance[z] of promising sweet pepper grown in spring and summer, 1987-1988.

Entry	Yield (t/ha)		Fruit size (g)		Virus[y] severity	Late fruit[x] set density	Remarks Remarks
	Spring	Summer	Spring	Summer			
Key Largo	37 b-e	11.3 a-f	73 klm	30 c-i	2.5 c-f	4.5 ab	
Annabell	47 a	11.8 a-e	85 jkl	26 d-i	2.5 c-f	3.5 a-d	selected
E 1821	41 a-d	2.2 e-i	154 a-c	19 e-i	2.0 def	4.5 ab	
Portos	44 ab	2.1 e-i	131 c-f	27 d-i	1.0 f	2.5 a-d	
Canape	28 e-i	16.5 a	71 lm	25 d-i	4.5 a-d	4.5 a-d	
Gypsy	41 a-d	10.9 a-g	67 lm	23 d-i	3.0 b-f	5.0 a	selected
Shauan-Fong	34 c-i	14.4 ab	74 klm	28 d-i	5.5 ab	3.0 a-d	
Blue Star	28 e-i	6.0 b-i	134 cde	39 b-g	5.5 ab	1.0 d	
Grand Mean[w]	34	7.0	109	30	3.7	2.6	

[z]Mean separation within columns by DMRT at 0.05 probability level. [y]Visually rated for each plot with a scale of 0 for no disease to six for highest degree of severity, at the end of the spring crop. [x]Visually rated for each plot with a scale of 0 for no new fruit to five for normal healthy fruit set, at the end of the spring crop. [w]Means of two replicates of 32 entries in spring, and of three replicates of 51 entries in summer.

Table 8. Yield and survival rate of some selected hot pepper entries.

Entry	Yield (t/ha)				Survival rate[x] from flooding (%)	Remarks
	Spring		Summer[y]			
	Early[z]	Total	East	West		
Magic Scarlet	6.8 bcd	12.1 fg	5.9 c-f	11.3 a	40 b-e	
HP 621	9.3 ab	25.5 a	11.4 a	10.8 ab	17 cde	Stable high yield
HPA 87400	4.1 efg	16.5 de	5.6 def	9.7 abc	11 de	
HPA 87401	2.0 ghi	11.0 g	1.2 gh	2.8 fg	55 a-d	
Seoul Hot	5.8 cde	15.9 def	3.5 d-h	7.6 a-e	50 b-e	
88P40	4.0 efg	20.8 bc	9.6 abc	7.7 a-e	60 a-c	Stable high yield + flood tolerance
88P41	5.0 def	11.9 fg	2.1 fgh	3.7 d-g	93 a	Flood tolerance
PP1	11.5 a	25.9 a	4.7 d-g	6.6 b-f	60 abc	Flood tolerance
Long Chilli	8.5 bc	22.3 ab	9.7 ab	9.3 a-c	23 b-e	Stable high yield
One Thousand	3.0 fgh	18.7 bcd	7.3 bcd	9.0 a-c	27 b-e	
Szechuan	0.6 hi	19.2 bcd	0.0 h	2.7 fg	36 b-e	
Passion	–	–	0.3 h	0.2 g	54 a-d	
Long Fruit	–	–	0.3 h	0.1 g	52 a-d	
Unknown 41	–	–	0.1 h	0.0 g	63 ab	Flood tolerance

[z]Yield obtained from first harvest. [y]Yield from east and west rows of the plastic film-mulched beds. [x]Data obtained from the summer planting after heavy rains of 480 mm on 13 and 14 August.

Multiplication of Disease-resistant Accessions

Disease resistant plants were identified through heavy exposure to diseases under controlled environment. The selected plants were transplanted to the field for seed multiplication.

A total of 219 plants of 34 accessions found resistant to diseases were multiplied (Table 9).

The seeds produced will be evaluated for their resistance and genetic purity with respect to the traits for which they were selected. They will also be utilized as donor parents in the crossing program.

Table 9. Number of disease-resistant accessions and plants which were multiplied.

Disease	Number of	
	Accessions	Plants
Alfalfa Mosaic Virus	7	77
Cucumber Mosaic Virus	3	33
Chili Veinal Mottle Virus	8	69
Pepper Veinal Mottle Virus	2	6
Anthracnose	1	10
Phytophthora rot	13	24

Purification of Popular Local Hot Pepper Varieties

Summary

Pure line selection was made on two local varieties, Szechuan and MC_4, to improve their uniformity and mean performance. The selected families from P_1 of Szechuan showed higher field tolerance to virus complex and the P_2 families showed improved uniformity in plant type. The performance of MC_4 was poor in all P_1 families evaluated.

Introduction

Hot pepper has been popularly grown for several centuries in different areas of the tropics mostly with landraces specifically adapted to each location. In spite of the long-proven adaptability to adverse tropical lowland environments, the local cultivars were not highly appreciated due to heterogeneity coupled with low yield and low quality. Pure line selection was, therefore, initiated in two local varieties, Szechuan from Taiwan and MC_4 from Malaysia, to genetically purify and, if possible, enhance their performance.

Source Materials

A Taiwan local variety, Szechuan, was selected because it was the most widely grown cultivar. It shows sizeable variation in plant and fruit characters. A Malaysian variety, MC_4, which had been partially improved by the Malaysian Agricultural Research and Development Institute (MARDI), also exhibited considerable variation in many important horticultural traits. Resistance to bacterial wilt, chili veinal mottle virus, and cucumber mosaic virus was also found, although the variety is known to be heterogeneous for the responsible genes. Source materials of Szechuan was first collected from the market and farmers' fields in central Taiwan, while that of MC_4 were collected in the seed multiplication nursery of MARDI. The plants found resistant to CMV or CVMV later replaced the P_1 generation from the original source population.

Procedures and Progress

Planting schedules for P_0 to P_2 generation are shown in Table 10. Entries were transplanted to the field in the early cool season and preliminary selection was done in the early warm season. The preliminary selection criteria were plant vigor, days to maturity, fruiting density, fruit shape and size, being free from diseases under natural epiphytotic conditions with standard spray schedule, etc. Soon after the preliminary selection, one secondary branch of each selected plant was bagged with screen net to secure the selfed seeds. Fruits and open flowers were removed from the branch before bagging. Open-pollinated seeds were also used in generation advancement. Entire fields were maintained, whenever possible, until the mid-late of the warm season for further observation before final selection.

Table 10. Planting schedule and selection in generation advancement of pure line selection of two open-pollinated local varieties.

Var.	Generation	Entries included	Selected	Date			Remarks
			Families/Plants	Sown	Transplanted	Selected	
Szechuan	P_0	10[z]	4/12	09-30-86	11-07-86	05-01-87	
	P_1	12	7/31	10-27-87	12-17-87	04-12-88	
	P_2	31	–	09-01-88	10-13-88	–	on-going
MC4	P_0	67[y]	2/13	09-30-86	11-07-86	05-01-87	
	P_1 (A)	4	0/0	10-27-87	12-17-87	04-12-88	
	P_1 (B)	19[x]	–	09-23-88	11-04-88	–	on-going

[z]From 10 different sources. [y]Sixty-six individual plants selected from MC_4 and one population of a sister variety, MC_5. [x]Selfed progenies of the plants resistant to CVMV or CMV.

Szechuan has been advanced to P_2 generation (Table 10). All selections from P_1 generation showed much less virus infection than unselected ones at the termination of the growth, although the difference was not observed during preselection. It is, however, yet to be investigated whether high performance of the selected plants is genetically associated with field tolerance to virus complex, which became clear only after the selection had been made. At early growth stage, P_2s were observed to be considerably more uniform in plant type than the generation P_0.

In the case of MC_4, the general performance of P_1 in summer 1988 was very poor in every family, although the reason is not clear. All P_1s were, therefore, discarded and replaced with the selfed progenies of the plants which were identified resistant to CVMV or CMV by artificial inoculation. Performance and variation of the new batch will be examined in 1989.

Pepper Pathology

Survey on Pepper Viruses in Indonesia, Korea and Taiwan

Summary

Virus diseases limit the successful cultivation of pepper in the tropics and subtropics. However, knowledge about the kind of viruses and their distribution in these areas is limited. In 1986, a survey of the major pepper growing areas in East Asia was initiated. Surveys in indonesia, Korea and Taiwan are reported here. Tobacco mosaic virus (TMV), cucumber mosaic virus (CMV), chili veinal mottle virus (CVMV) and potato virus Y (PVY) frequently occur in Taiwan and Indonesia. TMV and CMV, followed by alfalfa mosaic virus (AMV) and tomato spotted wilt virus (TSWV) are most important in Korea. There is a need to study TMV, PVY, CVMV and CMV since these viruses are most important in the tropics and subtropics of East Asia. TSWV needs to be looked into because of its importance not only in Korea but also in Malaysia.

Introduction

Virus diseases are a problem in pepper cultivation in the tropics and subtropics. In Taiwan, only potato virus × (PVX), pepper mottle virus (PeMV) and TMV were previously reported. In preliminary surveys undertaken in Taiwan, three additional viruses, namely CMV, PVY and CVMV, a virus so far only reported in Malaysia, were found. Similarly, in pepper samples collected from Thailand, PVY, CMV, TMV and CVMV were detected. The survey was extended to other countries to determine which viruses need most consideration in AVRDC's breeding program.

Materials and Methods

Sixty-four hot and sweet pepper samples from Indonesia, 477 from Korea and an additional 486 from Taiwan were collected (Table 1). The samples were processed (described in the 1987 Annual Review) and tested by ELISA for the presence of 12 of the most common pepper viruses.

Results and Discussion

It was confirmed that CVMV incidence is very high in Taiwan, followed by CMV, PVY and tomato mosaic virus (ToMV). In Indonesia, incidence of TMV was highest, followed by CVMV, CMV and PVY. PVX only occurred in a few samples. Similarly in Korea, incidence of TMV was highest, followed by CMV, AMV and TSWV. Incidence of CVMV and PVY was low and occurred in only 2% of the samples. PVX was found in only 0.2% of the samples.

It is evident from these surveys that TMV, CMV, CVMV and PVY are most prevalent in tropical Southeast Asia. In Korea, however, CVMV and PVY do not infect pepper as frequently as other viruses. Furthermore, two other viruses, AMV and TSWV are also important.

It is suggested that CMV, CVMV, PVY and TMV should be given priority in AVRDC's breeding program. Resistance to PVY and TMV is readily available in commercial and wild-type lines. However, sources of resistance to CVMV and CMV need to be investigated.

AMV appears to be of importance only in Korea and should be addressed by the national program. TSWV should receive further attention since there are indications that it may also be present in countries other than the two from which it has been reported so far.

Table 1. Survey of pepper viruses in Taiwan, Korea and Indonesia.

Country surveyed	Total no. of samples collected	Percent infection with							
		TMV	CMV	CVMV	PVY	AMV	TSWV	TEV	PVX
Taiwan	486	13.0	42.0	51.4	14.6	0.0	0.0	0.2	0
Korea	477	32.9	26.0	2.3	2.1	21.6	14.3	1.5	0.2
Indonesia	64	50.0	7.8	25.0	3.1	0.0	0.0	0.0	1.6

Screening for Resistance to PVMV, CVMV and PVY

Summary

Recent surveys of pepper viruses in Taiwan, Indonesia and Thailand indicated that TMV, CMV, CVMV and PVY are most important. Resistance to TMV and PVY is readily available. Screening has been initiated to identify materials with resistance to CMV, CVMV and PVMV, a common pepper virus in tropical Africa. About 291 lines, including materials with reported resistance and randomly chosen AVRDC wild-type germplasm were screened through mechanical inoculation followed by an ELISA test. Lines were identified with more (>50%) individual plants resistant to PVMV, CVMV and CMV. Seeds of these plants were saved for confirmation screening.

Introduction

Results of surveys in Taiwan, Indonesia and Thailand, and Korea revealed the incidence of TMV, CMV, CVMV and PVY in these countries. High incidence of AMV and TSWV has been detected in Korea. Collection of resistant germplasm, resistance screening and virus straintyping of the first four viruses are on-going.

PVMV has been reported to be widespread on pepper in several tropical countries in West Africa. Antiserum production, collection of resistant germplasm and screening for resistance of PVMV are also given attention.

Materials and Methods

The viruses used for inoculations were PVMV (received from A. T. Brunt, England), CVMV-Japan (received from Fujisawa, Japan), CVMV-AVRDC (CVMV isolate No. 1037 collected and isolated from pepper in Taiwan), and CMV (collected and isolated from pepper in Taiwan).

Pepper seedlings were mechanically inoculated at 4-5 leaf stage in an insect-proof screenhouse. Twenty to 40 plants per accession were inoculated at 3-4 leaf stage with a homogenate of 1 part virus-infected leaves, homogenized in 5 parts 0.1M phosphate buffer pH 7.0 containing 0.1% Na_2SO_3. After four weeks, all plants were tested by ELISA. Negative plants received second inoculation. After three-four weeks, plants were tested by ELISA.

Strict quarantine requirements were followed and the plant materials were inoculated with PVMV. All materials were disposed by autoclaving.

Materials with reported resistance and breeders' selections. Twenty-five accessions reportedly resistant to certain pepper viruses (VC 3, 5, 6, 10, 11, 13, 15–19, 23, 31, 43, 45, 47, 48, 100–102, 110, 170, 174-178) and seven breeding lines with good agronomic performance (HDA 832, Turrialba, Blue Star, Gypsy, Passion, Szechuan and Hungarian Wax) were screened for PVMV resistance.

Forty-four lines collected for resistance to various viruses (VC 3, 6, 10, 13, 15-19, 23, 31-37, 40, 41, 43-45, 47, 48, 51-53, 57a, 81, 83, 102, 103, 110, 112, 112a, 170-178) and the seven promising breeders' selections mentioned were also screened for resistance to CVMV-AVRDC and CVMV-Japan.

Twenty lines (VC 18a, 23a, 32a, 33a, 34, 35, 36a, 37, 41, 43a, 57a, 81, 102, 103a, 110, 112, 171a, 173, 174, 112A) resistant to various viruses were screened for CMV resistance.

***Capsicum chinense* lines from Brazil.** Eight *Capsicum chinense* lines (AMA 3, 6–12) received from Dr. Cheng, EMBRAPA, Brazil, were observed to be generally virus resistant in the Amazon region. The lines were screened for resistance to CVMV, PVMV, CMV and PVY.

Breeding lines from Malaysia. Lines MC4 and MC5 from Malaysia with reported virus resistance were received from Dr. Chew of MARDI, Malaysia. They were screened for CMV and CVMV, two of the most common viruses in Malaysia.

AVRDC GRSU accessions. Ninety-eight accessions comprising *C. annuum*, *C. frutescens* and *C. pubescens* were screened for resistance to CVMV. The accessions were 14A, 15A, 17B, 104A, 105A, 200A, 269, 270, 276, 294, 344, 352, 381, 435, 436, 439, 441, 466, 467, 470, 473, 474, 476-493, 543, 548, 550, 551, 559, 561-564, 573, 574, 581, 583-585, 590, 595, 596, 598, 599, 624, 625, 627-631, 633-635, 638-644, 1156-1170, 1172, 1173, 1175-1178.

Commercial lines from Korea. Thirty-five Korean lines (Ko Sung, Seo Dong, Nam Ji, Bang Bang, Pung Gac, Dae Pung, Jung Kong, Thae Ane, Dong Du Chun, Je Jue, Ke Ryong San, Jang Sue, Bung-0-Choe, Chun Ann, Kun Ja, Sue Bee Choe, Hoe, Chung Ryong, Chang Ryong, Chang Ryung, Dae Hoa Choe, Phal Bang, Jang Kac Choe, Sue Won, Je Chun, Thae Kuc, PI 315023, PI 163201, PI 260599) were screened for CVMV-AVRDC resistance. Twelve lines (Seo Dong, Pung Kac, Jung Kong, Dong Du Chun, Jea Ju, Kea Ryong San, Jang Su, Bong-0-Choe, Chang Ryong, Sue Won, Thae Kuc, PI 163201) were screened for CVMV-Japan resistance. Twenty-one lines (Seo Dong, Bang Bang, Pung Kac, Jung Kong, Thae Ann, Dong Du Chun, Jea Ju, Kea Ryong San, Jang Sue, Bang-0-Choe, Chun Ann, Kun Ja, Hoe, Chung Ryong, Chang Ryung, Dae Hoa Choe, Phal Bang, Jang Kac, Sue Won, Thae Kuc, PI 163201) were screened for CMV resistance.

Results and Discussion

Materials with reported resistance and breeders' selections. All lines were susceptible to PVMV except VC16 (Perennial), HDA 832 and Szechuan, which gave 59%, 89% and 62% resistant plants upon inoculation. Seeds of resistant plants were saved for confirmation screening.

All lines, except VC35, 36, 37, 40 and 41 were found 100% susceptible to both the Japanese and the Taiwan isolate of CVMV. VC35 and 36 were 100% resistant to CVMV-AVRDC, but produced 68% and 73% resistant plants upon inoculation with CVMV-Japan. Line 37 produced 59% resistant plants upon inoculation with CVMV-Taiwan and 50% resistant plants upon inoculation with CVMV-Japan. Lines VC40 and 41 contained 47% and 75% plants resistant to CVMV-Japan, respectively.

Likewise, all lines were found susceptible to CMV.

***Capsium chinense* lines from Brazil.** All *Capsicum chinense* lines from Brazil were found susceptible to CVMV, PVMV and CMV. All except AMA 3 were resistant to PVY.

Breeding lines from Malaysia. Lines MC4 and MC5 were found to be 100% susceptible to both CVMV and CMV. However, symptoms of the two viruses in both lines were very mild.

AVRDC GRSU accessions. All 98 AVRDC lines were found susceptible to CVMV.

Commercial lines from Korea. Two Korean lines (Kunja, Kea Ryong San) were found with high incidence (50% of plants) of resistance to CMV. Seeds of resistant plants were saved for confirmation screening.

All lines were found susceptible to two CVMV isolates.

Conclusion

Resistance genes are readily available in both commercial and wild type germplasm. However, resistance to CMV, PVMV, CVMV may not be easily accessible. Only a few lines (VC16, HDA832, Szechuan for PVMV, VC35–37, 40, 41 for CVMV and the Korean lines, Kunja Kea Ryong San for CMV) were found with high percentage (>50%) of resistant individuals. Seeds of these plants were saved for confirmation screening.

Since results of screening the Taiwan isolate of CVMV did not exactly match those of the Japanese isolate of CVMV, strains of this virus may exist.

Straintyping of PVY Isolates

Summary

Potato virus Y (PVY) occurs on pepper worldwide. Resistance to strains 0, 1, and 1.2 is available in commercial cultivars bred mainly for production in temperate regions. Twenty-nine pure pepper PVY isolates from Taiwan were straintyped. Twenty- five isolates belonged to strain 0. The four other isolates did not fall into any of the known strain groups.

Introduction

PVY is common on pepper in both tropical and temperate production areas. Resistance is available in commercial cultivars, like Yolo Y (resistant to strain 0), VR-2 (resistant to strain 1) and Serrano VC (resistant to strain 1.2). Information on the strains present in tropical countries is not available. Knowledge about strains is useful for breeders in determining which resistance sources can be used in pepper breeding for the tropics.

Materials and Methods

Twenty-nine pure PVY isolates of serotype 1 from AVRDC fields (16 isolates), Hualien (6), Pingtung (2), Yunlin (4) and Nantou (1) were straintyped through mechanical inoculation of 10 different hosts, including *Capsicum annuum* cvs. Serrano VC, Delray Bell, Yolo Y, Yolo Wonder HDV, Florida VR2, Perennial HDV, *Capsicum chinense* Miscucho PI 315008 and *Datura stramonium*. About 5-10 plants of each line were inoculated and rated after 14 and 30 days. All plants were tested by ELISA for the presence of virus.

Results

Twenty-five isolates from Taiwan can be classified as PVY strain 0 (Table 2). The other four isolates reacted similarly, except for their symptomless infection of *C. annuum* Perennial. These isolates are now under further investigation.

Straintyping of TMV

Summary

A search for tobamoviruses and their strains infecting *Capsicum* spp. in Taiwan was initiated. TMV-positive samples were identified by ELISA. Further characterization by host range was made.

Table 2. Straintyping of pepper PVY strains.

Line or Cultivar	PVY Strains					Taiwan Pepper Isolates	
	Tomato/Pepper				Potato		
	0 (S_1)[1]	1 (S_1)	1.2 (S_1)	1.2 (S_2)	0,N (S_1)	25[3] isolates (S_1)	4 isolates (S_1)
Capsicum annuum							
Bastidon	N[2]	N	N	M	R	M	M
Yolo Wonder	M	M	M	M	R	M	M
Yolo	Y	R	M	M	M	R	R
Florida VR-2	R	R	M	M	R	R	R
Serrano VC	R	R	R	M	R	R	R
Perennial	R	R	R	R	R	R	SL
Datura stramonium	R	R	R	R	R	R	R

[1] S_1 = serotype 1; S_2 = serotype 2 (does not react with common PVY antiserum) [2] N = systemic necrosis; M = mosaic; R = resistant; SL = symptomless infection, ELISA positive. [3] Classified as strain 0.

In straintyping, a set of strain differentials was used. All 22 isolates obtained by four successive local lesion transfers on *N. tabacum* 'Xanthi' were found to be tomato mosaic virus (ToMV) strains 1 and 0. The search for pepper strains of TMV continues.

Introduction

A search for different tobamoviruses was initiated to isolate these for later use in determining which resistance genes should be used in the breeding program.

Materials and Methods

Twenty-two TMV isolates, purified by four successive local lesion transfers on *N. tabacum* 'Xanthi' were straintyped using the system described in Table 3. The isolates originated from TMV ELISA positive plants collected during surveys in Taiwan.

Table 3. Reaction of tobamovirus isolates from pepper in Taiwan on TMV strain differentials.

Differential Host (genotype)	TMV pepper strains				Taiwan Isolates
	P0	P1	P1.2	P1.2.3	
C. annuum Early Calwonder (L^+/L^+)	M[1]	M	M	M	M
C. annuum Tisana (L1/L1)	LL	M	M	M	M
C. frutescens 'Tobasco' (L2/L2)	LL	LL	M	M	nLL
C. baccatum PI 260549 (L2/L2)	LL	LL	LL	M	nLL
C. chinense Miscucho (L3/L3)	LL	LL	LL	LL	–
C. chacoense (L4/L4)	LL	LL	LL	LL	–

[1] M = mosaic, LL = local lesions, – = no reaction, negative ELISA reaction.

Results

All isolates belonged to the same reaction group (Table 3). The reactions on pepper TMV strain differentials did not fit the reaction types of any of the known pepper TMV strains. A host range study on additional hosts indicated that reactions of isolates originating from pepper were those of the tomato strain of TMV (Table 4). The pepper strain of TMV is not known to infect tomato and the eggplant cv Black Beauty. It only produces latent infection on *Solanum giganteum*. The Taiwan isolates produced mosaic on *L. esculentum* and *S. giganteum* and local lesions on *Solanum melongena*. All 22 isolates were further straintyped on the ToMV differentials and mostly were found to be strain 0 (17 isolates) and strain 1 (5 isolates).

Conclusion

Evidently, the tomato strain of TMV is prevalent on pepper in Taiwan because tomato is widely grown in Taiwan and often planted in close proximity to sweet or hot pepper. A tobamovirus recently isolated from pepper in Indonesia was also found to be tomato strain.

A thorough search for pepper strains of TMV continues to gain knowledge on their presence in the tropics and subtropics.

Table 4. Reaction of tobamovirus isolates from pepper in Taiwan on various host plants.

Host	Taiwan TMV isolates	TMV pepper strains
L. esculentum Moneydor	M[1]	–
N. tabacum White Burley	M	nLL
N. tabacum Xanthi NC	M	nLL
N. sylvestris	nLL	nLL
S. giganteum	M	latent
C. chacoense PI 260429	nLL	LL or mosaic
S. melongena 'Black Beauty'	nLL	– or LL
C. annuum 'Bruinsma Wonder'	–	M
C. annuum Novi	–	M

[1]M = mosaic, LL = local lesions, – = no reaction, negative ELISA reaction.

Seed Transmission of CVMV

Summary

Chili veinal mottle virus (CVMV) is not reported to be seed-transmitted in *Capsicum* sp. The high incidence in farmers' fields prompted the study on possible seed transmission. Results indicated that a high percentage of seed transmission is present in certain pepper cultivars. However, results of this study need to be confirmed.

Introduction

CVMV was first described as a new virus from Malaysia. It was reported to be non-seed transmitted. However, because of high CVMV incidence observed in farmers' fields, seed transmission was investigated.

Materials and Methods

Seed transmission was tested in 36 *Capsicum* sp. lines. Forty plants of each line were sown on 25 May and mechanically inoculated twice on 1 June and 7 July with CVMV isolate 1037, previously recovered from pepper in Taiwan. The presence of virus was verified by an ELISA test on 22 July.

Only CVMV infected plants were transferred to the field for seed production. Pods were harvested and seeds were collected and dried at 26°C. Forty seeds per line were sown in flats in an insect proof screenhouse. At 56 days after sowing, symptoms were observed and an ELISA test was performed on each individual plant (using two leaves each from the top, middle and bottom of each plant). Six plants of each line showing virus symptoms were also tested for the presence of PVY, tobacco etch virus (TEV) and PeMV.

Results and Discussion

Seed transmission in lines tested ranged from 0 to 87% (Table 5). Symptoms of plants derived from infected seeds appeared 35 days after sowing. Symptoms varied from cultivar to cultivar. In some cultivars, there was severe mottling. In others, none or only mild symptoms were observed, although virus presence was detected in these plants by ELISA. Contamination by other potyviruses in the screenhouse was excluded.

The present finding on seed transmission of CVMV in *Capsicum* spp. contradicts other reports. The data, however may help explain the high incidence of CVMV in farmers' fields. Results of this study need to be confirmed.

Table 5. Seed transmission of CVMV in *Capsicum* spp.

Acc. no.	ELISA positive/ total no. tested	Seed transmission %	Acc.no.	ELISA positive/total no. tested	Seed transmission %
14A	9/42	21	482	12/42	29
15A	5/47	11	483	8/48	17
17B	14/46	30	484	8/48	17
104A	11/19	58	485	20/46	43
200A	4/11	36	486	29/47	62
269	0/14	0	487	16/36	44
352	12/42	29	488	0/47	0
436	9/43	21	489	7/38	18
439	18/32	56	492	6/47	13
441	12/47	26	543	29/46	63
466	23/48	48	548	22/40	55
467	25/47	53	551	17/34	50
470	26/48	54	559	30/48	63
474	40/46	87	561	21/45	47
477	26/48	54	562	7/48	15
478	11/47	23	563	13/48	27
480	32/49	65	564	38/48	79
481	7/48	15	VC 83	27/47	57

Purification of Pepper Viruses

Summary

Five viruses (AMV, CMV, CVMV, PeMV and TEV) were purified. The antisera were produced from them for use in disease surveys and resistance screening.

Introduction

There are at least 30 viruses which infect pepper. Not much information is avilable about these viruses in tropical areas of Southeast Asia. A survey was initiated to determine which viruses are present and most important in terms of incidence and effect on yield. The surveys were conducted through ELISA using a large number of antisera produced at AVRDC.

Materials and Methods

Alfalfa mosaic virus

Purification. The virus was originally supplied by BBA, Braunschweig and propagated in *N. tabacum* Samsun NN. Leaves were harvested two weeks after inoculation. A modified purification method by Van Vloten Doting and Jaspars (1972)[1] was used. One part fresh leaves was homogenized in a Waring blender with the same volume of 0.1 M K_2HPO_4 buffer, pH7.1, containing 0.1M ascorbic acid and 0.02M EDTA. The same volume of 1:1 chloroform-butanol was added and the mixture was homogenized. The homogenate was centrifuged at 5000rpm for 5 min at 4°C (GSA rotor). To precipitate the virus, a solution of 30% (w/v) PEG2000 in distilled water was added to the aqueous layer to a final concentration of 5%, and stirred for 30 min. The virus was collected by low speed centrifugation at 10,000 rpm for 10 min at 4°C (SS34 rotor).

[1]Van Vloten Doting, L. and E. M. J. Jaspars 1972. The uncoating of alfalfa mosaic virus by its own RNA. Virology 48, 699-788.

The pellets were resuspended in 0.01M phosphate buffer pH7.0 and subjected to two cycles of low (1,000 rpm/10 min) and high (45,000 rpm/90 min) speed centrifugation. The final pellet was suspended in 0.01 phosphate buffer pH 7.0. An equal volume of a solution of 0.06 M $MgSO_4$ and 0.01 M NaH_2PO_4 pH 7.0 was added to the virus solution (25 mg/ml). After standing for two hours, the solution was centrifuged through a sucrose cushion (100 mg sucrose/ml in 0.03 M $MgSO_4$ and 0.01 M NaH_2PO_4) at 23,000 rpm for 30 min at 4°C (Beckman 65 rotor). The pellets were suspended in 0.01 M NaH_2PO_4 buffer, pH 7.0 containing 0.001 M EDTA and 0.001 M NaN_3.

Immunization. Antiserum was prepared through four weekly intramuscular injections on a rabbit. For the first injection 1 ml antigen solution (containing 9.6 mg AMV) was emulsified with 1 ml Freund's complete adjuvant. The other three injections were done with Freund's incomplete adjuvant. The rabbit was first bled 1 week after the last injection. The antiserum was preserved with 0.01% Na-azide before freezing.

Tobacco etch virus, pepper mottle virus, chili veinal mottle virus.

Purification. TEV was originally supplied by BBA, Braunschweig and multiplied in *Nicotiana tabacum* 'Xanthi'. PeMV was obtained from Purcifull, University of Florida and multiplied in *N. sylvestris*. CVMV was obtained from Fujisawa (Japan) and multiplied in *Petunia hybrida*. Virus-infected leaves were harvested two to three weeks after inoculation. The same purification method was used for the three viruses. A modification of the method described by Lisa et al. (1981)[2] for the purification of zucchini yellow mosaic virus was used. One part fresh leaves was homogenized in a Waring blender with 2 parts 0.5 M K_2HPO_4 buffer, pH 8.5, containing 0.02 M Na_2SO_3, 0.01 M DIECA and 0.005 M EDTA.

The homogenate was filtered through two layers of cheesecloth. After adding 1 part FREON 113 and homogenization, the mixture was subjected to low speed centrifugation for 20 min (5000 rpm at 4°C, GSA rotor). Supernate was filtered through glass wool and subjected to a high speed centrifugation of 25,000 rpm for three hours 30 min at 4°C (Beckman 45 Ti rotor). Pellets were resuspended in 0.05 M sodium citrate containing 0.02 M Na_2SO_3 pH 7.5 and centrifuged at 5000 rpm for 10 min at 4°C (SS 34 rotor). The virus containing supernate was mixed with CsCl (0.4 g/ml) and centrifuged at 26,000 rpm for 18 hr at 10°C (Beckman SW41 rotor). The virus band was collected, diluted with 0.05 M Na citrate - 0.02Na_2SO_3 buffer pH 7.5. Virus was pelleted by high speed centrifugation at 30,000 rpm for 3 hr at 4°C (Beckman 65 rotor). The pellet was resuspended in 0.05 M Na citrate buffer pH 7.5 and observed under the electron microscope.

Immunization. Antiserum was prepared using the method described above. Antigen concentration used for the injections was 1.1 to 1.3 mg/ml for CVMV; 1.5 to 2 mg/ml for PeMV and 0.6 to 1.4 mg/ml for TEV.

Cucumber mosaic virus

Purification. An isolate (P522) collected from pepper in Taiwan was used. The isolate was multiplied in plants of *Nicotiana glutinosa*. Leaves were harvested two weeks after inoculation. The virus was purified through modification of Lot's method (Lot et al. 1972)[3]. One part fresh leaves was homogenized in a Waring blender with two parts 0.5 M citrate buffer, pH 6.5, containing 0.005 M EDTA and 0.1% thioglycollic acid. The homogenate was filtered through two layers of cheesecloth and clarified by adding the same volume of chloroform and homogenization. This was followed by a low speed centrifugation at 9,300 rpm for 10 min at 4°C (GSA rotor). To the supernate, 10% PEG 6000 was added and stirred for 30 min at 4°C. The virus was pelleted by centrifugation at 12,000 rpm for 10 min at 4°C (Beckman 45 Ti rotor) and resuspended in 50 ml of 0.005 M sodium borate

[2]Lisa, V., G. Boccardo, G. D'Agostino, G. Dellavalle, and M. d'Aquilio 1981. Characterization of a potyvirus that causes zucchini yellow mosaic. Phytopathology 71:667-672.

[3]Lot, H., J. Marrou, J. B. Quiot, and C. Esvan 1972. Contribution a l'etude du virus de la mosaique du concombre (CMV). II. Methode de purification rapide du virus. Ann. Phytopathol., 4(1), 25-38.

buffer pH 9.0 containing 0.005 M EDTA. Triton X-100 was added to 2% and the solution was stirred for 30 min at 4°C.

After centrifugation at 14,000 rpm for 15 min at 4°C (SS 34 rotor), the virus containing supernate was subjected to a high speed centrifugation (45,000 rpm, 90 min, 4°C, Beckman 65 p rotor). The virus pellet was resuspended in 0.005 M Borate-EDTA buffer pH 9.0, and centrifuged at 20,000 rpm for 10 min at 4°C (Beckman 65 rotor). The virus containing supernate was mixed with Cs_2SO_4 to a final concentration of 30% (w/w) and was subjected to a quasi-isopycnic centrifugation at 35,000 rpm for 18 hours at 4°C (Beckman SW41 rotor).

The virus containing band was collected, mixed with an equal volume of 0.005 M Borate-EDTA buffer pH 9.0 and centrifuged at 13,700 rpm for 10 min at 4°C (SS 34 rotor). An 8% PEG 6000 was added to the supernate. The solution was stirred for 30 min to allow precipitation of the virus. The virus was pelleted by centrifugation at 11,400 rpm for 10 min at 4°C (SS34 rotor) and resuspended in 0.005 M Borate buffer pH 9.0. This solution containing purified virus was used to view the virus in the electron microscope and produce antiserum.

Immunization. Antiserum was prepared as described earlier. The rabbits received four intramuscular injections of 1 ml antigen solution containing 2 mg purified virus.

Results

AMV. Observation through an electron microscope showed numerous unaggregated bacilliform particles of three different lengths. The virus yield was 192-200 mg/1000 g plant material. Using an extinction coefficient of E 0.1% 10 mm at 260 nm = 5.1 (Jaspars and Bos, 1980)[4], the virus concentration was calculated to be 19-20 mg/ml. In ELISA, the antiserum clearly distinguished between healthy and virus-infected tissue at a concentration of 10 μg/ml IgG and 1/200 enzyme conjugate. A high antiserum titer of 8192 was obtained through DAS ELISA.

TEV. Observation under an electron microscope showed numerous unaggregated filamentous particles. The yield was 4-8 mg virus per 100 g infected leaves. Using an extinction coefficient of E0.1% 10 mm at 260 mm = 2.4 (Purcifull 1966)[5], virus concentration was calculated at 0.8-1.4 mg/ml.

In ELISA, the antiserum clearly distinguished between healthy and virus infected tissue at a concentration of 10 μg/ml IgG and 1/200 conjugate. The antiserum titer obtained was 1024 through DAS ELISA.

CVMV. The electron microscope showed numerous unaggregated long-flexuous rod particles. The yield was 20 to 82 mg virus per 1000 g infected leaves. Using an extinction coefficient of 2.4 (Kurstak 1981)[6], virus concentration was calculated at 1.2-11.5 mg/ml.

In ELISA, the antiserum clearly distinguished between healthy and virus infected tissue at a concentration of 1 μg/ml. The antiserum titer obtained was 512 through DAS ELISA.

PeMV. Observation under an electron microscope showed numerous unaggregated flexuous, filamentous particles. The yield was 15-41 mg virus per 1000 g infected leaves. Using an extinction coefficient of 2.4 (Kurstak 1981), virus concentration was calculated at 3 to 4 mg/ml.

In ELISA, the antiserum clearly distinguished between healthy and virus infected tissue at a concentration of 1 μg/ml IgG and 1/200 conjugate. The antiserum titer obtained was 2048 through DAS ELISA.

CMV. Numerous unaggregated spherical particles were observed under the electron microscope. The virus yield was 29-137 mg/kg infected leaves. Using an extinction coefficient of E 0.1%/10 mm at 260 nm = 5.0 (Franckie et al. 1966)[7], the virus concentration was calculated at 3-14 mg/ml.

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[4]Jaspars, E. M. J. and L. Bos 1980. Alfalfa mosaic virus. CMI/AAB Descriptions of Plant Viruses, 22 p.
[5]Purcifull, D. E. 1966. Some properties of tobacco etch virus and its alkaline degradation products. Virology 29:8-14.
[6]Kurstak, E. 1981. Handbook of plant virus infections (II):732-799.
[7]Franckie, R. J. B., J. W. Randles, T. C. Chambers and S. B. Wilson 1966. Some properties of purified cucumber mosaic virus (Q strain). Virology 28:729-741.

In ELISA, the antiserum clearly distinguished between healthy and virus infected tissue at a concentration of 10 μg/ml IgG and 1/200 conjugate. The antiserum titer obtained through DAS ELISA was 1024.

Growth Characteristics of *Phytophthora capsici*

Summary

Pepper (*Capsicum* spp.) is affected by many diseases which cause serious damage. Phytophthora blight, caused by *Phytophthora capsici*, limits pepper production during warm and rainy seasons. No effective chemical control measure for the disease is yet available. This study aimed to determine the most suitable temperature for the growth of the pathogen and inoculum concentration. A temperature range of 28° – 32°C was found optimum for the growth of the pathogen. The most suitable inoculum concentration was 10^3 zoospores/ml.

Introduction

Pepper (*Capsicum* spp.) is widely cultivated. The plant requires abundant soil moisture, good drainage and relatively high temperature for good growth. Phytophthora blight caused by *Phytophthora capsici* (Leonian) is very serious particularly under warm and humid conditions.

When the fungus, *P. capsici*, attacks the stem near the ground, the stem usually develops dull, water soaked lesions which spread rapidly, later becoming dry and girdling the stem. Following the damage on the stem, the leaves exhibit primary wilting with no change in color. Then, the whole foliage wilts quickly and the plant eventually dies. Discoloration and destruction of the vascular system sometimes are observed in the infected stem. Seedling symptoms are either drying or damping off.

The study aimed to determine the effect of temperature on the growth of *P. capsici* and investigate the relationship between inoculum density and disease severity.

Materials and Methods

Effect of temperature on the growth of *P. capsici* A Phytophthora capsici isolate was collected from Yang-Ming mountain and maintained on a V-8 agar (10% V-8 juice; 0.2% $CaCO_3$; 2% agar) incubated at 28°C for seven days.

When the whole plate was covered with mycelium, the agar was cut into small pieces (4mm in diameter) using a cork borer. A piece of the agar block was placed on the center of a new V-8 agar plate using a sterile forcep. Five plates were incubated, each at 20°, 24°, 28°, 32° and 36°C. The growth of *P. capsici* was inspected and the diameter of its colony was measured daily.

Relationship between inoculum density and disease development Pepper cultivars, PI 201234, Szechuan and Blue Star, were cultivated in the greenhouse in 6-in clay pots containing sterile potting medium. The medium consisted of soil, compost, rice hull and sand at a ratio of 5:3:3:1. One plant was kept in each pot after germination. Three pots were arranged as three replications for each inoculum density. Inoculum densities were 10^5, 10^4, 10^3, 10^2 and 10 zoospores/ml. Inoculation was made 63 days after planting (DAP) by drenching the soil surface of each pot with 100 ml zoospore suspension. All pots in each concentration were inoculated at the same time. Disease development was evaluated at two-day intervals. Disease rating was based on: 0 = no symptoms; 1 = wilted top foliage; 2 = whole plant wilted; 3 = blight of the whole plant stem dry and hard; and 4 = plant dead.

The zoospore suspension was prepared by propagating *P. capsici* on a 9 cm-diameter plate of V-8 agar incubated at 28°C for one week. When the whole plate was covered with the mycelium and some sporangia of the pathogen, the plate was horizontally cut into four pieces. Each piece of the agar block was tranferred to an empty petri dish and then further cut into about 1 cm^2

pieces using a knife. Sterile water was added into each petri dish and the plate was shaken three times for 10-15 minutes (each time) to wash away the nutrition. Sterile water was again added in each petri dish, and water level was kept just close to the surface of the agar block. The petridish was incubated at 28°C for 24 hr to induce the growth of sporangia.

All petri dishes were moved to a cool room at a temperature of 4°C for 30-60 min. Suitable temperature ranged from 0°C to 8°C. The petri dishes were again moved back to a room temperature for 10-30 min. This procedure induced the release of zoospores. Sterile water was added to wash away the zoospores from the surface of the agar block. The samples of zoospores were collected and dropped on the Hemacytometer and moved to a cool room at 4°C for 5-10 min to stabilize the zoospores for counting. The Hemacytometer was taken out and put under a microscope to determine the concentration of zoospores before preparing the inoculum.

Results and Discussion

Effect of temperature on growth of *P. capsici* Table 6 shows the colony development of *P. capsici* on potato dextrose agar (PDA) incubated at different temperatures, of which 24°-32°C favored the growth of *P. capsici*. Temperature above 36°C completely inhibited the growth of *P. capsici*. The optimum temperature for the growth of *P. capsici* on PDA is 28-32°C.

In tropical or subtropical areas where the fungus is devastating, the maximum day temperatures are often higher than 36°C and night temperatures are lower than 36°C. This fluctuation in temperature under field condition is much different compared with the stable incubator at 36°C. An environment with higher temperature and humidity is more suitable for the infection and development of *P. capsici*.

Relationship between inoculum density and disease development Differences in disease development among cultivars were obvious among inoculum concentrations. Disease development on highly susceptible Blue Star showed no significant difference at 10^2, 10^3, 10^4, and 10^5 zoospore concentrations in the later evaluations, although 10^5 zoospore showed a significant difference in early evaluations (Table 7). Due to high susceptibility, Blue Star also showed disease development even at 10 zoospores/ml concentration.

Table 6. Effect of temperature on the growth of *Phytophthora capsici*.

Temperature	Diameter of colony (cm)[z]						
(°C)	1 DAI[y]	2 DAI	3 DAI	4 DAI	5 DAI	6 DAI	Mean
20	0.6 c[x]	2.3 b	3.8 b	4.9 b	6.0 b	7.2 b	4.1 b
24	1.1 b	3.1 a	4.6 a	6.1 a	7.3 a	8.8 a	5.1 ab
28	1.5 a	3.4 a	5.1 a	6.7 a	8.1 a	9.0 a	5.6 a
32	1.6 a	3.3 a	5.0 a	6.6 a	7.8 a	8.7 a	5.5 a
36	0.6 c	0.6 c	0.6 c	0.6 c	0.6 c	0.6 c	0.6 c

[z]Date incubated: 1 August 1988. The original inoculum source was 0.5 cm diameter and included in the colony diameter. [y]DAI: days after inoculation. [x]Mean separation within columns by DMRT at 5% probability level.

Table 7. Effect of inoculum density on the development of Phytophthora blight in Blue Star.[z]

Density	Disease Index[y]										
(zoospores/ml)	5 DAI[x]	8 DAI	10 DAI	12 DAI	14 DAI	16 DAI	18 DAI	20 DAI	22 DAI	24 DAI	Mean
10^5	2.0 a[w]	3.0 a	3.0 a	3.0 a	3.0 a	3.0 a	4.0 a	4.0 ab	4.0 a	4.0 a	3.3 a
10^4	0.7 b	1.3 b	2.3 ab	3.0 a	3.0 a	3.0 a	4.0 a	4.0 ab	4.0 a	4.0 a	2.9 a
10^3	0.0 c	0.0 c	1.3 bc	2.0 a	2.0 a	2.0 a	3.3 a	3.7 abc	3.7 a	3.7 a	2.2 b
10^2	0.0 c	0.0 c	0.7 cd	1.3 ab	1.7 ab	2.0 a	3.0 a	3.0 ac	3.7 a	3.7 a	1.9 b
10	0.0 c	0.0 c	0.0 d	0.0 b	0.0 b	0.0 b	0.0 b	1.7 d	2.3 b	2.7 b	0.7 c
ck	0.0 c	0.0 c	0.0 d	0.0 b	0.0 b	0.0 b	0.0 b	0.0 e	0.0 c	0.0 c	0.0 d

[z]Date inoculated, July 20, 1988. [y]Disease index: 0 = no symptoms. 1 = the top foliage wilted. 2 = the whole plant wilted. 3 = the whole plant blighted. 4 = the plant died. [x]DAI: days after inoculation. [w]Mean separation within columns at 5% probability level by DMRT.

Disease development on moderately susceptible cultivar, Szechuan, was shown clearly at 10^5 and 10^4 inoculum densities. Disease did not develop at other concentrations (Fig. 1). The final rating of the disease at 10^4 inoculum concentration was 2.33 only, lower than that obtained at 10^1 in Blue Star. Due to the unfavorable high temperature in the greenhouse, the disease was low even at higher inoculum concentration. Disease did not develop on cultivar PI 201234 in any inoculum concentration. These results confirmed the reported resistance of this cultivar.

Figure 2 clearly shows that 10^5 and 10^4 concentrations exhibited more conspicuous differences in disease index compared to other densities and the control. The 10^3 concentration also showed a difference compared to 10^2, 10^1 and the control. A 10^3 concentration (zoospores/ml) was found to be the optimum concentration for screening of phytophthora blight resistance.

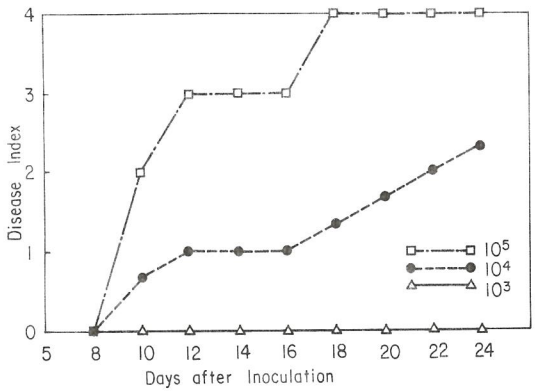

Fig. 1. Effect of inoculum concentration on the disease development of phytophthora blight on Szechuan.

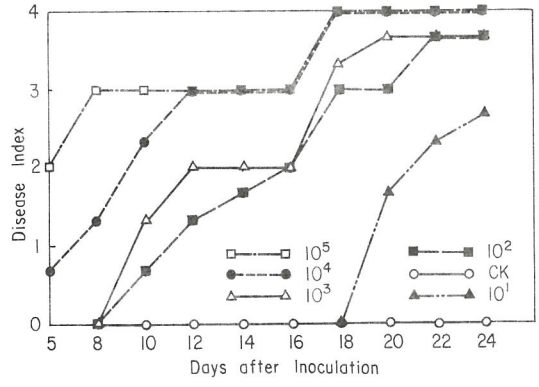

Fig. 2. Effect of inoculum concentration on the disease development of phytophthora blight on Blue Star.

Effect of Pepper Growth on *P. capsici* Development

Summary

Six growth stages of hot pepper Szechuan and sweet pepper Blue Star were studied to determine the effect of infection of two isolates (Yang-1 and Chuan-1) of *Phytophthora capsici*. Both isolates clearly produced susceptible reactions in each of the six growth stages of Blue Star. A trend on resistance was shown in 3 and 13-week old plants of Szechuan. The most susceptible reaction was found in Szechuan at five and seven weeks after planting. This period was suitable for evaluating resistance to *P. capsici*.

Introduction

The roots, leaves, stems and fruits of pepper are attacked by many diseases. Pepper blight caused by *Phytophthora capsici* is a major problem during cultivation. In previous studies, high level of resistance to Phytophthora blight was found in some lines.

Field screening for disease resistance is expensive and frequently affected by adverse environmental and biological factors. A screening technique for large populations, preferably at seedling or vegetative stage is ideal to reduce costs and environmental effects. This experiment was conducted to determine the effect of pepper growth on disease development of *Phytophthora capsici*.

Materials and Methods

Sweet pepper cv. Blue Star and hot pepper cv. Szechuan were grown in the greenhouse in 7-in diameter clay pots (1 plant/pot) in sterilized potting mixture (soil:compost:rice hull:sand, 5:3:1:1). Planting, in four replicates, started on 25 February 1988 and continued every two weeks. Plants at 3, 5, 7, 9, 11 and 13 weeks old were inoculated on 26 May.

The inoculum consisted of a zoospore suspension (1000 zoospores per ml and 100ml per pot). Disease evaluation was made at 4, 7, 10, 14, 17, 20 and 23 days after inoculation. Disease rating was based on the following criteria: 0 = no symptoms; 1 = top foliage wilted; 2 = whole plant wilted; 3 = whole plant blighted, dry and hard stem; and 4 = plant completely died.

Results and Discussion

On Blue Star, a susceptible reaction was produced by both isolates, Yang-1 and Chuan-1, at each of the six plant stages tested (Table 8). The disease progressed rapidly in each growth stage of this cultivar regardless of the isolate used. This result suggests that *P. capsici* may infect all plant ages of susceptible peppers.

Differences in susceptibility were observed in the moderately susceptible cultivar, Szechuan (Table 9). The 3 and 13-week old plants reacted less severely upon inoculation due to longer incubation of the fungus. For Szechuan, the most susceptible growth stage for inoculation was found to be 5 and 7 weeks. Results confirmed the finding of Reifschneider (1986)[8] who suggested that the ideal artificial inoculation for pepper blight resistance screening is 45 days from sowing.

Table 8. Effect of plant age[z] on disease development of *P. capsici*.[y]

Weeks after planting	Days after inoculation	Disease[x] index (Yang 1)	Disease[x] index (Chuan 1)	Weeks after planting	Days after inoculation	Disease[x] index (Yang 1)	Disease[x] index (Chuan 1)
13	4	0	0	7	4	1	0
	7	1	0.25		7	1	0.5
	10	2	1.25		10	2.75	1.5
	14	3	2.0		14	3.75	4.0
	17	4	3.50		17	4	4.0
	20	4	4		20	4	4
	24	4	4		24	4	4
11	4	0	0	5	4	0.75	0.50
	7	1	0.25		7	0.75	1.25
	10	2	1.75		10	2.25	1.50
	14	3	3.00		14	3.00	2.50
	17	4	4		17	3.25	4
	20	4	4		20	3.50	4
	24	4	4		24	4.00	4
9	4	0	2.50	3	4	0.50	0.75
	7	1	1.25		7	2.25	1.75
	10	2	2.25		10	3.00	2.50
	14	3	3.25		14	3.00	4
	17	4	4		17	3.25	4
	20	4	4		20	3.75	4
	24	4	4		24	4.00	4

[z]Cultivar: Sweet pepper Blue Star. [y]Isolate: Yang-1 and Chuan-1. [x]The values are the means of 4 replications. Disease index: 0 - no symptoms; 1 - the top foliage wilted; 2 - the whole plant wilted; 3 - blight of the whole plant; 4 - plant completely died.

[8]Reifschneider, F.J.B. A.C. Cafe-Filho and A.M. Rego. 1986. Factors affecting expression of resistance to blight caused by *P. capcisi* in screening trials. Plant Path., 35, 451-456.

Table 9. Effect of pepper[z] development on *P. capsici* infection.

Weeks after planting	Days after inoculation	Disease[x] index (Yang-1)	Disease[x] index (Chuan-1)	Weeks after planting	Days after inoculation	Disease[x] index (Yang-1)	Disease[x] index (Chuan-1)
13	4	0	0	7	4	1	0
	7	0			7	1	0.50
	10	0	0		10	3	1
	14	0.25	0		14	4	2.25
	17	1.50	0.25		17	4	3
	20	2.00	0.25		20	4	3
	24	2.75	1		24	4	3
11	4	0	0	5	4	0.50	0
	7	0.50	0		7	0.50	0.25
	10	1	0		10	1.50	0.25
	14	3	0		14	2.00	1.25
	17	4	0.50		17	2.25	3.50
	20	4	1		20	2.50	4
	24	4	1		24	3.25	4
9	4	0	0	3	4	0.25	0
	7	1	0		7	0.75	0.25
	10	1.75	0		10	1.00	0.50
	14	3	0.25		14	1.00	1
	17	4	1		17	1.00	1
	20	4	1		20	1.00	1
	24	4	1		24	1.00	1

[z]Cultivar: Hot pepper Szechuan. [y]Isolate: Yang-1. [x]The values are means of 4 replications. Disease index: 0 - no symptoms; 1 - the top foliage wilted; 2 - the whole plant wilted; 3 - blight of the whole plant; 4 - plant dead.

Phytophthora Blight Resistance Screening

Summary

A total of 678 entries were screened for Phytophthora blight resistance in 1988. Three accessions, C01175 (PM 702), C00352 (PM 217) and C01176 (PI201234) were identified as highly resistant and 11 accessions were rated moderately resistant to the disease.

Introduction

Phytophthora blight, caused by *Phytophthora capsici*, can be devastating on pepper grown during the hot and wet season. The use of a resistant variety is presently the most practical method to control the disease. Seven very highly resistant lines, C00113, C02227, C02230, C02284, C02289, C01176A and TC3191 were identified from the resistance screening trials in 1987. A series of preliminary screening trials had been conducted to evaluate and select lines with high levels of blight resistance.

Materials and Methods

A total of 618 AVRDC accessions were screened. Several batches of lines were planted on 30 November (180 lines), 15 December 1987 (41 lines), 22 February (111 lines), 22 April (82 lines), 22 June (148 lines) and 26 August 1988 (116 lines). Four checks, PI 201232 (highly resistant), PI 201234 (highly resistant), Szechuan (moderately susceptible) and Blue Star (highly susceptible) were included in the experiment. Ten seedlings per accession per pot with two replications were screened under greenhouse conditions. The inoculum source, *P. capsici* (isolate Yang-1), was propagated on V- 8 agar to produce sporangia and induce the release of zoospores. The concentration was adjusted to 10^3 zoospores/ml and each plant was inoculated at the base with 100 ml of the zoospore suspension.

Artificial inoculations were made approximately 33 to 58 days after sowing depending on plant growth. The disease reaction was evaluated once a week for a month and was rated according to: highly resistant (HR) = the mortality is less than or equal to PI 201234 or PI 201232 (<20%); moderately resistant (MR) = mortality is less than Szechuan (20-50%); moderately susceptible (MS) = mortality is equal to Szechuan (50-70%); and, highly susceptible (HS) = mortality is more than or equal to Blue Star (>70%).

Results and Discussion

Three accessions, C01175 (PM 702), C00352 (PM 217) and C01176 (PI 201234) were identified highly resistant to Phytophthora blight. Eleven accessions were rated moderately resistant. Twenty-two and 642 accessions were rated moderately susceptible and highly susceptible, respectively. All highly resistant and moderately resistant accessions will be evaluated further.

Growth Characters and Inoculation Methods of Anthracnose Pathogens

Summary

Anthracnose is a serious disease in pepper mainly caused by *Colletotrichum capsici* and *C. gloeosporioides*. To develop an effective resistance screening technique, experiments were conducted to understand the growth characters of the causal organism, relationship between temperature and disease development, and search for the best method in identifying the resistant germplasm.

C. capsici grew more quickly than *C. gloeosporioides* at 28-32°C on PDA plate, the optimum temperature for the growth of *C. capsici*. On the other hand, 28°C was the optimum temperature for the growth of *C. gloeosporioides*.

The optimum temperature for the development of *C. capsici* on inoculated fruits was 28-32°C in sweet pepper and 36°C in hot pepper. Therefore, 28-36°C is the most suitable for the development of *C. capsici* in pepper.

Soaking or spraying of the fruits with spore suspension was the best inoculation method.

Introduction

Pepper is affected by a variety of diseases. One of these is fruit rot caused by *Colletotrichum* spp. which reduces crop yield and market quality. Anthracnose or fruit rot has been considered one of the most serious diseases around the world. Chohan (1965)[9] reported 10-75% yield loss in pepper due to anthracnose.

Black (1986)[10] reported that four species of *Colletotrichum* namely, *C. capsici*, *C. gloeosporioides*, *C. acutatum* and *C. coccodes*, cause fruit rot in pepper. However, the major incitants are *C. capsici* and *C. gloeosporioides*.

C. capsici and *C. gloeosporioides* were also identified as major causal organisms of anthracnose in pepper in Taiwan. *C. capsici* causes a dark infection on the fruit. Its conidia taper on both ends, resulting in a sharp pointed shape and the colony shows grayish white to dark gray on potato dextrose agar (PDA). In contrast, *C. gloeosporioides* causes slightly sunken, dark yellow spots on the red ripe fruit and its conidia have rather dull or round ends. The colony shows white in the early stage, then easily becomes gray.

Although some chemicals can reduce the disease, development of resistant varieties is the best way to combat it. Thus, experiments were conducted to understand the growth behavior of the pathogen, determine the relationship between temperature and disease development and to search for the best inoculation method.

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[9]Chohan, J.S. 1965. Studies on variation and perpetuation of *Colletotrichum capsici* (Syd.) Butl & Bisb, causing fruit rot of chillies in Punjab. Jour. of Res. PAV, Ludhiana; 3, p. 10.

[10]Black, L. 1986. The status of ripe rot in Louisiana peppers. Eighth National Pepper Conference, 14 p.

Materials and Methods

Effect of temperature on growth of *C. capsici* and *C. gloeosporioides* The isolates of *C. capsici* and *C. gloeosporioides* were taken from naturally infected red and ripe pepper fruits collected from AVRDC's experimental field. The infected tissue was isolated on PDA plate and maintained in an incubator at 28°C for one week. The fungal colony was cut into pieces 0.4 cm in diameter using a cork borer. One piece was transferred to each new PDA plate. Four plates, containing each of the isolate and arranged as four replicates, were moved to five incubators set at 20°, 24°, 28°, 32° and 36°C.

The diameter of each colony in every plate was measured on the 10th day of incubation to determine the optimum temperature for growth of the two species.

Effect of temperature after artificial inoculation. Ten red and ripe fruits of Blue Star, Ching Yeu, 5210, 622 and Szechuan were harvested from the experimental field, washed, dried and punctured with five pins within 5 mm diameter. The fruits were placed on a layer of stainless net in five plastic trays. Sweet pepper, 5210, Blue Star and Ching Yeu were put in a larger (27.0 × 18.5 × 9.5 cm) plastic tray containing 100 ml of distilled water. Hot pepper, 622 and Szechuan were placed in a smaller (20.5 × 12.0 × 6.5 cm) tray containing 50 ml of sterilized water.

The conidia from four-day old cultures of *C. capsici* were washed in a beaker. The conidia concentration in the solution was adjusted to 3×10^6 spores/ml. The inoculum was dropped on the punctured region of each fruit. The plastic tray was then sealed in a plastic bag to maintain high humidity for penetration and development of pathogens.

Trays were incubated at 20°, 24°, 28°, 32° and 36°C.

Disease development was evaluated by measuring the diameter of the lesions twice a week for 14 days after inoculation.

Five sweet pepper and 10 hot pepper fruits were used. *C. capsici* and *C. gloeosporioides* inocula were prepared in the same manner as in the earlier experiment. Inoculation was done by: 1) puncturing the fruits with five pins within a 5 mm diameter area using a spore suspension of 3×10^6 spores/ml dropped on the punctured region; 2) soaking fruits in spore suspension (3×10^6 spores/ml) and moving them out immediately; and 3) uniformly spraying the fruit's surface with spore suspension (3×10^6 spores/ml).

Each tray was also sealed in a plastic bag to maintain high humidity and incubated at 28°C.

Evaluation of the puncture method was done by measuring the lesion diameter. The two methods were evaluated by counting the developing lesions. The disease scale used was 0 = no lesion; 1 = 1 to 2; 2 = 3 to 8; 3 = 9 to 15; 4 = more than 15 lesions per fruit.

To compare the various data obtained from different inoculation methods, the correlation coefficient (r) between disease development and days after inoculation (DAI) was also calculated.

Results and Discussion

Effect of temperature on growth of *C. capsici* and *C. gloeosporioides*. The *C. capsici* colony on PDA was white in the early stage, turning gray after rapid growth. Light to dark gray aerial mycelia formed over the surface of the colony, sometimes showing diurnal zones in density. Spore droplets were pale buff to salmon. In contrast, the colony of *C. gloeosporioides* on PDA was grayish white to dark gray. Conidia was commonly a pale salmon mass.

Table 10a shows 28-32°C as the optimum temperature for the growth of *C. capsici*. Growth at 24 and 20°C was much slower than at 28-32°C. Growth was suppressed at 36°C. In contrast, 28°C was the optimum temperature for the growth of *C. gloeosporioides* (Table 10b); its growth was almost completely inhibited at 36°C.

Effect of temperature on artificial inoculation. Results of this experiment are shown in Table 11. The disease developed very slowly at 20°C. Disease development on sweet pepper fruits was significantly faster at 28-32°C than at other temperatures. On hot pepper, disease development was fastest at 36°C. Therefore, 28-36°C is the optimum temperature range for the development of

Table 10a. Effect of temperature on the colony development of *C. capsici*.[z]

Temperature	Colony size (cm diameter[y])								
(°C)	8/3	8/4	8/5	8/6	8/7	8/8	8/9	8/10	8/11
20	0.4 d[x]	1.3 c	2.0 c	2.8 c	3.6 c	4.6 c	5.3 c	6.4 c	7.3 c
24	0.5 c	1.5 b	2.5 b	3.4 b	4.6 b	5.6 b	6.4 b	7.5 b	8.6 b
28	0.1 a	1.9 a	2.9 a	3.9 a	5.4 a	6.8 a	7.7 a	8.7 a	9.0 a
32	1.0 a	2.0 a	3.0 a	4.0 a	5.5 a	6.9 a	8.0 a	8.6 a	9.0 a
36	0.8 b	1.2 c	1.1 d	1.4 d	2.0 d	2.3 d	3.3 d	3.9 d	4.8 d

[z]Incubated: 2 August 1988. [y]Including the original source (0.4 cm diameter). [x]Means within a column followed by the same letter are not significantly different at 5% level by DMRT.

Table 10b. Effect of temperature on the colony development of *C. gloeosporioides*.[z]

Temperature	Colony size (cm diameter[y])								
(°C)	8/3	8/4	8/5	8/6	8/7	8/8	8/9	8/10	8/11
20	0.4 c[x]	1.3 c	2.0 b	2.8 b	3.8 b	4.7 c	5.3 b	6.0 c	6.8 c
24	0.4 c	1.4 b	2.3 a	3.3 a	4.7 a	5.1 b	5.8 a	6.6 b	7.3 b
28	0.7 a	1.7 a	2.5 a	3.3 a	5.0 a	5.9 a	6.1 a	7.2 a	8.0 a
32	0.5 b	1.4 bc	2.0 b	2.7 b	3.8 b	4.4 d	4.7 c	5.5 d	5.8 d
36	0.4 c	0.4 d	0.4 c	0.4 c	0.4 c	0.4 e	0.5 d	0.5 e	0.7 e

[z]Incubated: 2 August 1988. Replication: 4 plates as four replications. [y]Including the original source (0.4 cm diameter). [x]Means within a column followed by the same letter are not significantly different at 5% level by DMRT.

Table 11. Effect of temperature on anthracnose development after artificial inoculation.[z]

Pepper[y]	Temperature	Diameter of lesion (cm)			
	(°C)	3 DAI[x]	7 DAI	10 DAI	14 DAI
3 sweet pepper cultivars	20	0	0.18	0.43	0.87
	24	0.25	0.67	1.15	1.95
	28	0.30	1.20	2.15	2.47
	32	0.18	1.43	2.13	2.83
	36	0	0.56	1.06	1.68
2 hot pepper cultivars	20	0.06	0.26	0.39	0.46
	24	0.07	0.10	0.24	0.80
	28	0.09	0.43	0.80	1.82
	32	0.06	0.37	1.25	2.21
	36	0.27	0.89	1.56	2.16
Mean	20	0.03 a[w]	0.22 b	0.41 c	0.76 c
	24	0.16 a	0.39 ab	0.69 bc	1.38 bc
	28	0.20 a	0.81 a	1.48 a	2.15 ab
	32	0.12 a	0.90 a	1.69 a	2.52 a
	36	0.14 a	0.72 ab	1.31 ab	1.93 ab

[z]Inoculated: 2 August 1988. 10 hot pepper/fruits; 5 sweet pepper/fruits were inoculated. Inoculation concentration: 3×10^5 spores/ml. Evaluated: 5, 8, 12, 16 August 1988. [y]Sweet pepper, Blue Star, Ching Yeu & 5210. Hot pepper, Szechuan & 622. [x]Days after inoculation. [w]Means within a column followed by the same letter are not significantly different at 5% level by DMRT.

C. capsici on pepper fruit. Previous experiments [11] reported that pepper anthracnose was enhanced by high temperature and high humidity. This experiment confirmed the results of those studies.

In hot pepper variety 622, the largest lesion diameter was obtained at 32°C. This was significantly larger than in other temperatures. Lesion development seemed to stop at 20°C.

Effect of inoculation method. Results of tests on three inoculation methods on five pepper varieties are shown in Tables 12a and 12b. Spraying and soaking in spore suspension on the fruit resulted in uniform infection on every fruit in all entries. These are, therefore, the best inoculation methods in the experiment. Very high correlation was found between disease development and days

[11]Mordue, J.E.M. 1971. C.M.I. Description of pathogenic fungi and bacteria, No. 315 & 317. AVRDC. 1990. Progress Report 1987. Arden, F. Sherf and Alan A. Macnab 1986 Vegetable diseases and their control. p. 512-515.

Table 12a. Effect of inoculation method on anthracnose development.[z]

Cultivar	Inoculation method	DAI				
		3	7	10	14	17
Szechuan	puncture[y]	0.00	0.00	0.00	0.00	0.06
	soak	0.00	0.20	0.30	0.70	1.30
	spray	0.00	0.20	0.60	0.70	1.50
622	puncture	0.00	0.08	0.32	0.62	1.04
	soak	0.00	0.00	0.10	0.40	0.90
	spray	0.00	0.20	0.50	0.80	1.40
5210	puncture	0.13	0.37	1.09	1.77	1.84
	soak	0.25	1.38	2.63	3.63	3.75
	spray	1.13	2.25	3.38	4.00	4.00
Blue Star	puncture	0.00	0.22	0.68	1.28	1.92
	soak	0.13	0.88	1.75	3.25	3.50
	spray	0.38	1.13	2.50	3.75	4.00
Ching Yeu	puncture	0.08	0.28	0.86	1.31	1.80
	soak	0.13	1.13	2.25	3.13	3.38
	spray	0.00	1.38	2.50	3.50	3.75

[z]Inoculated, 18 July 1988. 10 hot pepper/fruits; 8 sweet pepper/fruits were inoculated. Inoculation concentration: 3×10^6 spores/ml. Evaluated, 21, 25, 28 July, 1 & 4 August 1988. [y]The puncture method was evaluated by measuring the lesion diameter; the soaking and spraying methods were evaluated by disease scales (0-4).

Table 12b. Correlation of anthracnose development parameters and days after inoculation in different inoculation methods.

Cultivar	Inoculation method		
	puncture	soak	spray
Szechuan	0.4707[z]	0.7980	0.8897
622	0.9310	0.8041	0.9418
5210	0.9471	0.9567	0.9162
Blue Star	0.9604	0.9750	0.9674
Ching Yeu	0.9736	0.9691	0.9648
Mean	0.85656	0.90058	0.93598

[z]Square of the correlation coefficient.

after inoculation. In general, the spray method showed the highest correlation in all five varieties.

A moderately resistant reaction was found in Szechuan. Disease development was very light in all three inoculation methods. Means of 0.058 (puncture), 1.3 (soak) and 1.5 (spray) were obtained from 10 inoculated fruits.

Effect of Fruit Maturity on Anthracnose Development

Summary

Sweet pepper (cv. Blue Star) and hot pepper cultivars (cv. Szechuan and PI 201234) were tested to study the effect of fruit maturity on anthracnose development. Anthracnose pathogens were found to attack both ripe and green fruit, but the disease developed slower on green fruit than on the ripe one. Fruit maturity affected disease severity but not the infection caused by the pathogen.

Introduction

Anthracnose is mainly caused by *Colletotrichum gloeosporioides* and *C. capsici*. The disease is usually found on red fruits but rarely on green fruits. The present experiment was designed to study the effect of fruit maturity on anthracnose development in pepper.

Materials and Methods

One sweet pepper, Blue Star and two hot pepper cultivars, Szechuan and PI 201234 were planted in 7-in diameter clay pots with growing media of soil:compost:rice hull:sand at 5:3:1:1 ratio. When plants reached the flowering stage, a tag indicating the date of flowering was hung on the flower stalk. A tag was hung at weekly intervals to ensure the collection of different mature fruits. Both green and red fruits of each cultivar were harvested on 17 October 1988. Ten fruits for every cultivar were collected randomly at each maturity level. The fruits were washed, dried and placed on a stainless net layer in plastic trays (20.5 × 12.0 × 6.5 cm) containing 50 ml of distilled water. The surfaces of the fruits were uniformly sprayed with a mixed spore suspension (3×10^6 spores/ml) of *C. gloeosporioides* and *C. capsici*. The trays were sealed individually in a plastic bag to maintain high humidity and incubated at 28°C.

Disease development was evaluated once a week by counting the developing lesions. The disease indices were: 0 = no lesion; 1 = 1 to 2; 2 = 3 to 8; 3 = 9 to 15; 4 = more than 15 lesions per fruit.

Results and Discussion

Blue Star showed a significant difference in disease development between ripe fruits and green fruits. The older the fruit the earlier the disease development (Table 14). The disease was more serious on mature fruits than on green fruits.

Disease development in hot pepper, PI 201234, was the same as in sweet pepper. This line appeared more susceptible to the disease which developed more easily and severely infected both ripe and green fruits (Table 13).

Szechuan was found more resistant than PI 201234. The disease developed slower in either ripe or green fruit than in PI 201234 (Table 13). The more mature the fruit is, the higher the disease infection.

Results showed that anthracnose pathogens attacked both ripe and green fruits although disease development was slower in the green fruits than the ripe fruits. Fruit maturity affected disease severity.

Table 13. Effect of fruit maturity on anthracnose development in pepper.

Variety	DAI[z]	Disease Index[y] DAF[x]								
		60	56	53	46	39	32	25	18	11
Blue Star	4		0(R)[w]	0(R)	0(R/G)	0(G)[w]	0(G)	0(G)	0(G)	
	11		1.00	1.00	1.00	0	0	0		
	18		2.00	1.50	2.00	1.00	0	0	0.25	
	25		4.00	3.50	4.00	2.00	1.00	0.67	0.25	
PI 201234	4		0(R)	0(R)	0(R/G)	0(G)	0(G)	0(G)	0(G)	
	11		2.50	2.50	2.00	3.22	2.00	0.14	0.66	
	18		4.00	4.00	4.00	4.00	4.00	3.57	3.56	
	25		4.00	4.00	4.00	4.00	4.00	3.71	3.89	
Szechuan	4	0(R)	0(R)	0.56(R)	0(R/G)	0(G/R)	0(G)	0(G)	0(G)	0(G)
	11	1.17	0.50	0.11	0.33	0.67	0.06	0.25	0.38	0.06
	18	2.50	2.00	2.56	1.67	1.67	0.45	0.50	3.50	0.35
	25	3.33	3.50	3.22	3.67	2.83	1.90	2.00	4.00	2.05

[z]DAI: Days after artificial inoculation. The spore concentration 3×10^6 spores/ml was used. Inoculated 17 October 1988. [y]The disease index used was: 0 = no lesion; 1 = 1 to 2; 2 = 3 to 8; 3 = 9-15; 4 = more than 15 lesions per fruit. [x]DAF: Days after flowering. [w]R: red fruit; G: green fruit.

Screening for Anthracnose Resistance

Summary

A total of 305 accessions were screened for anthracnose resistance in 1988. Two accessions, C01826 and C02220 were identified as very highly resistant. Lesions failed to develop on the fruit after artificial inoculation. Eight accessions — C00632, C00708, C00918, C01172, C01676, C01768, C01777 and C01807 — were rated highly resistant.

Introduction

Pepper is affected by a number of diseases. Fruit rot, mainly caused by *Colletotrichum gloeosporioides* and *C. capsici*, is one of the most serious diseases that reduce the crop yield and market quality. Although use of chemicals can reduce disease development, varietal resistance is still more efficient in combating the disease. A series of screening trials was conducted in 1988 to identify anthracnose resistance sources which may be useful for breeding programs.

Materials and Methods

A total of 305 accessions were tested. Ten red and ripe fruits of each entry were collected from the GRSU plantings. The fruits were washed with tap water, dried with paper towels and punctured with five pins within 5 mm diameter. Ten fruits were placed on a layer inside platic trays containing 50 ml of sterilized water.

The conidia from four-day-old cultures of *C. capsici* and *C. gloeosporioides* grown on PDA in petri dishes were washed off in a beaker. The conidial concentration was adjusted to 3×10^6 spores/ml. The inoculum was dropped on the punctured region of each fruit. The plastic tray was sealed in a plastic bag (to maintain high humidity to allow penetration and development of pathogen) and kept at room temperature.

The disease was evaluated by measuring the diameter of the developing lesions, twice a week for three weeks following inoculation. Disease reaction was rated as very highly resistant (VR) = the lesion failed to develop; highly resistant (HR) = the lesion diameter is 0-0.5cm; moderately resistant (MR) = the lesion diameter is 0.5-1 cm; moderately susceptible (MS) = the lesion diameter is 1-2 cm; highly susceptible (HS) = the lesion diameter is more than 2 cm.

Two check cultivars, Blue Star (highly susceptible) and Szechuan (moderately susceptible), were used in the trials.

Results and Discussion

C01826 and C02220 were found without lesions, and thus were rated very highly resistant. Only lesions of less than 0.5 cm diameter developed on accessions C00632, C00708, C00918, C01172, C01676, C01768, C01777 and C01807. These accessions were rated highly resistant because the lesion diameter was small and limited to the original inoculated region. It was observed that 38 entries were moderately resistant; 132 entries, moderately susceptible; and 125 entries, highly susceptible. All very highly resistant and highly resistant accessions will be further screened.

Screening Method for *Xanthomonas campestris* pv. *vesicatoria*

Summary

AVRDC studied bacterial spot and its causal organism because it is a serious foliar disease of pepper worldwide. To develop an effective resistance screening method, infiltration, puncturing, atomization and mechanical inoculation were investigated. The optimum inoculation concentration was 10^8 cfu/ml for puncturing, atomization and mechanical inoculation and 10^5 for infiltration. Although susceptible pepper plants could develop bacterial spot symptoms through these inoculation methods, atomization seemed to be more practical for mass resistance screening. The optimum inoculation pressure was 1.5 kg/cm^2 and optimum age was when plants reached 5-7 true leaf stage. The different disease reactions in susceptible, incompletely dominant and completely dominant resistant pepper varieties need further investigation.

Introduction

Bacterial spot of pepper, caused by *Xanthomonas campestris* pv. *vesicatoria* (XCV), is one of the major foliar diseases which cause considerable reduction in pepper yield and fruit quality. A windy, warm and rainy climate favors disease occurrence and development. The pathogen infects all the

aboveground parts of the plant. When it attacks the leaves, these may become ragged, turn yellow and drop.

AVRDC recently began research on bacterial spot in pepper. To develop an effective method for resistance screening, suitable conditions of artificial inoculation must be determined. These studies aimed to determine the best inoculation method and the suitable conditions for artificial inoculation.

Materials and Methods

Inoculum preparation. The isolates XVP16 (race 1), XVP3 (race 2) amd XVP14 (race 3) of *X. campestris* pv. *vesicatoria* were used in the experiment.

The inoculum was prepared from a dense bacterial suspension of a 24-hour-old culture on 523 (Kado and Heskeh 1970)[11] medium slants incubated at 32°C. On each of 523 plates, 0.2 ml of bacterial suspension was placed and fully spread out. The plates were incubated at 32°C for 24 hours. Bacterial cells were washed from the plates and suspended in distilled water. The suspension was passed through four layers of cheesecloth. Bacterial concentration was determined by a spectrophotometer (Jasco, UVIDEC-340) at a wave length of 600nm. The cfu/ml values of the three bacteria races were determined based on the regression of O.D. absorption values.

Effect of Inoculation Methods on Symptom Development

Four inoculation methods — infiltration, puncturing, mechanical inoculation and atomization — were tested. Thirty-day-old seedlings of Early Calwonder and isolates XVP16, XVP3 and XVP14 were used. Distilled water was used as a control with six replicates for each treatment. Ratings were taken daily for three weeks following the inoculation.

Infiltration. All fully expanded leaves per plant were injected with 10^5 and 10^8 cfu/ml each of the three races. The area near the midrib was punctured through the hypodermis with hypodermic needle. The bacterial suspension was injected in this punctured wound by a 1-ml syringe. Inoculated seedlings were transferred to the screenhouse where temperature and relative humidity ranged from 23.5 to 35°C and 52 to 100%, respectively.

Puncturing. Fine thin pins were dipped in the bacterial suspension (10^8cfu/ml) and then pressed slightly (not passed through the leaf) on the hypodermis of all fully expanded leaves of each plant.

Mechanical inoculation. Test plants were dusted with carborundum (600 mesh). A cotton swab was dipped into the bacterial suspension (10^8cfu/ml) and wiped across the leaf from the bottom margin near the petiole to the leaf tip. After inoculation, the carborundum was washed off the leaves with distilled water.

Atomization. All above ground parts of the test plant were sprayed with bacterial suspension (10^8cfu/ml) using an atomizer at 1.16 kg/cm^2 pressure. The inoculated seedlings were placed in a moist plastic chamber for two days after inoculation and then transferred to the screenhouse.

Effect of inoculum density, inoculum pressure and plant age on disease severity

Inoculum density. Four concentrations, namely, 10^6, 10^7, 10^8 and 5×10^8 cfu/ml of XVP16 (race 1) were tested. Three susceptible pepper varieties, Blue Star, Early Calwonder and Florida VR2 (with BS_1 gene), were used. The 30-day-old seedlings were inoculated with an air brush at 1.5 kg/cm^2. The control seedlings were inoculated with distilled water and there were six replicates for each treatment. The percentage of lesion coverage per plant was investigated 12 days after inoculation.

[11]Kado, C. I., and M. G. Keskett. 1970. Selective media for isolation of Agrobacterium, Corynebacterium, Erwinia, Pseudomonas, and Xanthomonas. Phytopathology, 60, 969-976.

Inoculation pressure. Four inoculation pressures, namely 1.0, 1.5, 2.0 and 3.0 kg/cm^2 adjusted by an air compressor were tested. Varieties Blue Star, Early Calwonder and Florida VR2 were also used. The inoculum, a bacterial suspension of 10^8cfu/ml of XVP16, was sprayed on above ground parts of the 30-day-old seedlings. The control seedlings were sprayed with distilled water. There were six replicates per treatment. The percentage of lesion coverage per plant was determined 14 days after inoculation.

Plant age. Seeds of Blue Star, Florida VR2 and Early Calwonder were sown in clay pots and thinned to one plant per pot. The 30, 50, 71, 81 and 111-day old plants were selected and inoculated at the same time. A bacterial suspension of 10^8 cfu/ml was sprayed with an air brush at 1.5 kg/cm^2 pressure. There were four replicates per treatment. The percentage of lesion coverage was determined 12 days after inoculation.

Results and Discussion

Effect of inoculation methods on symptom development. Early Calwonder could be infected by *Xanthomonas campestris* pv. *vesicatoria* races 1, 2 and 3 with each of the four inoculation methods. All races developed water-soaked lesions although at different times.

On the third day after infiltration, infected leaves exhibited water-soaked spots at the infiltration areas with all XCV races at a 10^8 cfu/ml concentration, then assumed a dehydrated appearance. When leaves were injected with 10^5 cfu/ml, all races caused sparse water-soaked spots within 10-12 days, which then developed into brown spots.

When leaves were punctured with different races of a 10^8 cfu/ml solution, they developed similar symptoms. Water-soaked symptoms appeared on the margins of the punctured areas at the fifth day after inoculation, after which these spots became brown with yellow halos around the infected areas.

Seven days after mechanical inoculation, small water-soaked spots on the infected leaves appeared at the hypodermis; spots then became brown and leaves turned yellow.

On the third day after inoculation by atomization (1.16 kg/cm^2), water-soaked spots appeared on the leaves and became dark brown with yellow halos two weeks after inoculation.

All four inoculation methods caused the disease. However, infiltration caused more damage on the leaves. With too deep punctures, damage on the leaves easily occurred. With mechanical inoculation, leaves turned yellow easily and spots could not continue to develop. However, atomization did not only cause typical symptoms but also could evenly spread the inoculum on the plants tested. Atomization was thus found convenient, time saving and practical for mass resistance screening.

Effect of inoculum density delivered by atomization on disease severity. The disease parameters increased as the inoculum density increased (Table 14). However, the 10^7 cfu/ml caused low disease parameters in all pepper varieties tested. Varieties tested did not significantly differ (at 5% level) in their disease reactions, when inoculated with XCV at 10^8 and 5×10^8 cfu/ml.

Table 14. Effect of inoculum density delivered by atomization on security of bacterial spot on pepper.

Inoculum[z] density	Area per leaf infected (%)[y]		
(cfu/ml)	Blue star	Florida VR2	Early calwonder
5×10^8	14.2 a[x]	19.3 a	17.8 a
10^8	12.5 a	16.4 a	14.7 a
10^7	0.1 b	0.9 b	0.4 b
10^6	0.0 b	0.0 b	0.0 b

[z]Tested plants were inoculated 30 days after sowing by an air brush with 1.5 kg/cm^2 pressure. [y]Measured at 12 days after inoculation. [x]Values followed by the same letter within each column do not differ significantly at 5% level by DMRT.

Effect of inoculum application pressure on disease severity. Increasing inoculation pressures (1.0, 1.5, 2.0 and 3.0 kg/cm^2) through an atomizer did not enhance the disease parameter in Blue Star and Florida VR2 (Table 15). However, the 3.0 kg/cm^2 inoculation pressure caused damage in all pepper varieties tested.

Considering the low disease parameters in Early Calwonder with a 1.0 kg/cm^2 inoculation pressure and to avoid possible harm to the plants tested, 1.5 kg/cm^2 pressure was chosen for the mass resistance screening test.

Effect of plant age on disease severity. Disease severity decreased as the plant attained maturity. Most susceptible plants were 30 days old (Table 16). Therefore, this implied that seedlings before the blossom stage (5-7 true leaves) are most suitable for resistance screening tests.

Conclusion

After plants developed 5-7 true leaves, atomizer inoculation at 1.5 kg/cm^2, using a bacterial suspension of 10^8 cfu/ml is the best condition for artificial inoculation of pepper with bacterial spot.

Table 15. Effect of inoculation pressure on the severity of bacterial spot on pepper.

Inoculation[z] pressure (kg/cm^2)	Infected area per leaf(%)[y]		
	Blue Star	Florida VR2	Early Calwonder
3.0	25.3 A[x]	22.2 A	22.5 A
2.0	17.8 B	20.2 A	19.3 A
1.5	21.8 A	23.2 A	17.5 AB
1.0	23.5 A	21.2 A	11.8 B

[z]Plants were inoculated 30 days after sowing with a bacterial suspension of 10^8cfu/ml. [y]Measured 14 days after inoculation. [x]Values followed by the same letter within each column do not differ significantly at 5% level by DMRT.

Table 16. Effect of plant age on disease severity of bacterial spot in pepper inoculated by atomization.

Inoculation[z] date	Infected area per leaf (%)[y]		
	Blue Star	Florida VR2	Early Calwonder
30	12.5 A[x]	23.3 A	19.0 A
50	12.3 A	14.0 B	10.5 B
70	13.0 A	11.0 C	11.3 B
81	8.3 B	11.8 C	10.0 B
111	11.1 B	2.3 D	1.1 C

[z]Days after sowing to pot. Test plants were inoculated with an airbrush at 1.5 kg/cm^2 pressure using a 10^8cfu/ml bacterial suspension. [y]Measured 12 days after inoculation. [x]Values followed by the same letter within each column do not differ significantly at 5% level by DMRT.

Race Distribution of *Xanthomonas campestris* pv. *vesicatoria* in Taiwan

Summary

Bacterial spot of pepper and tomato, caused by *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye, is one of the most important diseases worldwide. Different races which differ in their pathogenicity on different hosts of pepper have been found. So far, 45 isolates from pepper and tomato have been collected and identified in seven locations in Taiwan. Of these, 27 were identified as race 1, 5 as race 2 and 13 as race 3.

Introduction

Bacterial spot caused by *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye (XCV), is a major problem in pepper (*Capsicum annuum* L.). Different races of the pathogen with different pathogenicities to pepper varieties have been found. *Xanthomonas campestris* pv. *vesicatoria* race 1 is predominant in most pepper production areas worldwide (Cook et al. 1982)[12]. Race 2 is found only in Florida. Race 3 was recently identified in the same place by Hibberd et al. (1987)[13]. This study aimed to identify the races in Taiwan, investigate their distribution and maintain the isolates for further resistance screening.

Materials and Methods

All 45 isolates of XCV were obtained from naturally infected pepper and tomato plants grown in Taichung, Nantou, Yunlin, Tainan, Kaohsiung, Pingtung, Taitung and Hualien in 1988. Six isolates (collected from pepper and tomato fields) originated from Dr. S. T. Hsu (Department of Plant Pathology, National Chung Hsing University, Taichung) and 12 isolates were obtained from pepper fields at the Taiwan Agriculture Research Institute in Taichung.

Inoculum was prepared from bacteria grown on 523 (Kado and Heskeh 1970) at 32°C for 24 hours. Bacterial cells were collected from the plants and diluted with sterilized distilled water to a concentration of 10^8cfu/ml (determined by a spectrophotometer, at 600 nm wave length). The bacterial suspension was injected into the leaves using the infiltration technique described by Hibberd et al. (1987)[2]. One-month old seedlings were used and the three youngest fully expanded leaves below the first fork were infiltrated. Inoculated plants were incubated in a plastic shade house where temperatures ranged from 21 to 32°C.

Race identification was made on *C. annuum* ECW-10R (BS1 gene), Line 3-25-27 (BS2 gene), ECW-30R (BS3 gene) and Early Calwonder (susceptible control) (Table 18). Isolates of XCV that induced a susceptible response in ECW-10R and hypersensitive responses (HR) in both 3-25-27 and ECW-30R were classified as race 1 of the bacterium. Those that induced HR response in both ECW-10R and Line 3-25-27 and a susceptible response in ECW-30R were classified as race 2. Those that only induced HR in Line 3-25-27 were classified as race 3.

Results and Discussion

Races 1, 2 and 3 were found in Taiwan (Table 17). Of the 45 isolates collected, 27 were identified as race 1, 5 as race 2 and 13 as race 3. Based on this preliminary survey, race 1 seems to be dominant in Taiwan.

More XCV isolates from important pepper and tomato production zones need to be collected and identified in future studies.

Table 17. Reaction of *Capsicum* plants possessing 3 different dominant resistance genes to inoculation with 3 races of *Xanthomonas campestris* pv. *vesicatoria*.

Pathogenic race	Reaction type		
	ECW-10R[z] (BS_1)	3-25-27 (BS_2)	ECW-30R (BS_3)
1	S[y]	HR	HR
2	HR	HR	S
3	S	HR	S

[z]Different cultivar name (resistance gene). [y]S: susceptible (virulent reaction); HR: hypersensitive (a virulent reaction).

[12]Cook, A.A., and Stall, R.E. 1982. Distribution of races of *Xanthomonas vesicatoria* pathogenic on pepper. Plant Disease 66:388-389.

[13]Hibberd, A. M., Stall, R. E., and Bassett, M. J. 1987. Different phenotypes associated with incompatible races and resistance genes in bacterial spot disease of pepper. Plant Disease 71:1075-1078.

Screening of Germplasm for Root Knot Nematode Resistance

Summary

Root knot nematode *Meloidogyne incognita* infects pepper worldwide and causes considerable loss in yield. Resistant varieties are not yet available. Screening of germplasm for resistance to *M. incognita* was initiated. Of the 112 accessions screened, 20 were classified as highly resistant, 7 as resistant, 12 as moderately resistant; the remaining ranged from susceptible to highly susceptible. The resistant lines will undergo a second confirmation screening.

Introduction

Root knot nematode (*Meloidogne incognita*) has been reported to be pathogenic to pepper producing symptoms such as yellowing of the leaves, reduced leaf size, shortened petioles, stunted plant growth, shortening of roots, etc. Resistant varieties are not yet available. The screening of germplasm for resistance to *M. incognita* was initiated.

Materials and Methods

One hundred and twelve Capsicum accessions randomly selected from GRSU collection were screened. Three seeds of each accession were sown in 5-cm diameter plastic pots, containing 150g autoclaved potting mixture (soil:compost:sand 1:1:1). The experiment was conducted in the greenhouse in six replications. Pots were arranged in flats. Ten-day old seedlings were thinned to one per pot and inoculated with 1000 freshly hatched juveniles of *M. incognita* per pot. The inoculum was obtained from a pure culture maintained on tomato, which had previously been collected from infected pepper. Plants were treated with Hoagland's solution and water as required. At 40 days after inoculation, the number of galls and egg masses per plant were recorded. Roots were rated for galling on a scale of 1 to 5, and the resistance levels were categorized as follows:

1 = no galls, no egg masses - highly resistant (HR)
2 = 1 to 10 galls and/or egg masses - resistant (R)
3 = 11 to 30 galls etc. - moderately resistant (MR)
4 = 31 to 100 galls etc. - susceptible (S)
5 = 101+ galls etc. - highly susceptible (HS)

Results and Discussion

Disease reactions among the 112 accessions varied markedly and ranged from highly resistant to highly susceptible (Table 18). Twenty accessions were classified as highly resistant namely C 104A, C466, C474, C476, C490, C543, C550, C551, C561, C563, C573, C574, C584, C585, C590, C602, C1171, C1173, C1175, C1176; seven as resistant, 12 as moderately resistant, and the remaining accessions ranged from susceptible to highly susceptible. The resistant lines will undergo confirmation screening.

Table 18. Reaction of selected pepper germplasm to artificial inoculation by *M. incognita*.

Disease reaction	No. of accessions	%
HR	20	(17.7)
R	7	(6.2)
MR	12	(10.6)
S	26	(23.0)
HS	48	(42.5)

Pepper Physiology

Evaluation of Generative Characteristics of *Capsicum*

Summary

Forty-eight sweet pepper and 40 hot pepper lines were investigated for generative characteristics and fruit set under hot summer conditions. Results showed that most *Capsicum* plants are relatively tolerant to high temperature in terms of generative characteristics and fruit set. However, both *Capsicum* types were sensitive to soil temperatures exceeding 30°C.

Introduction

The shedding of floral buds, flowers, and partially developed fruits in *Capsicum* plants is a general phenomenon. Reports claim that the yield is seriously reduced in the hot season. The cause of this shedding under high temperature conditions is not well understood in *Capsicum* plants. This study aimed to investigate the generative characteristics related to yield and yield components in hot and sweet pepper.

Materials and Methods

Seeds of 40 hot peppers and 48 sweet peppers were sown on 25 April 1988. Seedlings of hot and sweet pepper were transplanted to the field on 3 and 6 June 1988, respectively. Plots were arranged in a randomized complete block design with three replicates. Each plot was composed of 30 plants. One plant from each replicate was randomly tagged. The flowers and fruits were counted two times a week. At four and eight weeks from transplanting, 20 newly-open flowers of each replicate were randomly sampled and investigated for number of corolla lobes, percentage of style exsertion, length of exserted style, and fresh and dry weights of ovary. Mature fruits of each replicate were investigated for the number of fruit per plant, average fruit size, number of seeds per fruit, and fresh and dry weights of fruits. Yield, yield component, and other growth and quality characteristics were also investigated. Mean maximum and minimum temperatures during the study were 31°C and 24°C, respectively.

Results and Discussion

Soil temperature at 10-cm depth within the row differed between east and west rows of the same bed due to mulching of silver polyethylene cloth and rice straw in the field. Soil temperature in the east row was about 3-4°C higher than the west row, because the east slope of raised bed received more solar radiation than the west slope. Both hot and sweet peppers were sensitive to this increased soil temperature in the east row. Plant heights of both Capsicums in the east row were about 87% of the west row (Table 1). The decrease in plant height evoked by the increase in soil temperature ranged from no reduction to 24% reduction for hot pepper, and no reduction to 20% for sweet pepper. Polyethylene may be beneficial in controlling weeds.

In hot pepper, ovary dry weight or number of seeds was positively correlated to individual fruit weight. A similar trend was also observed between number of seeds and fruit weight of sweet pepper. On the other hand, the ovary of sweet pepper was significantly larger than that of hot pepper (Table 2). These results suggested that potential fruit size of *Capsicum* plants may be determined by the size of ovary at flowering stage, and the number of ovules fertilized. Most flowers of both hot and sweet peppers exserted their style, which was relatively short, the longest about 3.2 mm under high temperature conditions in this planting season. In terms of fruitset, hot pepper produced more flowers and set more fruits than sweet pepper. Furthermore, fruits of both Capsicums had seeds. This suggested that Capsicums, in contrast to tomato, can produce viable pollens and ovule under high temperature conditions.

Table 1. Differences in plant height and soil temperature between east and west rows for 40 hot and 48 sweet peppers measured at 25 days after transplanting.

Observation		East	West
Plant height (cm)			
Hot pepper	Mean	25.7	29.8**[z]
	Range	15.4-31.4	19.2-38.5
Sweet pepper	Mean	37.9	44.0***
	Range	16.9-52.3	18.5-58.4
Soil temperature (°C)	Mean	35.5	32.5**
	Range	35.5-36.0	31.5-32.5

[z]Significant difference by t-test at 1% (**) and 0.1% (***) levels.

Table 2. Means and ranges of generative characteristics of 40 hot and 48 sweet peppers grown in the hot season.

Characteristics	Hot Pepper		Sweet Pepper	
	Mean	Range	Mean	Range
No. of flowers/plant	142	54 - 337	45	16 - 108
No. of petals/flower	5.6	5.1 - 6.1	6.2	4.5 - 6.7
Length of exserted style (mm)	1.9	0.8 - 3.2	1.3	0.7 - 2.4
Flowers with exserted style (%)	88	45 - 100	75	18 - 95
100-ovary dry wt. (mg)	179	55 - 337	773	262 - 1,271
Total fruit no./plant	64	23 - 332	14	3 - 39
Total fruit set (%)	71	8 - 100	41	12 - 86
Marketable fruit no./plant	17	1 - 50	10	0 - 29
Fruit fresh wt. (g)/fruit	5.1	1.6 - 21.0	26.4	9.7 - 72.8
No. of seeds/fruit	24	4 - 61	41	18 - 69

Water Uptake, Growth and Fruit-set of Pepper

Summary

Capsicum plants were grown in three distinct seasons. Water uptake, distribution of dry matter, and fruit-set were observed during 120 days of growing period. High temperature reduced fruit-set and caused less dry matter directed to the fruits but more to the stems. No apparent difference was found in water use efficiency between hot and sweet pepper. However, pepper grown in the hot season utilized more water.

Introduction

Water use and dry matter production are interrelated. Both are dependent upon the amount of radiant energy and the ambient temperature.

Not much is known about water uptake or water requirement of *Capsicum* plants as related to growth and yield under different temperature conditions. The purpose of this study was to examine the relationship between water usage and growth of sweet pepper and hot pepper grown during hot and cool seasons of the year.

Materials and Methods

Seedlings of sweet pepper (Blue Star) and hot pepper (Szechuan) were transplanted to wooden boxes underlaid with PVF strip, as a water carrier on 27 March, 14 August, and 22 December 1987. Plants were grown in the greenhouse, and water uptake was recorded daily. Mean maximum/minimum temperatures during the 120-day growing period were 34.3-23.5°C (March), 32.4/20.6°C (August), and 27.4-15.0°C (December). Four plants, randomly sampled from three replicates at 30, 60, 90 and 120 days after transplanting were measured for dry matter, leaf area, number of fruits, and yield. Four plants from each replicate were investigated for fruitset percentage twice a week.

Results and Discussion

Leaf area ratio (LAR) expresses the ratio between leaf area and total dry matter. Both *Capsicum* types had lower LARs when they were grown under high temperatures in March (Figure 1). This suggested that high temperature is detrimental to leaf development. LARs of both *Capsicum* types also decreased with advancing growth stages, and sweet pepper tended to have a higher LAR than hot pepper. On the contrary, both *Capsicum* types had high net assimilation rate (NAR) in the March planting, and sweet pepper tended to have a lower NAR than hot pepper (Fig. 2). These results indicated that high temperature reduced leaf development but increased high photosynthetic potential. Both *Capsicum* plants had low NAR's when they were grown under decreasing temperature conditions. The higher total dry matter production in hot than in sweet pepper (Fig. 3) could be due to a higher NAR in hot pepper, whereas low total dry matter of sweet pepper could be due to low NAR under decreasing temperature conditions.

Capsicums required more water to produce unit dry matter under high temperature conditions than low temperature conditions. More water was transpired by hot pepper than sweet pepper (Table 3).

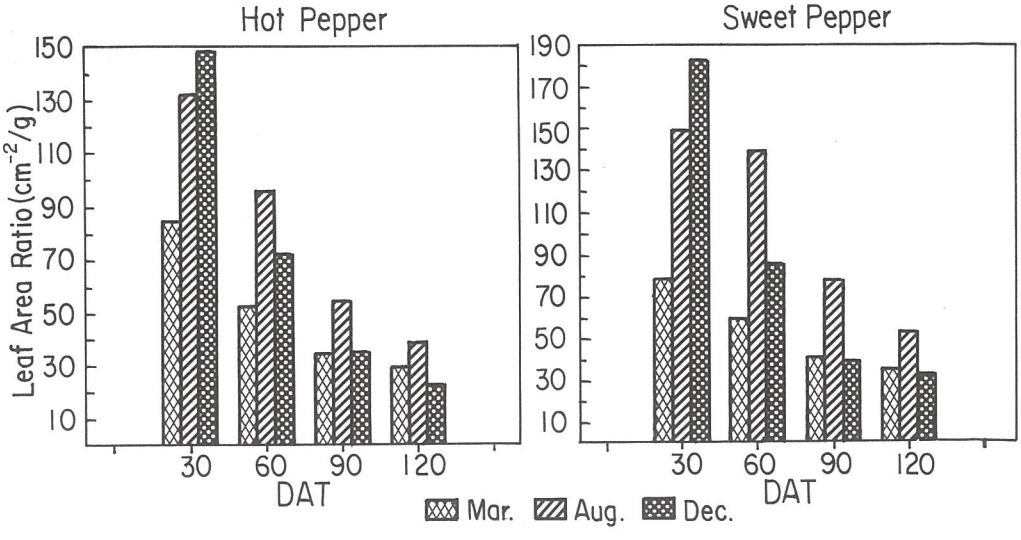

Fig. 1. Changes in leaf area ratio of *Capsicum* plants grown in three seasons.

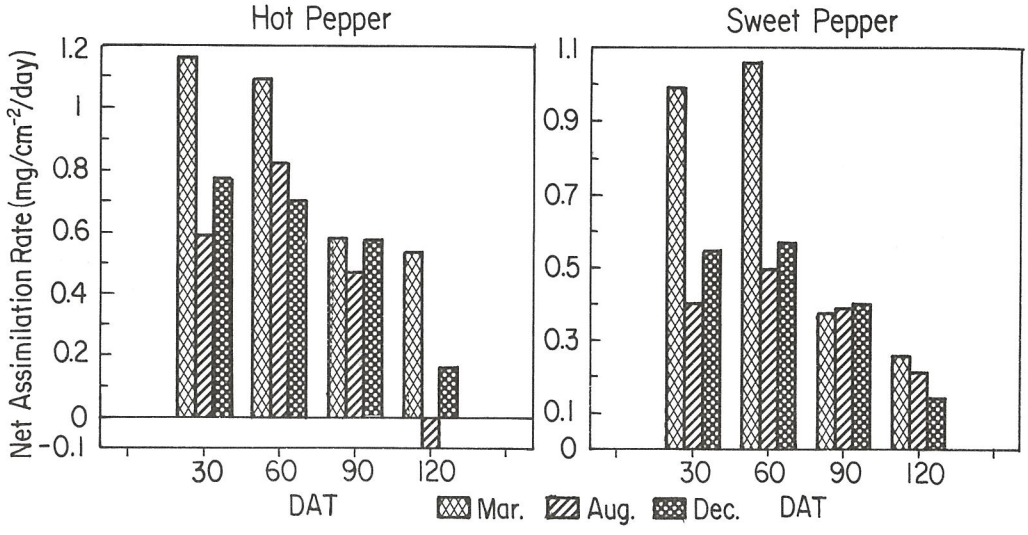

Fig. 2. Changes in net assimilation rate of *Capsicum* plants grown in three seasons.

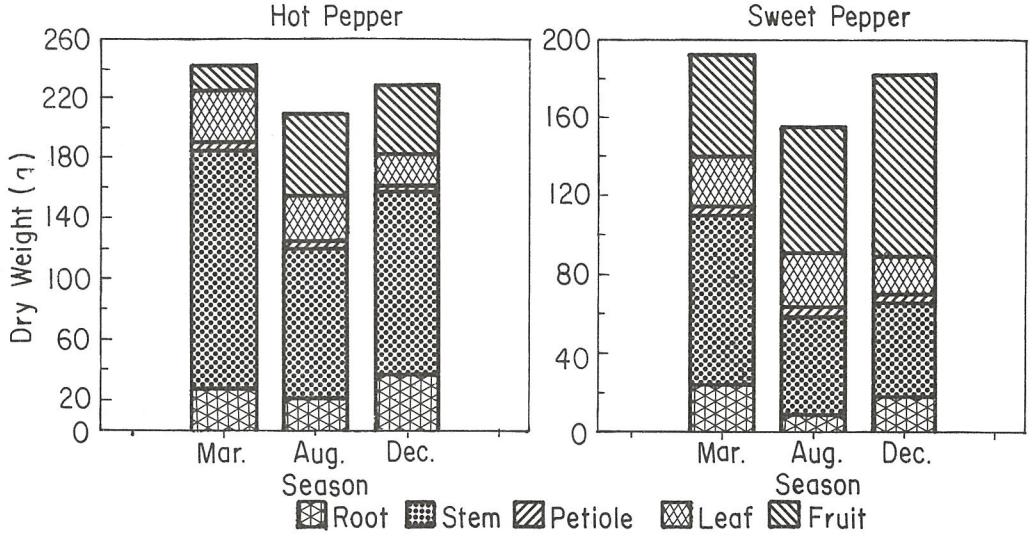

Fig. 3. Total dry matter and dry matter partition of *Capsicum* plants after 120 days in three seasons.

Table 3. Fruit yield, yield components, seed number and water consumption of *Capsicum* plants grown in three seasons.

Pepper type	Planting	Market. fruit yield (g/plant)	Market. fruit no. (/plant)	Fruit wt. (g/fruit)	Seed no. (/fruit)	Water use (l/plant)
Hot	March	120 b[z]	36 b	3.3 b	16	85 a
	Aug.	398 a	87 a	4.6 a	20	57 b
	Dec.	369 a	77 a	4.9 a	15	60 b
Sweet	March	627 b	12	52.5 c	62	73 a
	Aug.	819 b	10	80.5 b	62	39 b
	Dec.	1,467 a	13	115.9 a	70	50 b

[z]Means separation within column of same pepper type by DMRT at 5% level.

Both *Capsicum* types started to set fruit after 30 days in three plantings. Hot pepper produced more flowers than sweet pepper, and both Capsicums produced more flowers under high temperatures in March than in the other two plantings. Both Capsicums had least fruit-set rates in March, and hot pepper had a higher fruit-set rate than sweet pepper. Even though fruit-set of both Capsicums was low in March, they still produced fruits under high temperatures (Table 3). The number of seeds per fruit of both *Capsicum* plants did not differ significantly among plantings. These results clearly indicated that both *Capsicum* types carried certain levels of heat tolerance, as expressed by the ability of plants to produce abundant flowers with viable pollens and ovules to compensate for reduced fruit-set caused by high temperature.

Fruit development is important in bringing a significant change in sink load. The presence of fruits did not alter the total accumulation of dry matter in this experiment. Instead the development of generative organs, i.e. fruit-set and development, altered partitioning of dry matter between the vegetative and generative parts (Fig. 3). Poor fruit-set and development under high temperature conditions reduced the strength of fruit sink, causing the stem to take up a steadily increasing part of the dry weight. High temperature resulted in less fruits in hot pepper and small fruits in sweet pepper. On the other hand, high K accumulation by pepper under low temperature conditions in December (Fig. 4) may facilitate translocation to the generative parts of the plants.

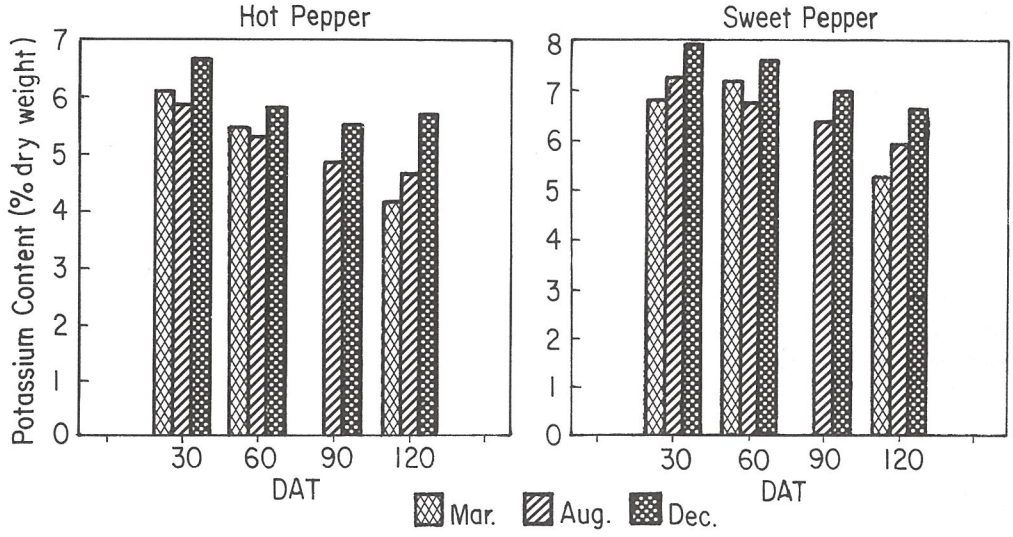

Fig. 4. Changes in leaf potassium content of *Capsicum* plants grown in three seasons.

Physiological Responses of Pepper to Flooding Stress

Summary

Flooding for three days greatly reduced shoot growth of *Capsicum* plants, much more in sweet pepper than in hot pepper. Flooding also reduced fruit yield as it affected both floral development and plant growth. Flooding increased activity of cellulase in the basal stem, and alcohol dehydrogenase and nitrate reductase in the fibrous root. Lesser activities of cellulase and nitrate reductase but greater alcohol dehydrogenase functions occurred in hot pepper after flooding.

Introduction

Capsicum is particularly sensitive to soil inundation. Information concerning the physiological response of this genus to such stress is largely unavailable. The present study was conducted to

evaluate some of the physiological responses of sweet pepper and hot pepper plants to short term flooding, especially biochemical processes associated with soil anaerobiosis and post-flooding recovery in terms of growth and yield.

Materials and Methods

Seeds of sweet pepper Blue Star and hot pepper Passion were first sown in seedling flats. Seedlings were later transplanted to PVC pots (30 cm × 35 cm) with one plant/pot on 17 June 1988 and grown in the greenhouse. Five treatments consisted of (1) well-watered control without flooding, (2) flooding to 1-2 cm above soil surface for one day at three or six weeks after transplanting, and 3) flooding to 1-2 cm above soil surface for three days at three or six weeks after transplanting. Plants of each investigation from various treatments were randomly assigned in three replications, each composed of two plants. Means (and ranges) of maximum and minimum temperatures (°C) during the experiment were 35.1 (31.4-37.8) and 23.7 (21.8-25.4), respectively.

The activities of cellulase in the basal stem, and alcohol dehydrogenase (ADH) and nitrate reductase (NR) in the fibrous root were determined, one week after flooding. Growth parameters of plant height, leaf count and leaf area, and chlorophyll and NPK contents in the petiole of middle canopy were investigated. At 16 weeks after transplanting, vegetative growth parameters and reproductive growth parameters such as days to anthesis, fruit-set rate, number of fruits, fruit size and number of seeds were also investigated.

Results and Discussion

Flooding of *Capsicum* plants at three or six weeks after transplanting for three days increased the activities of cellulase in the basal stem measured at one week after flooding, but with less cellulase activities in hot pepper (Figure 5). No apparent increased activities were measured immediately after flooding for one or three days at three or six weeks after transplanting, nor at one week after flooding for one day at three or six weeks after transplanting. Flooding induces formation of lysigenous aerenchyma which facilitates air carriage from the aerial parts to the root system under anaerobic conditions. Therefore, elevated cellulase activities in the basal stem effected by flooding would subsequently lead to aerenchyma development for plants to survive under flooding conditions. However, the lysigenous process of the basal stem would also contribute to the weakening of stem,

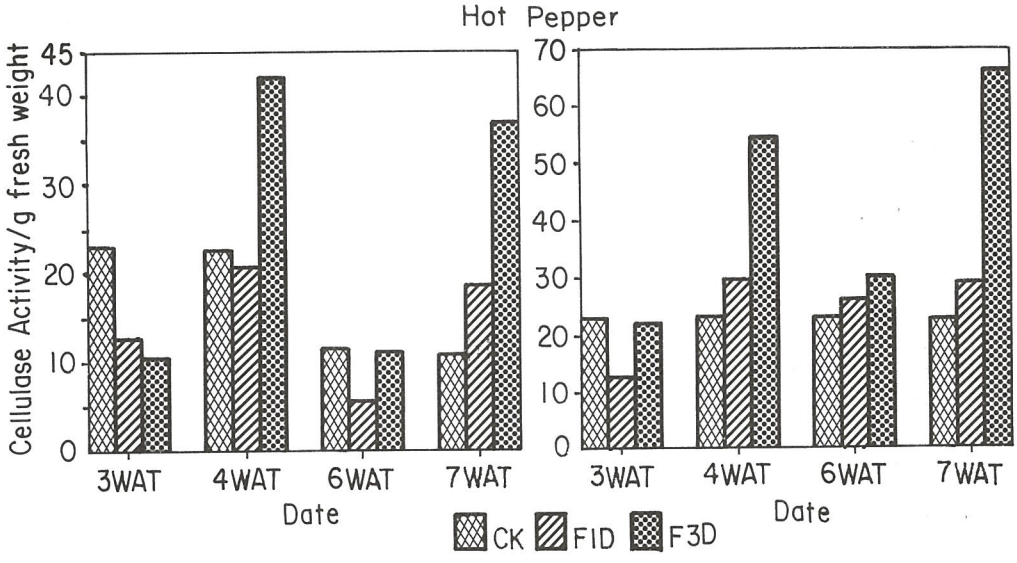

Fig. 5. Effect of one or three-day flooding at three or six weeks after transplanting (WAT) on cellulase activities in the basal stem of *Capsicum* plants.

and consequently cause lodging. It is possible that survival of plants after flooding was due to less cellulase activity in hot pepper.

Flooding also increased ADH activity in the fibrous root of both Capsicums. Greater increase of ADH activity occurred at six weeks after transplanting (Fig. 6). Flooding-tolerant plants usually exhibited increased ADH activity in the root. Therefore, it is possible that greater increases in ADH activity in the root system particularly in older plants of hot pepper contributed to its flooding tolerance. However, the relationship between flooding tolerance and increased ADH activity requires further investigation.

Further analysis of NR in the fibrous root system indicated that flooding increased its activity, especially with long days of flooding after transplanting (Fig. 7). A large increase of nitrite was

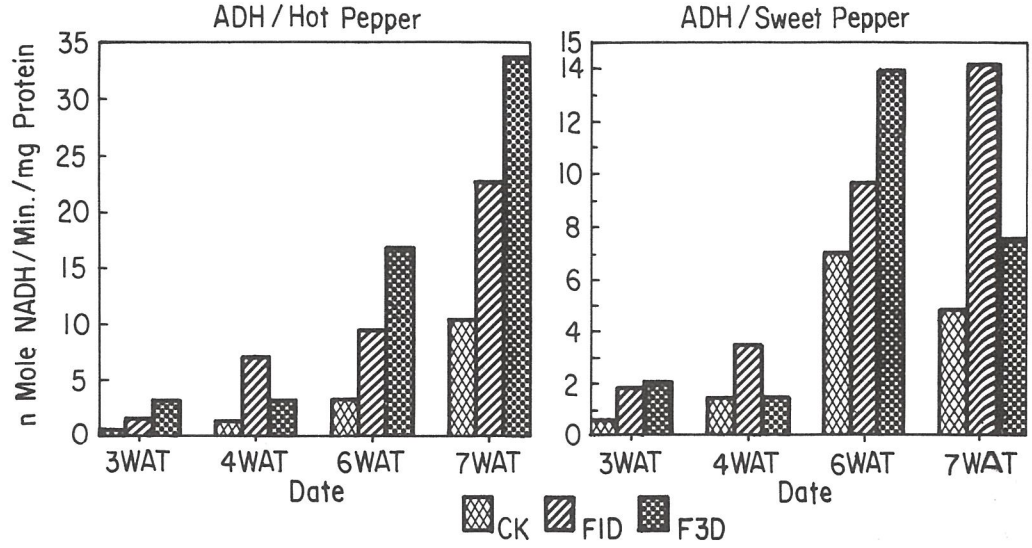

Fig. 6. Effect of one or three-day flooding at three or six weeks after transplanting (WAT) on ADH activities in the fibrous root system of *Capsicum* plants.

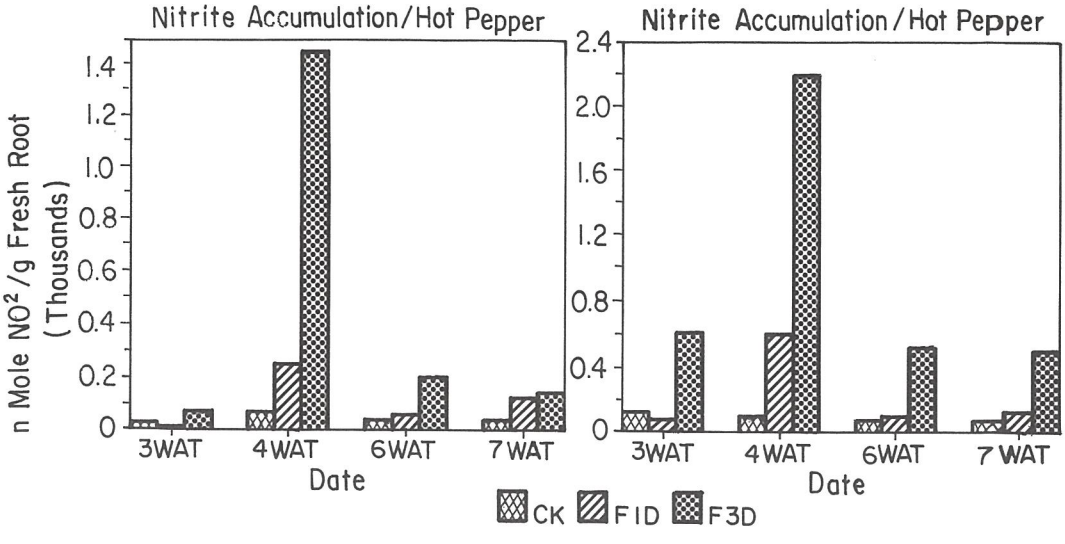

Fig. 7. Effect of one or three-day flooding at three or six weeks after transplanting (WAT) on NR activities in the fibrous root system of *Capsicum* plants.

observed in both *Capsicum* plants at one week after three days of flooding imposed at three weeks after transplanting. It is suggested that nitrate in the root can serve as an electron acceptor and alleviate the stress under anaerobic conditions. Therefore, the increased NR activities in *Capsicum* plants in response to flooding may enable the plants to resist anaerobic stress by the reduction of nitrate, especially at early plant growth. In this connection, it would be worthwhile to examine in the future whether the enhanced nitrate fertilization immediately after flooding can reduce the magnitude of damage. Increased NR activities may cause less ADH activities of the root system in the same stage of plant growth; high NR activities of sweet pepper would reduce ADH activities (Fig. 6).

There was no significant difference in chlorophyll content of the leaf after flooding. However, substantial reductions of leaf area, leaf count, plant height and total dry weight of *Capsicum* plants occurred after flooding (Table 4). Greatest reductions occurred in *Capsicum* plants exposed to three-day flooding in three or six weeks after transplanting. Of the 12 sweet pepper plants, none survived after flooding. There were no significant differences in chlorophyll and NPK content in the leaf at harvest (Table 5). On the other hand, lack of recovery in leaf area and total dry weight after flooding despite maintaining comparable chlorophyll and NPK content in the leaf implied that the carbon-fixation system might have been permanently damaged even by a short flooding period.

Flooding for three days at three or six weeks after transplanting substantially reduced the number of flowers and consequently the number of fruits (Table 6). There was also a slight reduction in fruit size but not in the number of seeds per fruit. These results suggested that a significant effect of flooding on the photosynthetic capacity of *Capsicum* plants could unfavorably alter flower development. However, how flooding stress experienced in the root system is transmitted to influence the photosynthetic capacity in the leaf requires further investigation.

Table 4. Effect of flooding at three or six weeks after transplanting on growth of *Capsicum* plants.

Treatment		Leaf area (dm^2)	Leaf no. (/plant)	Plant height (cm)	Total dry wt. (g/plant)
Hot Pepper					
Control		112 a[z]	1141 b	130 b	352 a
3 WAT	1 D	83 b	1078 c	116 b	227 b
	3 D	62 bc	610 d	94 c	81 c
6 WAT	1 D	119 a	1495 a	151 a	376 a
	3 D	46 c	477 d	141 a	79 c
Sweet Pepper					
Control		120 a	571 b	117	247 a
3 WAT	1 D	109 c	609 a	112	189 b
	3 D	–	–	–	–
6 WAT	1 D	117 b	516 c	116	215 ab
	3 D	–	–	–	–

[z]Mean separation within column of same entry by DMRT at 5% probability level.

Table 5. Effect of flooding on chlorophyll (mg/dm^2) and NPK content (%) in the leaf of *Capsicum* plants at three or six weeks after transplanting (WAT).

Treatment		Chlorophyll	N	P	K
Hot Pepper					
Control		5.90	1.46	0.43	8.03
3 WAT	1 D	4.90	2.32	0.49	8.99
	3 D	6.87	2.51	0.56	10.82
6 WAT	1 D	5.58	2.18	0.49	8.53
	3 D	6.32	1.63	0.37	9.34
Sweet Pepper					
Control		6.48	2.18	0.70	9.50 b[z]
3 WAT	1 D	6.32	2.48	0.71	10.40 a
	3 D	–	–	–	
6 WAT	1 D	5.97	2.69	0.57	10.82 a
	3 D	–	–	–	–

[z]Mean separation within column of same type by DMRT at 5% probability level.

Table 6. Effect of flooding at three or six weeks after transplanting on yield and yield components of *Capsicum* plants.

Treatment	Flower no. (/plant)	Fruit no. (/plant)		Seed no. (/fruit)	Harvest index (%)	Fruit size (g/fruit)
		Marketable	Total			
Hot Pepper						
Control	676 a	132 a[z]	297 a	49	53 a	10.3
3 WAT 1 D	330 ab	79 ab	150 c	47	47 b	10.8
3 D	60 b	16 b	58 d	67	25 d	9.0
6 WAT 1 D	667 a	124 a	276 b	49	46 c	9.5
3 D	314 ab	59 b	86 d	24	66 a	7.6
Sweet Pepper						
Control	200 a	16 a	47 a	56	34 c	63.1 a
3 WAT 1 D	215 a	12 b	43 ab	39	30 e	62.2 b
3 D	5 b	–	–	–	–	–
6 WAT 1 D	152 a	15 ab	35 ab	31	33 d	59.2 c
3 D	25 b	–	–	–	–	–

[z]Mean separation within columns of same type by DMRT at 5% probability level.

Growth Analysis and Distribution of Dry Matter in Pepper under Three Spacings

Summary

Hot and sweet pepper plants were grown in three spacings under hot summer conditions to evaluate growth and yield. There is a potential difference in the dry matter production between hot and sweet pepper. Hot pepper accumulated more dry matter, a large amount of which was diverted to the fruit. Close spacing at 30 × 50 cm^2 produced more dry matter and fruit yield per unit land area.

Introduction

To attain maximum harvest in *Capsicum* types, important consideration is given to maximum dry matter production and the desirable balance between the supply and use of assimilates. Maximum dry matter production depends on the plant's photosynthetic potential, and environmental conditions and canopy structures. The generation of desirable balance between the supply and use of assimilates requires a reduced competition for assimilates by other plant parts and/or the increased sink strength of fruit. This study aimed to examine the maximum dry matter production and the relationship between vegetative parts and generative development of hot pepper and sweet pepper plants and to assess the effect of spacings on dry matter production and distribution.

Materials and Methods

Seeds of sweet pepper Blue Star and hot pepper Passion were sown in seedling flats on 20 May 1988. Seedlings were transplanted to the field on 17 June 1988. Mean maximum and minimum temperatures during the study were 31.1°C and 24.2°C, respectively.

Plots were arranged in a randomized complete block design with four replications. Inter-row spacing was 50 cm, and intra-row spacings were 30, 45 and 60 cm. Three plants from each replicate were randomly sampled at 3, 6, 9, 12 and 15 weeks after transplanting, and were separated into root, stem, leaves and fruits. Leaf area, plant height, and fresh and dry weights of plant parts were measured. Total dry weight and relative distribution between plant parts were determined. NPK and chlorophyll content in petiole were analyzed. The data on light penetration by the canopy was recorded every two weeks. The number of flower and fruits was investigated twice a week. Growth analytical parameters such as leaf area index (LAI), crop growth rate (CGR), net assimilation rate (NAR), relative growth rate (RGR), leaf area ratio (LAR), and fruit-setting rate were calculated.

Results and Discussion

On a single plant basis, the accumulated dry matter in hot pepper differed significantly among three spacings. Plants from both 60 × 50 cm^2 spacings had higher dry matter than plants from 30 × 50 and 45 × 50 cm^2 spacings (Fig. 8). Plants from sparse spacing tended to have more branches and showed an increased dry matter in the stem. After flowering, a significant amount of growth was recorded in the fruits, more than 40% dry matter at 15 weeks after transplanting.

CGR in hot pepper significantly differed at various growth stages among three spacings. Close spacing at 30 × 50 cm^2 had higher CGR than the other two sparse spacings (Fig. 9). This could be attributed to high LAI (Fig. 10). Hot pepper plants in sparse spacings at 45 × 50 cm^2 and 60 × 50 cm^2 tended to have slightly high photosynthetic potential (NAR) due to excess light source for photosynthetic process within the canopy. However, this increased NAR was not enough to compensate for the low LAI as a result of sparse spacing.

In contrast, sweet pepper plants at 30 × 50 cm^2 tended to accumulate more dry matter on a single plant basis (Fig. 8). Only about 20-30% of dry matter was accounted for in the fruit at 15 weeks after transplanting. On community basis, CGR in sweet pepper also tended to be higher in close spacing at 30 × 50 cm^2 than other spacings at early stages (Fig. 9). CGR of sweet pepper declined at six weeks after transplanting due to excess rainfall of 418 mm on 13 August. Survival rate of sweet pepper plants right after flooding was generally lower (42-74%) than hot pepper (more than 90%) among three spacings. Sparse spacing at 60 × 50 cm^2 tended to have a lower survival rate than close spacing. This was probably due to high soil temperature right after flooding resulting from ready exposure of soil to solar radiation. The accumulated dry matter and CGR in sweet pepper plants was lower than in hot pepper plants due to low LAI and NAR in the former. High shoot/root ratio at nine weeks after transplanting clearly indicated the damage in the root system caused by flooding. However, hot pepper plants tended to readily recover from flooding.

Hot pepper plants from sparse spacings tended to have more flowers and fruits. However, this trend was not conspicuous in sweet pepper. Hot pepper had more flowers and fruits, and higher fruit-set rate than sweet pepper at 15 weeks after transplanting. In terms of fruit yield per unit land basis, hot pepper in close spacing had the largest yield mainly due to higher number of fruits (Table 7). The trend was also observed in sweet pepper. The number of seeds in fruit was not influenced by spacing.

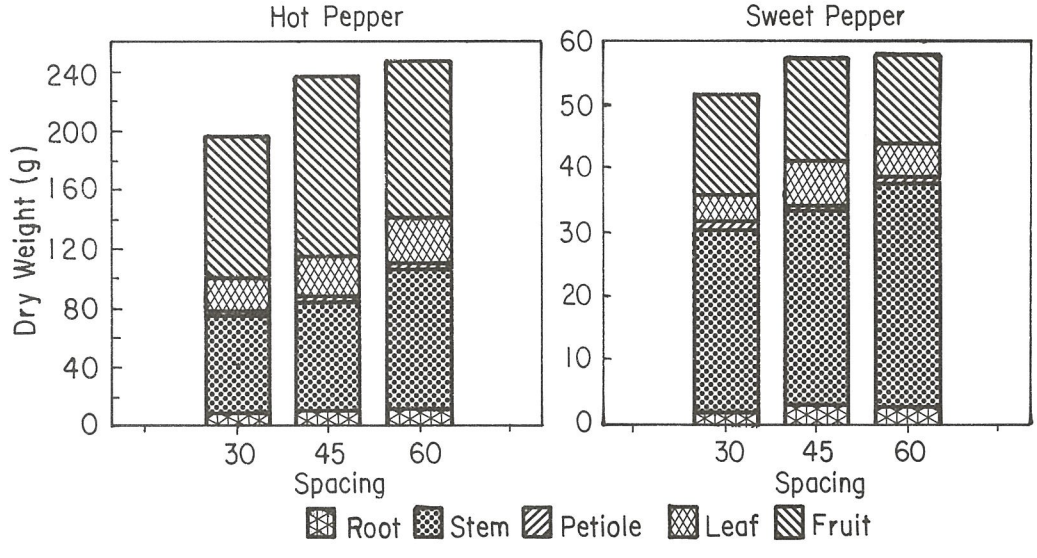

Fig. 8. Total dry matter and dry matter distribution in hot and sweet peppers grown under three spacings.

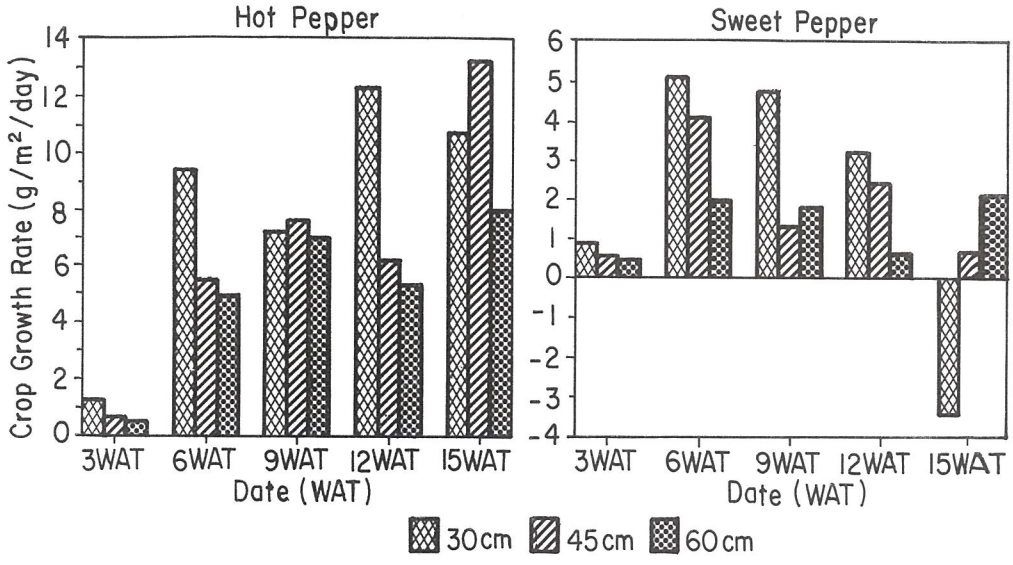

Fig. 9. Crop growth rates (g/m^2/day) of hot and sweet peppers grown under three spacings.

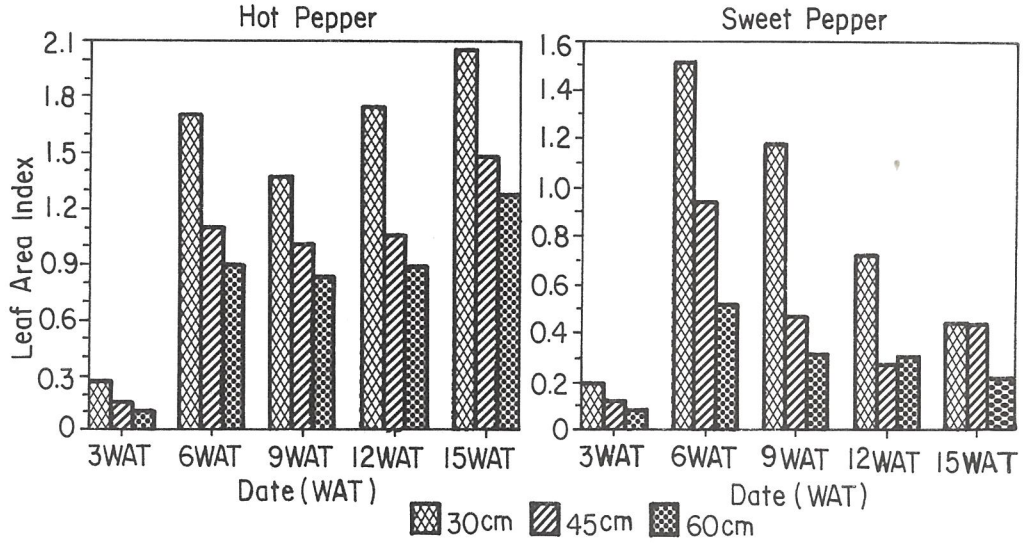

Fig. 10. Leaf area index of hot and sweet peppers grown under three spacings.

Table 7. Yield and yield components of *Capsicum* plants grown under three spacings.

Pepper	Intrarow spacing (cm)	Fruit yield (kg/m^2)		Fruit no. (/plant)	Fruit size (g/fruit)
		Marketable	Total		
Hot	30	3.5 a[z]	4.1 a	107 b	8.9
	45	3.0 ab	3.6 ab	139 ab	8.2
	60	2.3 b	2.7 b	148 a	5.6
Sweet	30	1.3	1.6	10	26.8
	45	0.8	0.9	8	15.8
	60	0.5	0.5	5	25.0

[z]Mean separation within column of same species by DMRT at 5% probability level.

As far as NPK content in the petiole is concerned, N content in hot and sweet peppers tended to decrease as the plants grew. The slight increase in N content at nine weeks after transplanting could be due to flooding. Phosphorus content, on the other hand, tended to increase plant growth for both hot and sweet peppers. Heavy rainfall could furnish more available phosphorus in the soil. Potassium content of hot and sweet peppers started to decrease at six weeks after transplanting. This may be an indication of high demand of potassium during fruit development or the leakage of soil potassium due to heavy rainfall. No great difference of NPK content in the petiole appeared among treatments; however, hot pepper plants at close spacing of 30 × 50 cm^2 tended to have more N and P contents in the petiole.

In conclusion, there is potential difference in dry matter production between hot pepper and sweet pepper. There was a constant partition in the dry matter of vegetative and fruit parts; more dry matter was accumulated in the fruit of hot pepper than sweet pepper. Close spacing at 30 × 50 cm^2 produced more dry matter and fruit per unit land area. The root system of both hot and sweet peppers was sensitive to flooding, but hot pepper readily recovered after flooding. Further investigations of the physiological aspects of root-top interactions under flooding or high soil temperature conditions, and source-sink relationships between vegetative and generative parts in *Capsicum* plants could give important information about how the source-sink relationship under stressed conditions can be manipulated for high yield potential.

Soybean Breeding

Hybridization

Summary

Efforts on backcrossing and modified backcrossing were continued to develop productive, good quality vegetable soybean. Crosses were also made to combine multiple disease resistance characters. Backcrosses and intercrosses between selected progenies were undertaken to develop soybean rust tolerance. Specific crosses were made to incorporate lx_1 or lx_1 and lx_2 genes into highly productive multiple disease resistant genotypes.

Introduction

Improved vegetable and grain type tropical soybean with multiple disease resistance, high yield and good seed quality were the goals of the crossing program. The lipoxygenase-2 free gene has been reported to eliminate or considerably reduce the beany flavor in soybean. Therefore, crosses were attempted to introduce lx_2 gene into varieties from national programs to eliminate beany flavor.

Materials and Methods

Almost 90% of the parents used in the crosses were F_1s, selections from F_2, F_3 or later generations or breeding lines developed at AVRDC. Some accessions used included large-seeded varieties like Tanbaguro (70g for 100 seeds), G 9650 (Emerald), G 10134 (Ryokkoh); glabrous gene types such as AGS 80, G 10137, D 62-7815, G 2030; lipoxygenase null genes such as G 6133, L 2-3; and rust-resistant accessions like PI 459025.

For modified backcrossing of vegetable soybean crosses Tanbaguro and Emerald were used as the recurrent parents to obtain large seed size.

Results and Discussion

A total of 118 crosses, of which 58 were either backcrosses or modified backcrosses were made. Selected progenies from the vegetable soybean crosses will undergo further backcrossing to large-seeded type depending upon the need.

Since glabrous pods may be more attractive and appealing to the consumer, crosses were made to introduce the glabrous gene into the vegetable soybean background. Advantages and disadvantages of having the glabrous gene in vegetable soybean will be explored further.

The second and third backcross to AGS129 was made and the development of lx_1 isogenic line of AGS 129 is ongoing.

Intercrossing of selected high yielding lines with highly rust-tolerant lines was made. The F_1s from these had been intercrossed for two or three cycles and the selection will be initiated in the subsequent population for soybean rust tolerance.

Yield Trials

Summary

Results of PYT-I, II and IYT-I, II with selected pedigrees and accessions during three seasons and AYT-I and II during summer are highlighted in this report. Genotype 269 was consistently superior in 1987 as well as 1988. Significantly higher yields than the check AGS 129 with a combination of multiple disease resistance had been incorporated in the improved selections. Diverse sources of resistance to bacterial pustule had also been identified. Resistance of all selected entries will be reconfirmed in 1989.

Introduction

Breeding lines selected from different generations were evaluated in different stages for yield and other desirable traits. Preliminary (PYT), intermediate (IYT) and advanced yield trials (AYT) were conducted in three seasons to compare with improved checks so that high yielding, agronomically desirable genotypes can be identified. AYT is discussed under breeding for rust resistance. Vegetable soybean trials are discussed under breeding vegetable soybean. Only the PYT, IYT and AYT (summer) of the grain type are discussed in this section.

Materials and Methods

Details of the trials are given in Table 1. Plot size for both PYT and IYT were 2 m x 3 m. Data on yield, other agronomic traits and disease ratings were collected and analyzed. Selection of genotypes for the next stage of the trial was based on yield, resistance or tolerance to diseases, days to maturity, seed quality and adaptation to specific seasons or multiple seasons. AVRDC's recommended cultural practices were used.

Table 1. Planting dates and experimental designs for AYT, IYT and PYT, 1988.

Experiment	No. of entries plus (checks)	Design (replication)	Date of planting
AYT-I	11 (3)	Split plot (4)	9 February 1988
AYT-II	12 (2)	Split plot (4)	9 February 1988
AYT-I	11 (3)	RCBD	12 July 12 1988
AYT-II	12 (2)	RCBD	26 July 1988
IYT-I	30 (2)	RCBD	10 February 1988
IYT-II	29 (2)	RCBD	10 February 1988
IYT-I	30 (2)	RCBD	12 July 1988
IYT-II	29 (2)	RCBD	12 July 1988
PYT-I	47 (2)	7 × 7 lattice	10 February 1988
PYT-II	47 (2)	7 × 7 lattice	10 February 1988
PYT-I	47 (2)	7 × 7 lattice	12 July 1988
PYT-II	47 (2)	7 × 7 lattice	12 July 1988

Results and Discussion

In PYT-I spring and summer, none of the selections was different in yield compared to the check AGS 129. However, some lines with different genetic background had as good yield (Table 2) and similar level of bacterial pustule resistance as AGS 129, and possibly, downy mildew resistance (needs to be verified) unlike the susceptible AGS 129.

In PYT-II spring, GC 84012-20-7 (Shinsei × PI 248407) × (Shih Shih × PI 230971) yielded 5.0 t/ha which was significantly higher than the check AGS 129 with 3.4 t/ha. However, the selection was 19 days later maturing than AGS 129. Furthermore, during summer, it was not as good as AGS 129 and was susceptible to bacterial pustule (Table 3). Therefore, it has to be crossed to incorporate bacterial pustule resistance.

Out of 30 selected accessions evaluated in IYT-1, 10 entries were either moderately or highly resistant to bacterial pustule. They are GC 81027-16-1 (HR), 311-14C, D 59-2537, PI 417569, Geduld #7, GC 81075-13, PI 407767 (HR), PI 417564, PI 399045 and D 64-8707. These will be evaluated again in 1989. Although none of them was superior in yield to AGS 129 either in spring (Table 4) or summer (Table 5), three entries were resistant to downy mildew and bacterial pustule and tolerant to soybean rust. They are GC 81027-16-1, GC 82347-60-1 and PI 417563 (Table 5). These will be evaluated again for disease resistance in 1989.

Table 2. Genotypes selected for high yield in PYT-I spring and summer, 1988.

Entry	Yield (t/ha)		Days to maturity		100-seed weight (g)		BPR[z]
	SP	SU	SP	SU	SP	SU	
GC 82252-6-6-1	4.3	3.2	120	96	19.2	12.6	MS
GC 84007-9-5-1	4.2	3.4	119	100	12.7	11.7	MR
GC 82161-6-6-1	4.1	3.2	117	100	22.0	14.3	MR
GC 82180-18-6-1	3.7	3.0	109	96	20.4	14.0	MR
GC 82346-36-7-1	3.6	3.6	114	96	25.7	20.8	
GC 84012-24-4-1	3.6	2.7	104	96	20.8	16.9	
AGS 129 (check)	4.2	4.1	113	96	19.2	15.5	MR
AGS 302 (check)	3.2	1.6	109	100	23.5	22.1	HS
LSD (0.05)	**0.98**	**0.62**					

[z]Bacterial pustule rating.

Table 3. Genotypes selected for high yield in PYT-II spring and summer, 1988.

Entry	Yield (t/ha)		Days to maturity		100-seed weight (g)		BPR
	SP	SU	SP	SU	SP	SU	
GC 84012-20-7	4.9	3.7	130	102	19.5	13.6	HS
GC 84007-20-6	4.4	2.5	124	96	10.9	9.7	MS
GC 84010-14-2	4.1	3.0	107	86	14.1	11.8	HS
GC 82355-16-7	4.1	2.5	116	96	19.7	13.9	MS
GC 82334-7-8 NL	4.1	3.7	128	106	18.1	15.4	MR
GC 82034-9-10 NL	3.9	3.3	114	96	14.7	11.4	MS
AGS 302 (check)	3.9	1.4	106	100	23.4	20.8	MS
AGS 129 (check)	3.4	3.5	111	96	18.4	14.3	MR
LSD (0.05)	**1.1**	**0.9**					

Table 4. Selections from IYT-I in spring, 1988.

Entry	Yield (t/ha)	Days to maturity	100-seed weight (g)	BPR
G 12179	4.4	112	19.7	
GC 82347-60-1	4.2	109	24	MR
311-14C	4.1	110	18.4	MR
GC 82345-20-2	4.0	101	20.4	MS
AGS 129 (check)	3.9	112	18.3	MR
AGS 302 (check)	3.6	108	22.9	HS
Mean of 32 entries	**3.5**	**104.6**	**18.2**	
LSD (0.05)	**0.69**	**4.81**	**1.71**	

Table 5. Selections from IYT-I in summer, 1988.

Entry	Yield (t/ha)	Days to maturity	100-seed weight (g)	Diseases		
				Downy mildew	Bacterial pustule	Rust
311-14C	4.3	87	16.3	HS	MR	T
GC 81027-16-1	4.1	91	13.4	R	R	T
GC 82347-60-1	4.1	91	20.5	R	MR	T
PI 417563	3.9	98	12.7	R	R	T
GC 81075-13	3.9	96	16.9	HS	R	T
AGS 129 (check)	4.2	91	17.0	HS	R	T
AGS 302 (check)	1.9	98	21.7	R	MS	T
Means of 32 entries	**3.4**	**91.4**	**16.1**			
LSD (0.05)	**0.89**	**7.57**	**1.43**			

In IYT-II during spring, GC 82334-29-5 significantly yielded higher than AGS 129, although it was moderately susceptible to bacterial pustule. GC 82349-6-1 also yielded significantly higher in both spring and summer seasons and showed resistance to downy mildew and bacterial pustule (Tables 6 and 7) and tolerance to soybean rust (Table 7). Three entries had multiple disease resistance.

Of the 29 entries evaluated, 11 were moderately or highly resistant to bacterial pustule and will be confirmed in 1989. They are GC 82344-29-2, GC 82344-29-5, G 12342, GC 82841-14-2, Welkom, GC 81038-18-3, Gujarat soybean-1, Durga, D 71-9966, GC 882349-6-1 and Gaurav.

Among the advanced yield trial entries, #269 (a selection from the Land O'Lakes material) yielded significantly higher than AGS 129. It also exhibited resistance to all three diseases (Table 8). Four selections combined resistance to all three diseases, with yields comparable to AGS 129. The introduction from Thailand, OCB, was high yielding and matured in 81 days (10 and 20 days earlier than AGS 129 and AGS 302, respectively) but it was susceptible to downy mildew (Table 8).

Five selections significantly outyielded the check AGS 129 and did not show any downy mildew symptoms. In summer, they appeared to be distinctly superior than the checks (Table 9).

Table 6. Selections from IYT-II in spring, 1988.

Entry	Yield (t/ha)	Days to maturity	100-seed weight (g)
GC 82334-29-5[z]	4.6	115	13.9
GC 82349-6-1	4.5	120	22.0
GC 82355-8-3	4.1	121	19.8
GC 82350-18-2	4.1	114	19.1
AGS 129 (check)	3.7	110	17.6
AGS 302 (check)	3.1	110	21.3
Mean of 31 entries	**3.5**	**115**	**19.2**
LSD (0.05)	**0.82**	**4.44**	**1.53**

[z]Moderately susceptible to BP.

Table 7. Selections from IYT-II in summer, 1988.

Entry	Yield (t/ha)	Days to maturity	100-seed weight (g)	Diseases		
				Downy mildew	Bacterial pustule	Rust[z]
GC 82349-6-1	4.2	102	21.1	R	R	T
Gaurav	4.1	102	13.9	MS	R	T
GC 82335-35-3	4.0	102	15.2	R	R	T
Khsb-2	3.9	106	13.9	R	R	T
Gujarat Soybean-1	3.9	102	12.9	HS	R	T
AGS 129 (check)	3.3	97	16.5	HS	R	T
AGS 302 (check)	2.1	103	22.2	R	MS	T
Means of 31 entries	**3.3**	**101**	**17.3**			
LSD (0.05)	**0.84**	**3**	**1.6**			

[z]During spring as well.

Table 8. Five high yielding lines selected from AYT-I in July planting, 1988.

Entry	Yield (t/ha)	Days to maturity	100-seed weight (g)	Diseases		
				Rust	Downy mildew	Bacterial pustule
269	3.4	89	18.8	R	R	R
SRE-D-14B	3.2	99	23.8	MR	HR	MR
SRE-D-14A	3.0	112	36.8	HR	R	HR
GC 82146-43-9-9	2.8	88	18.2	R	R	MR
SRE-B-15C	2.7	91	17.6	R	R	MR
OCB (check)	3.3	81	20.1	MS	MS	R
AGS 129 (check)	2.8	91	16.3	R	HS	R
AGS 302 (check)	1.5	100	23.2	R	R	MS
Means of 14 entries	**2.7**	**93.7**	**19.0**			
LSD (0.05)	0.59	4.86	1.38			

Table 9. Five high yielding lines selected from advanced yield trial II in July planting, 1988.

Entry	Yield (t/ha)	Days to maturity	100-seed weight (g)	Diseases	
				Downy mildew	Bacterial pustule
GC 00062-107-6	3.4	102	16.4	–	HR
GC 00062-31	3.3	98	19.2	–	HR
GC 00097-56-6	3.2	99	20.7	–	HR
GC 81090-48	3.2	102	18.8	–	HR
GC 81083-42	3.2	100	17.4	MS	MR
AGS 129 (check)	2.8	101	16.9	MS	MR
AGS 302 (check)	1.8	102	23.3	–	MS
Mean of 14 entries	**2.9**	**100**	**18.2**		
LSD (0.05)	**0.23**	**3.33**	**1.02**		

– No disease observed.

Breeding Vegetable Soybean

Summary

There are no available vegetable soybean varieties adapted to the tropics and subtropics yet. Those that are tropically adapted were developed at AVRDC by crossing vegetable soybean adapted to temperate regions with tropical grain types. New breeding lines GC 83011-35, GC 84136-P-4-1-8 and GC 83005-9 appeared to be adapted to three seasons at AVRDC with a mean yield potential (graded pod) of 5.9, 5.6 and 5.5 t/ha respectively. Variation in yield was attributed mainly to season (31%) and G × E interaction (46%). However, variation due to genotypes was predominant in 100-seed weight (56%). From the preliminary yield trial 52 selections had 100-seed weight (dry) of 35 g or more. These will be evaluated in IYT in 1989. DAIS Kaohsiung in Taiwan and FCRC, Chiang Mai in Thailand collaborated on breeding vegetable soybean. Among the 14 AVRDC accessions evaluated in 10 locations in Thailand, Yoshida1, PI 85658, Vesoy #4, Kanrich, 7016 (ck) and NS #1 (ck) were found superior. A major portion of variation in yield (79%) was due to location. Variation due to genotype was only 6.3%. Therefore, selection of site, season and management practices play a major role in increasing the yield of vegetable soybean. The rainy season is better than the dry season for growing vegetable soybean in Thailand. Of the 48 breeding lines, 15 selections were chosen for further evaluation in 1989 at Chiang Mai, Thailand.

Introduction

Soybean is consumed as a vegetable in many tropical countries where suitable varieties are available. Specific vegetable soybean varieties are currently unavailable. Thus, breeding efforts at AVRDC are geared towards examining the possibility of selecting suitable vegetable soybean varieties for the tropics and subtropics.

Materials and Methods

In an advanced generation trial in AVRDC, seven F_2 and two BC_1F_1 populations were planted on 25 February 1988. All F_2 populations were from crosses involving either AGS 292 or G 10134 (vegetable type) with tropically adapted grain types. The BC_1F_1s are crosses between AGS 292 and AGS 129 backcrossed to AGS 292 to recover large seed size and vegetable soybean characters, but selection will be made for narrow leaf as well. Narrow leaf is associated with three- or four-seeded pods.

Modified backcross was also used. In such instances, the F_1 was backcrossed to G 10134 (Ryokkoh), or G 9650 (Emerald) or G 9053 (Tzurunoko). G 9053, G 10134 and AGS 292 were planted as checks for comparison. For the F_2 population, SSD and pedigree methods were used. Pedigree selection was based on visual observation of the pods and seeds per pod in relation to the check varieties. Pedigrees were selected from BC_1F_1s for further backcrossing.

SSD and pedigrees in spring were planted in a 5 × 1 m row on 26 July 1988. Pedigree selections were made for large pod and seed. Out of 120 pedigrees, 23 were selected. Breeding lines with AGS 129 background appeared to develop anthocyanin pigment on the green pod.

A preliminary yield trial and an advanced yield trial were conducted in AVRDC. Details are given in Table 10. Data on horticultural characteristics were collected and analyzed.

Six BC_1F_3 pedigrees and four BC_1F_3 bulk populations were planted in Pingtung, Taiwan to make the selections for that specific location and share the selection for evaluation with Kaohsiung DAIS. Selections were based on pod and seed size in relation to the check varieties.

In Thailand, with the help of Mr. Anek Chotiyarnwong, vegetable soybean accessions (Trial A), selected AVRDC breeding lines (preliminary yield trial-Trial B) and 20 vegetable soybean accessions (Trial C) were evaluated. Details about the trials are shown in Table 11.

Vegetable soybean accessions were evaluated (Trial A) in five locations, each during rainy and dry seasons. Fourteen accessions and two local checks were used. At Chiang Mai, 20 accessions were evaluated separately during the dry season. For PYT, 48 breeding lines were evaluated along with local varieties NS #1 and 7016 during the dry and rainy seasons. Trial A was planted in 3 × 4.4 m^2 plots. The spacing between rows was 50 cm and within the row, 20 cm with two plants/hill. The harvest plot size was 2 × 4 m^2. An N:P:K fertilizer mixture 12-24-12 was applied at the rate of 150 kg/ha.

Trial B, PYT VS, had a plot size of 3 × 5 m^2 and harvest plot size of 2 × 4 m^2. The same spacing was used as in the rainy season, with two plants/hill; during the dry season there were three plants/hill. All other management practices were similar to Trial A.

Trial C at Chiang Mai during the dry season followed the same management as Trial B.

All trials followed the RCBD. Data were collected on 18 different horticultural characteristics. Only preliminary analysis of selected data are presented in this report.

Table 10. Number of entries, experimental design and planting date for vegetable soybean yield trials, 1988.

Experiment	No. of entries plus checks	Design (replication)	Date of planting
AYT VS	12 (3)	RCBD	24 February 1988
	12 (3)	RCBD	25 July 1988
	12 (3)	RCBD	25 August 1988
PYT VS	97 (3)	RCBD	24 February 1988

Harvested plot size for AYT was 5 m^2. Five plant-sample was used for data collection in PYT.

Table 11. Season, location and date of planting of vegetable soybean in Thailand, 1987-1988.[z]

Season	Location	Planting date
Rainy	Chiang Mai FCRC	21 July 1987
Rainy	Phraputtabat FCES	14 July 1987
Rainy	Khamphaengsaen (Kasetsart University)	3 June 1987
Rainy	Mahasarakarm FCES	22 June 1987
Rainy	Sakolnakorn FCES	21 August 1987
Rainy	Chiang Mai FCRC (PYT VS)	July 1987
Dry	Chiang Mai FCRC	December 1987
Dry	Phitsanuloke FCES	
Dry	Suphanburi	
Dry	Sakolnakorn FCES	
Dry	Kalasin FCES	
Dry	Chiang Mai FCRC (20 accessions)	December 1987
Dry	Chiang Mai FCRC (PYT VS)	December 1987

Cooperator: Mr. Anek Chotiyarnwong.

Results and Discussion

Although pedigrees have been selected from the F_2 generation at AVRDC, the seed and pod size of the selections were not comparable to the vegetable soybean types. Therefore, one backcross to

the vegetable soybean was required. However, if one of the parent's seed size was smaller than 20 g, it appeared that two or more backcrosses to the vegetable type would hasten the recovery of vegetable soybean characteristics. In the future, sieving the seeds of progenies to select large-seeded types will be attempted from different crosses and the efficiency and type of breeding method that will hasten the development of vegetable types will be studied.

Although narrow leaflet is expected to enhance the percentage of two- or more-seeded pods, direct sunlight produces the undesirable anthocyanin pigments on the pod. Such a problem is especially serious with crosses involving the narrow leaflet parent, AGS129. Some narrow leaflet Korean lines have large leaves which may be more desirable than small narrow leaf types.

Since many selections do not have sufficiently large pod and seed, although they appear to be productive, they have been crossed with one of the desirable vegetable types. Selections from the succeeding inbreeding generation are expected to have more productive vegetable types. Bravo et al.[1] (1981) showed that the number of F_2 plants needed at 0.10 probability to recover 0.5% frequency of desirable type is 450. As differences in seed size between the two parents increase, the population needed to recover the vegetable type likely also increases. Therefore, backcrossing is a better and more efficient approach than simple inbreeding following crossing.

Among the 12 breeding lines evaluated and compared with the three check varieties in the spring, summer and autumn, GC 83011-25 in summer and GC 83011-35, GC 83005-9, and GC 84136-P-4-1-42 in autumn gave significantly higher yields than the check varieties (Tables 12 and 13). In spring, however, none of the breeding lines was superior in yield to the checks but several were at par with the checks (Table 12).

In 1987 spring and summer, the highest graded pod yield recorded was around 13 t/ha but in 1988 it was only 7.5 t/ha. The environmental conditions in 1988 were in general not so favorable for vegetable soybean.

Table 12. Promising selections from advanced yield trial of vegetable soybean in spring, 1988.

Entry no.	Parents	Graded pod yield (t/ha)	Total pod yield (t/ha)	DM	100-seed weight (g)	Acceptable pods/ 500 g	Harvest index
AGS 292	Selection from Taishoshiroge	7.5 a	11.9	77	74	157	31
G 9053	Tzurunoko	6.9 ab	12.0	82	74	181	26
GC 83006-7	PI 157424 × Ryokkoh	6.8 abc	10.8	84	82	166	27
AGS 294	Imperial	6.3 bcd	10.3	82	77	170	29
GC 84136-P-4-1-8	Ryokkoh × Mikawajima	6.2 bcd	13.0	91	72	178	21
GC 84134-P-9-3-1 -5-1	Ryokkoh × Disoy	6.2 bcde	12.6	86	72	209	22
GC 83006-15	PI 157424 × Ryokkoh	6.0 bcde	10.4	84	76	189	24
G 10134	Ryokkoh	5.7 cdef	12.1	86	81	174	22
LSD 0.05			1.2	1.8	3.1	16.3	

Table 13. Promising selections from AYT of vegetable soybean in summer, 1988.

Entry no.	Parents	Graded pod yield (t/ha)	Total pod yield (t/ha)	DM	100-seed weight (g)	Acceptable pods/ 500 g	Harvest index
GC 83011-25	Vesoy #4 × KS #8	6.4 a	8.6 ab	82	56	254	33
GC 84136-P-4-1-8	Ryokkoh × Mikawajima	5.0 b	7.5 abc	78	69	178	33
GC 84136-P-4-1-42	Ryokkoh × Mikawajima	4.9 b	9.0 a	80	62	211	25
GC 83006-25	PI 157424 × Ryokkoh	4.9 b	8.5 ab	82	79	196	26
GC 83005-9	PI 157424 × KS #8	4.9 b	8.9 a	81	55	276	21
G 9053	Tzurunoko	4.2 bcd	6.2 cd	78	63	222	32
G 10134	Ryokkoh	3.9 bcd	6.6 bcd	72	60	227	26
AGS 292	KS #1	3.3 cde	4.8 d	72	57	209	32
LSD (0.05)				1.3	5.5	13	

[1]Bravo, J.S., W.R. Fehr and S. Rodriguez de Cianzio. 1981. Use of small seeded soybean parents for the improvement of large-seeded cultivars. Crop Science 21:430-431.

The harvest index during autumn was higher than that in summer and spring. The high yielding improved genotypes generally had a high harvest index (Tables 12, 13 and 14). Among the 12 breeding lines, GC 84136-P-4-1-8 had fairly stable graded pod yield (5,607 kg/ha, mean of 3 seasons) and the number of acceptable or graded pods per 500 g also remained at 179 ± 2.3 regardless of the season which is quite acceptable to the vegetable soybean industry.

A combined analysis of data in three seasons revealed that GC 83011-35, GC 84136-P-4-1-8, and GC 83005-9 gave the highest yields with 5.9, 5.6 and 5.5 t/ha graded pod yield, respectively compared to the checks AGS 292 (4.9 t/ha) , G 9053 (5 t/ha), and G 10134 (4.6 t/ha). Variation in graded pod yield attributed to seasons was 31% with 22% due to genotypes and the major portion 47% due to G × E interaction (Table 15). The results suggested the sufficient genotypic variation in selecting suitable ones.

The genotypic variation dominant to 100-seed weight (56%) and the G × E interaction is only 17% while variation due to season is 28% (Table 15). The results indicated that although seasonal change in 100-seed weight is expected there is sufficient genotypic variation in the selection of desired genotype.

The mean 100-seed weight (in three seasons) of GC 83006-25, AGS 293, GC 83006-7 and GC 83006-13 varied from 72 to 74 g and was significantly higher than that of the three check varieties whose 100-seed weight was 63 to 68 g.

Among 100 preliminary yield trial entries, 52 had 100-seed weights above the population mean of 34.7 g (Fig. 1). The highest grain yield recorded in this trial was 3.8 t/ha (100-seed weight was 30 g). Selections will be based on 100-seed weight, pod length and pod width.

A number of pedigrees were selected in cooperation with the Kaohsiung DAIS and given to cooperators in DAIS for further evaluation in Kaohsiung.

Results of analysis in 10 locations in Thailand showed that variation in biological yield as well as pod yield attributed to genotypes was 6%. Major portions of variation in pod yield (79%) and 50% of variation in biological yield are due to environment. Variations due to location are significant compared to those due to seasons (Table 16). Genotype × environment interaction for biological and pod yield are 0.74% and 14%, respectively. There were considerable variations in yields. Results, therefore, suggested that opportunities for growing vegetable soybean depend on careful

Table 14. Promising vegetable soybean selections from AYT in autumn, 1988.

Entry no.	Parents	Graded pod yield (t/ha)	Total pod yield (t/ha)	DM	100-seed weight (g)	Acceptable pods/ 500 g	Harvest index
GC 83011-35	AGS 190 × KS #8	6.9 a	8.7 ab	74	62	260	40
GC 83005-9	PI 157424 × KS #8	6.3 ab	9.7 a	74	50	266	31
GC 84136-P-4-1-42	Ryokkoh × Mikawajima	6.3 ab	9.3 ab	74	59	205	36
GC 84136-P-4-1-8	Ryokkoh × Mikawajima	5.6 bc	9.0 ab	72	65	182	33
GC 83006-25	PI 157424 × Ryokkoh	5.1 cd	8.5 ab	71	65	226	30
G 10134	Ryokkoh	4.1 de	6.6 de	68	64	227	32
G 9053	Tzurunoko	3.9 e	6.0 de	74	66	211	36
AGS 292	KS #1	3.7 e	5.5 e	70	58	195	39
LSD (0.05)				1.2	4.5	14.3	

Table 15. Combined analysis of variance of AYT data on vegetable soybean in spring, summer and autumn, 1988.

Source of variation	Graded pod yield			100-seed weight		
	DF	SS(x 10^6)	MS(x 10^6)	DF	SS	MS
Between seasons (S)	2	77.3371 (31%)	38.6685	2	4112.19 (28%)	2056.09
Between genotypes (G)	14	54.5055 (22%)	3.8924	14	8229.19 (56%)	587.80
G × S	28	115.0392 (47%)	4.1085	28	2464.00 (17%)	88.00
Total	44	246.6882	5.6066	44	14795.38	336.26
R^2		0.7962			0.9447	
CV		18.15			4.83	

selection of site, growing season and proper management practices rather than considering only the variety to be grown.

Based on the preliminary stability data analysis using Finlay and Wilkinson's (1963)[2] regression method, the entries, Yoshida 1, PI 85658, 7016 (check), Nakhonsawan #1, Vesoy #4 and Kanrich had above average yield in most locations (Figs. 2, and 3). Phraputtabat FCES, Chiang Mai FCRC and Kamphaengsan were high yielding locations. In both dry and rainy seasons, Chiang Mai was high yielding across locations.

Before data analysis, Mr. Anek selected Vesoy #4, BPI #4 and PI 85658 for a farmer's field trial in the 1988 rainy season.

Among varieties evaluated, the 100-seed weights of BPI #4, PI 90550 and PI 157442 were above the mean of all the entries and quite stable across locations. PI 243549, PI 90241, Ryokkoh and Tzurunoko also had 100-seed weight above the average in all locations (Figs. 4, 5 and 6).

Among 20 accessions evaluated in the 1987 dry season in Chiang Mai, PI 85658 gave the highest pod yield of 11.9 t/ha, followed by Yoshida 1 and PI 90241 (10 t/ha each). One hundred-seed weight varied from 35 g for NS #1 to 84 g for Ryokkoh with yield of only 7.5 t/ha.

Table 16. Data analysis of vegetable soybean trial in Thailand, 1987-1988.

Source of variation	Biological yield			Pod yield		
	DF	SS(x 10^6)	MS (x 10^6)	DF	SS(x 10^6)	MS(x 10^6)
Between genotypes (G)	15	37.4300 (6%)	2.4953**	15	6.6138 (6%)	0.4409**
Between locations (L)	9	253.8393 (42%)	28.2044**	9	70.7227 (67%)	7.8581**
G x L	131[z]	2.9451 (0.5%)	0.2248	131[z]	12.6201 (12%)	0.0963
		258.1214	1.6653			
Between seasons (S)	1	45.1571 (8%)	45.1571**	1	12.5664 (12%)	12.5664**
G x S	15	1.4783 (0.5%)	0.0986	15	2.3102 (2%)	0.0154
Total	171	598.9712	3.5028	171	104.8332	0.6131

[z]There were four missing values.

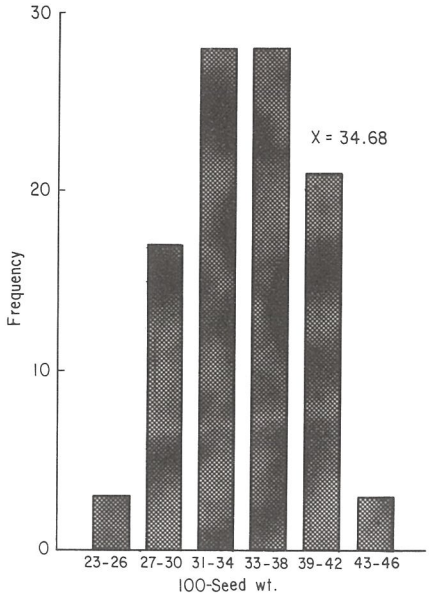

Fig. 1. Frequency distribution for 100-seed weight of vegetable soybean entries in PYT during 1988 spring season.

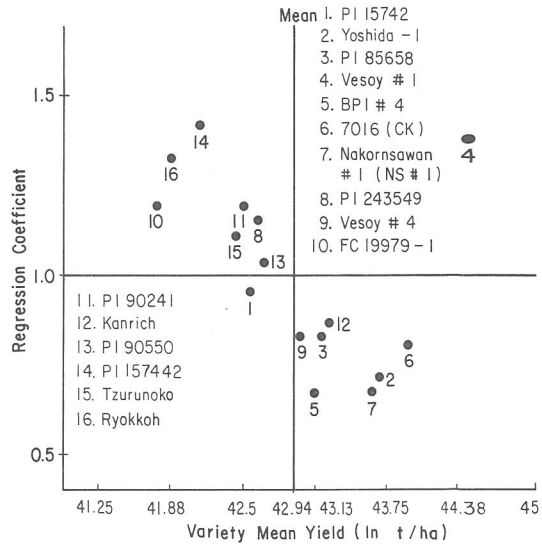

Fig. 2. The relationship of variety adaptation (regression coefficient) and variety mean yield of 16 vegetable soybean varieties grown in 9 different sites in Thailand.

[2]Finlay, K.W. and G.N. Wilkinson. 1963. The analysis of adaptation in a plant breeding programme. Aust. J. Agric. Res. 14:742-754.

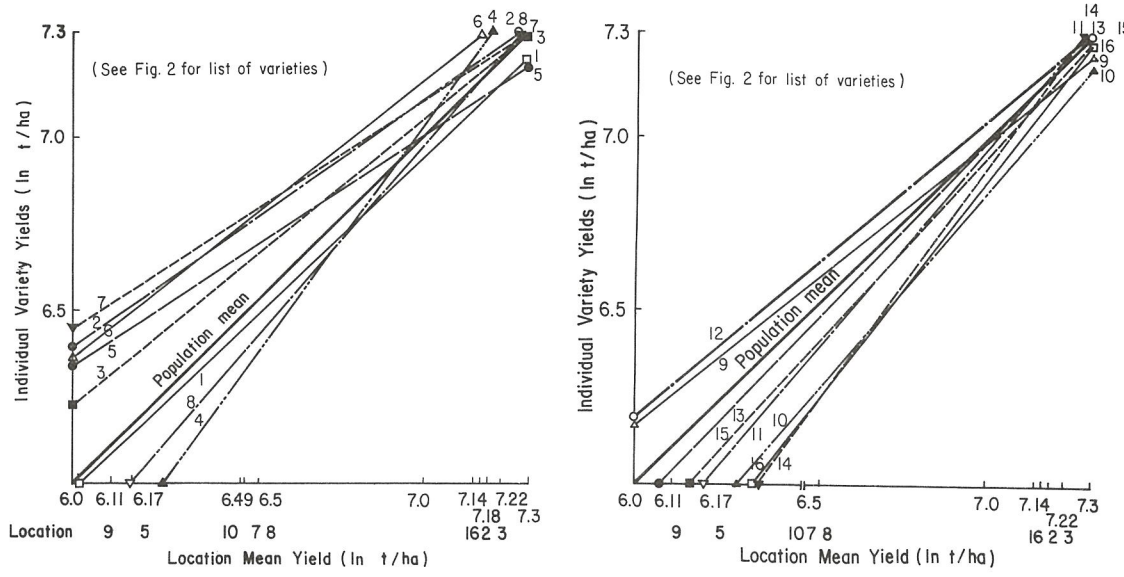

Fig. 3. Regression lines showing the relationship of individual yield and population mean of 16 vegetable soybean varieties grown in 9 sites in Thailand.

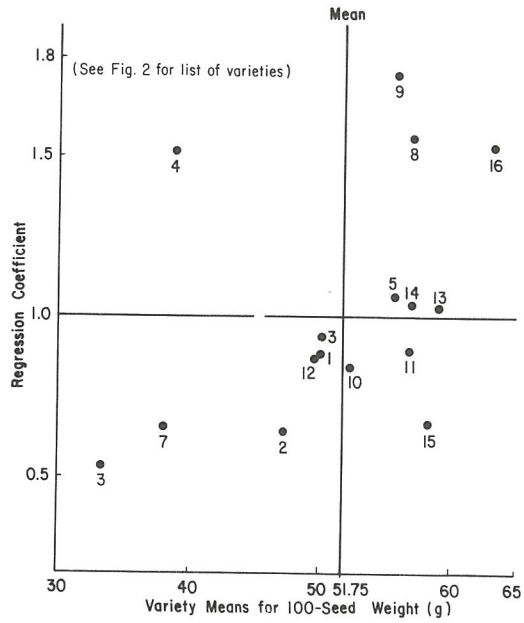

Fig. 4. The relationship of variety adaptation (regression coefficient) and 100-seed weight of 16 vegetable soybean varieties grown in 9 different locations in Thailand.

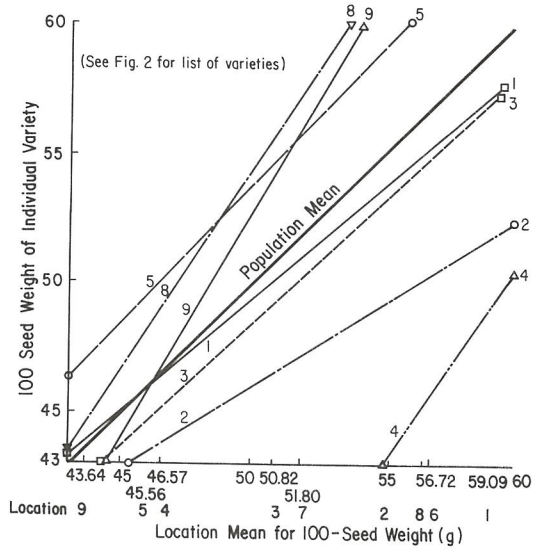

Fig. 5. Regression lines showing the relationship of 100-seed weight of individual entries and population mean of 16 vegetable soybean varieties grown in 9 sites in Thailand.

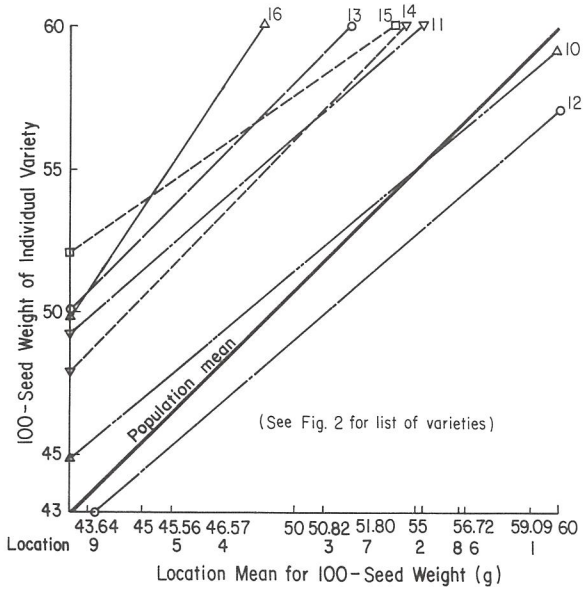

Fig. 6.
Regression lines showing the relationship of 100-seed weight of individual entries and population mean of 16 vegetable soybean varieties grown in 9 sites in Thailand.

Forty-eight selections from two crosses, GC 83005 (17 selections) and GC 83010 (37 selections) were evaluated in a PYT during 1987 rainy and 1988 dry season in Chiang Mai. The two check varieties had only 38 g for 100-seeds (fresh weight). Promising selections from two crosses had a 100-seed weight of 43 to 78 g. A pod yield of up to 12.8 t/ha was obtained (Table 17) in the rainy season in 80 days. Compared to the 100-seed weight of 35 and 39 g for the checks in the dry season, the promising selections had a 100 seed weight of up to 73 g. In the dry season, the selections matured in about 74 to 78 days and pod yield varied from 10 to 10.9 t/ha (Table 18). Both in dry and rainy seasons, the harvest index (HI) was as high as 70% or more. However, since the biological yield included only stem and pod, the HI should be viewed with caution.

Table 17. Data on vegetable soybean PYT during rainy season in Chiang Mai, Thailand, 1987.

Entry no.	Biological[z] yield (t/ha)	Pod yield (t/ha)	100-seed weight (g)	DM	Harvest index
GC 83010-14-2	18.7 a	10.0	78 a	80 a	54
GC 83010-3-13	18.3 ab	12.8 a	54 kl	80 a	70
GC 83010-1-13	17.8 abc	12.1 abc	58 kl	77 b	68
7016 (check)	17.6 abc	11.3 a-f	38 n	77 b	64
GC 83005-13-1	17.4 abcd	10.6 a-f	43 mn	74 c	61
GC 83005-41-9	17.2 a-e	10.0 a-f	62 ij	80 a	58
GC 83005-41-1	17.2 a-e	12.2 ab	52 jkl	80 a	71
GC 83010-B-8	17.4 abcd	12.3 ab	54 jkl	80 a	71
NS #1 (check)	13.9 c-h	10.2 a-f	38 n	67 f	73

[z]Includes stem and pod only. Mean separation by DMRT.

Table 18. Data on vegetable soybean PYT during dry season in Chiang Mai, Thailand, 1988.

Entry no.	Biological[z] yield (t/ha)	Pod yield (t/ha)	100-seed weight (g)	DM	Harvest index
GC 83005-20-B-9	15.2	10.9	64	78	72
GC 83010-15-B-2	14.2	10.4	60	75	73
GC 83005-16-B-12	13.5	10.3	64	78	76
GC 83010-39-1	13.9	10.3	61	75	74
GC 83010-1-B-21	15.2	10.2	66	74	67
GC 83010-1-B-20	15.0	10.1	60	74	67
GC 83005-20-B-36	15.1	10.0	73	78	66
7016 (check)	15.1	10.6	39	75	70
NS #1	8.7	6.4	35	71	74
LSD (0.05)	**2.1**	**1.7**	**6.7**	**NS**	

Labor-saving Tools for Vegetable Soybean

Summary

Cost of production and processing is a major problem for vegetable soybean. Peeling of the pod to shelling the seed from pod is a tedious job. A simple wooden handle with a nail head on one end has been used to allow more efficient shelling of beans.

Presently, pods are stripped from the harvested plant individually. A wooden board with a 'V' slot mounted on a bench has been developed to strip the pods from the whole plant in one operation.

Introduction

In vegetable soybean production, harvesting, stripping the pods from the plant, sorting and shelling the beans from the pods are time-consuming, labor-intensive and expensive operations. Therefore, attempts were made to reduce the labor cost through the development of simple tools using locally available materials.

Materials Needed

The following materials were used: wooden board, 1.5 cm thick and about 40 cm long; wooden bench and a 3-5 cm nail.

Vegetable soybean pod splitting tool. A 12-cm long and 1.5-cm thick round handle was prepared. At one end of the handle, a 3.5-cm flat head nail was driven in. The head of the nail was used to open the pod instead of tedious and painful manual labor. Figure 7 shows the details of the low-cost tool.

Vegetable soybean pod stripping tool. A wooden board, 1.5-cm thick and 36-cm long is cut on either side (Fig. 8). At the middle from the top, the board is cut at a slanting angle of 5 cm depth to form a hopper. From that position a 'V' shaped slot is made to give a 20° angle at another 5 cm depth (Fig. 8). The plants with pods are inserted with the root end towards the operator and the pods and leaves away from the operator and outside the slot. A wooden board is simply placed in front to hold the pods and leaves outside. The operator sitting on a bench pulls the plant through the hole. All pods and leaves are stripped in one operation. The pods and leaves are thrown into a blower, which are then collected separately. A laborer can strip about 250 plants in one hour. Normally with traditional handpicking, he can strip only about 30 to 40 plants/hour.

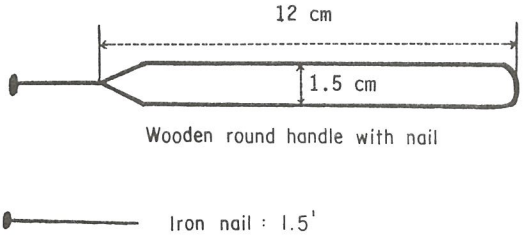

Fig. 7. Vegetable soybean pod splitting tool.

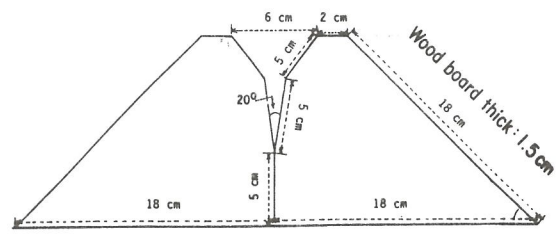

Fig. 8. Vegetable soybean pod stripping tool.

Breeding for Soybean Rust Tolerance

Summary

The F_1 between PI 459025 (a rust resistant accession) and AGS 129 was backcrossed four times to AGS 129 and all progenies from different backcross generations except BC_2 and F_2 and F_3 were evaluated for soybean rust tolerance. Out of 1,439 pedigrees evaluated, 375 were selected based on seed filling, yield and percent rust infection. All selected entries will be evaluated in a replicated trial in 1989. Severe rust infection resulted in plants with empty pods. The frequency of such plants in the inbreeding generation was as high as 10%. Among AYT-1 and AYT-2 entries, SRE-C-56A had the best rust tolerance but not the best yield under favorable environment. But it had a low stable yield of 2.0 t/ha. The tolerance was due to low rust infection consistent across seasons and years. A soybean rust-tolerance index (RTI) was proposed. RTI was defined as the ratio between the yield without fungicide and with fungicide expressed in percent.

Introduction

Soybean rust caused by *Phakopsora pachyrhizi* Syd can reduce yield up to 90%. Four monogenic resistant genotypes were identified and reported (Hartwig 1986)[3]. All were susceptible to Taiwan isolates of the fungus. The strategies used and the progress attained in developing soybean rust tolerant selections are presented in this report.

Materials and Methods

In 1984, the light green seeded PI 459025 from China was identified to be almost immune to soybean rust. At that time AGS 129 was rated as moderately tolerant. Since it was high yielding and resistant to bacterial pustule, it was crossed with PI 459025. The F_2 generation was planted along with the parents during 1987 autumn. The F_1 was also backcrossed up to four times to AGS 129 to recover the desirable characters of AGS 129. Each backcross population was planted in autumn 1987 to compare differences in yield and rust tolerance between different levels of backcrossing. In autumn 1987, selected single plants were harvested from each generation. A plant was selected based on seed filling on the pod, despite severe rust infection, compared to the parents. Rust severity, yield per plant and days to maturity were recorded.

In spring 1988, all progenies from autumn 1987 were planted in 3-m long rows along with the parents and the check varieties TK #5 (susceptible), PI 230970, PI 230971, TN #4 and PI 459025 (resistant/tolerant checks).

In autumn 1987, 57 BC_1F_1, 60 BC_1F_2, 534 F_2, 765 BC_3F_2 and 23 BC_4F_1 plants were selected. The mean yield of each population was determined. They were planted in spring 1988. Selection in spring was based primarily on percent of plants without any or with very few pods, percent of rust infection and seed weight per plant. Mean seed weight per plant for each population was also determined.

Advanced yield trials I and II in autumn 1987 and spring 1988 were conducted using a split plot design in four replicates. The main plots consisted of fungicide treated and nontreated plots, and the sub-plots, the genotypes. Both AYT-I and AYT-II were planted on 9 February 1988.

Both segregating generation plots and the AYTs were inoculated with a rust spore suspension eight times, 22 and 30 March, 5, 7, 11, 13, 26 and 28 April. For the fungicide-treated plots, Dithane M-45 was sprayed on 23, 30 March, 8, 28 April and on 12 May. Bayleton was sprayed to protect the plants from rust.

Results and Discussion

A varying number of selections were made in different backcross generations and in the F_2. Selection differential for yield per plant was highest in BC_1F_1 but the number of selections was low; 15% of the plants were selected (Table 19).

[3]Hartwig, E.E. 1986. Identification of a fourth major gene conferring resistance to soybean rust. Crop Science. 26(6):1135-1136.

The mean percent rust infection in selected plants was generally low except for BC_4F_1 which was almost similar to that of the original population (Table 20).

Similarly, the percent of plants with empty pods was considerably reduced in all selected populations except the BC_1F_1 generation (Table 21). Further selection in BC_1F_1 generation would rectify this discrepancy.

The mean yield of selections from those planted in spring was generally higher than that of the original population from which they were obtained (Table 22).

All selected entries will be evaluated in a replicated trial in 1989 to compare the performance of the selection from different generations.

In the F_2 and various backcross generations there were plants without pods or pods without seeds due to severe rust infection. It appeared that a population of selected plants had the ability to produce pods and fill them properly with seeds.

In subsequent generations, the plants without pods and those without seed will be investigated against rust infection.

In AYT-1, SRE-D-14B was highly tolerant to rust infection and had high yield potential (Table 23).

From AYT-2, GC 00062-107-6 exhibited high yield potential with 45% rust in the treatment without fungicide (Table 24).

The differences in yield between fungicide-treated and nontreated plants and genotype × fungicide treatment interaction were significant during autumn and spring 1987 respectively. AGS 129 and G 9947-21-9 in AYT-1 and SRE-C-56A, AGS 129 and SRE-D-14 B in AYT-2 appeared to be the most tolerant to rust (Figs. 9, 10). SRE-C-56A also had high yield in both fungicide-treated and nontreated plants.

Table 19. Variation in mean yield per plant of selections from different generations in soybean rust resistant crosses in autumn, 1987.

Cross no.	No. of selections	Mean yield of selections	Population		Selection differential
			Mean	Count	
GC 86002 (BC_1F_1)	9	19.7 ± 4.1	11.6 ± 5.2	57.0	8.1
GC 87001 (BC_4F_1)	5	13.6 ± 2.2	11.2 ± 3.7	23.0	2.4
GC 86059 (BC_1F_2)	12	15.4 ± 3.4	11.7 ± 4.8	60.0	3.7
GC 86001 (F_2)	135	13.9 ± 3.7	10.0 ± 4.2	534.0	3.9
GC 86004 (BC_3F_2)	114	12.6 ± 2.9	9.1 ± 3.4	765.0	3.5

Table 20. Variation in percent rust of selections from different generations in soybean rust resistant crosses in spring, 1988.

Cross no.	No. of selection	Mean % rust in selections	Total no.	Population		Selection differential
				Mean	Count	
GC 86002	9	47.8 ± 5.8	57	51.8 ± 7.6	19.0	-4.0
GC 87001	5	51.0 ± 3.7	23	50.5 ± 3.3	11.0	0.5
GC 86059	12	49.6 ± 6.6	60	51.1 ± 6.0	27.0	-1.5
GC 86001	135	47.4 ± 7.2	534	48.1 ± 7.3	246.0	-0.7
GC 86004	114	44.2 ± 5.8	765	46.6 ± 6.1	323.0	-2.4

Table 21. Variation in percent empty pod of selections from different generations in soybean rust resistant crosses in spring, 1988.

Cross no.	No. of selection	Mean % rust in selections	Total no.	Population		Selection differential
				Mean	Count	
GC 86002	9	10.1 ± 13.2	57	9.4 ± 20.7	19.0	0.7
GC 87001	5	8.6 ± 9.3	23	30.6 ± 26.5	11.0	-22.0
GC 86059	12	8.6 ± 9.5	60	23.0 ± 22.0	27.0	-14.4
GC 86001	135	11.1 ± 12.7	534	20.7 ± 19.5	246.0	-9.6
GC 86004	114	5.0 ± 7.6	765	16.3 ± 18.6	323.0	-11.3

Table 22. Variation in mean yield per plant of selections from different generations in soybean rust resistant crosses in spring, 1988.

Cross no.	No. of selection	Mean % rust in selections	Total no.	Population		Selection differential
				Mean	Count	
GC 86002	9	9.4 ± 1.5	57	9.4 ± 1.5	19.0	0
GC 87001	5	7.0 ± 0.3	23	6.9 ± 0.4	11.0	0.1
GC 86059	12	10.5 ± 1.8	60	9.9 ± 1.6	27.0	0.6
GC 86001	135	12.1 ± 1.4	534	11.4 ± 1.5	246.0	0.7
GC 86004	114	8.3 ± 1.0	765	7.9 ± 1.0	323.0	0.4

Table 23. High yielding lines selected from AYT-1 in spring, 1988.

Entry	Yield (t/ha)		Days to maturity		100-seed wt. (g)		Rust lesion (%)	
	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide
SRE-D-14A	3.0	1.8	113	105	25.2	20.6	19	50
GC 82146-43-9-9	2.9	1.5	107	102	18.9	14.4	22	54
SRE-D-14B	2.8	1.9	103	100	25.1	20.6	26	48
GC 00002-100	2.7	1.2	114	107	20.7	16.0	19	50
GC 60020-8-7-7-18	2.7	1.2	104	97	21.4	14.2	19	62
AGS 129 (check)	3.0	1.6	112	104	17.8	12.0	30	43
AGS 302 (check)	2.7	1.7	109	105	22.0	18.8	22	49
OCB (check)	2.4	1.0	100	96	22.3	15.9	22	62
Mean of 14 entries	**2.7**	**1.5**	**108.2**	**102.9**	**20.2**	**15.6**	**21.8**	**50.6**
LSD (0.05)	**0.3**	**0.2**	**3.8**	**3.5**	**2.4**	**1.7**	**7.0**	**11.3**

Table 24. High yielding lines selected from AYT-2 in spring, 1988.

Entry	Yield (t/ha)		Days to maturity		100-seed wt. (g)		Rust lesion (%)	
	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide
GC 81090-48	3.1	1.8	117	106	20.0	14.8	10	46
GC 00062-107-6	3.0	2.0	117	106	18.4	14.0	8	45
GC 81075-10	2.8	1.9	111	106	18.0	14.0	11	39
GC 81075-72	2.8	1.4	112	106	15.4	12.9	10	43
-39-2	2.8	1.6	103	98	16.8	12.2	15	70
AGS 129 (check)	3.0	1.6	114	106	17.9	12.4	14	38
AGS 302 (check)	2.7	1.9	108	106	22.6	19.5	13	44
Mean of 14 entries	**2.8**	**1.5**	**111.0**	**104.4**	**19.2**	**14.5**	**11.5**	**51.1**
LSD (0.05)	**NS 0.3**		**2.6**		**1.3**		**7.1**	

Again in 1988, SRE-C-56A was the most rust-tolerant in AYT-1. SRE-D-14B was also equally good (Fig. 11). In AYT-2 (spring 1988) AGS 302 and G 81090-72-7 were the best rust-tolerant varieties (Fig. 12).

There were nine entries common to spring and autumn 1987 and spring 1988. An analysis of nine entries was conducted in three seasons. Results showed that SRE-C-56A had the least rust infection of 20% and SRE-D-14A and SRE-C-56A gave yields of 2.4 t/ha and 2.3 t/ha respectively.

In spring 1987, the average yield was 2.3 t/ha while in spring 1988, it was 2.1 t/ha. In autumn 1987, it was 2.1 t/ha. In 1987, rust infection was milder whereas in spring 1988, it was rather severe (Table 25). However, SRE-C-56A had consistently low percent of rust infection in all treatments and in all seasons. Yield was also stable but at a lower level (Table 25). The interaction between seasons was primarily due to variation in the degree of rust infection in addition to variation in environmental factors. As a result, the ranking of yield of entries with fungicide and without fungicide treatment and yield reduction due to rust was significantly affected (Table 26).

The soybean rust-tolerance index indicates the tolerance level in a genotype. Soybean rust primarily affects 100-seed weight and yield. Therefore, the rust-tolerance index may consider either 100-seed weight or yield.

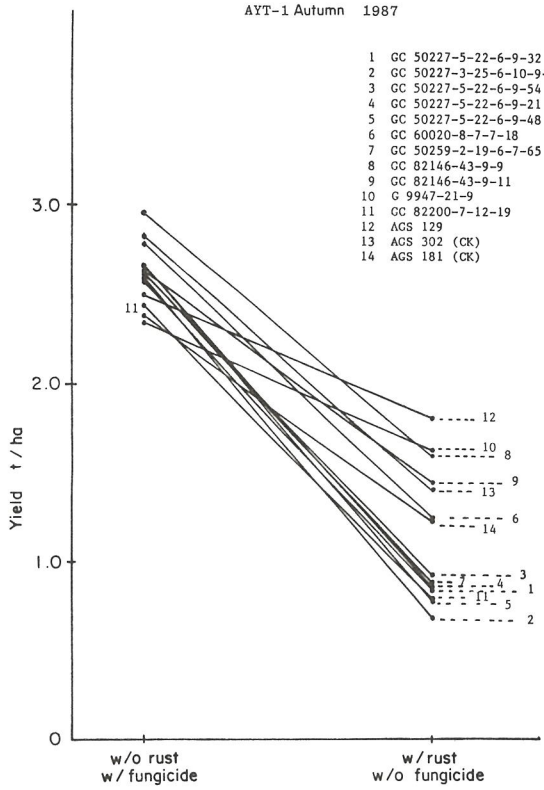

Fig. 9. Yield differences between genotypes with and without fungicide treatment, AYT-1, autumn, 1987.

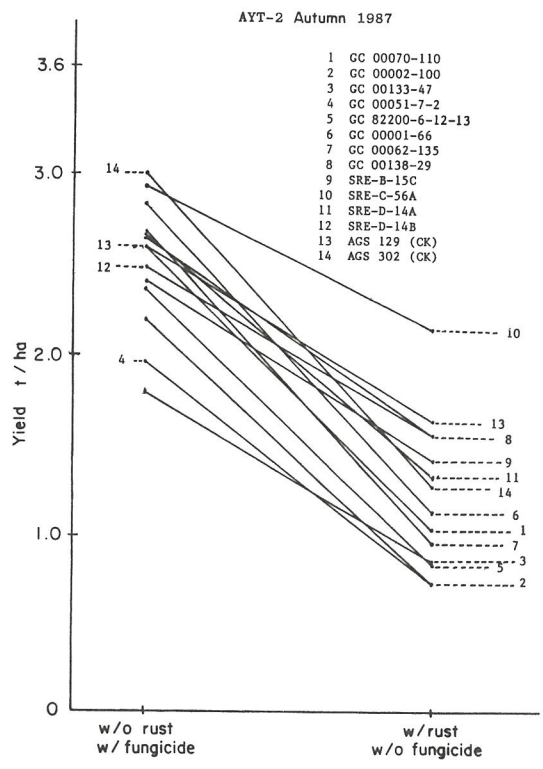

Fig. 10. Yield differences between genotypes with and without fungicide treatment, AYT-2, autumn, 1987.

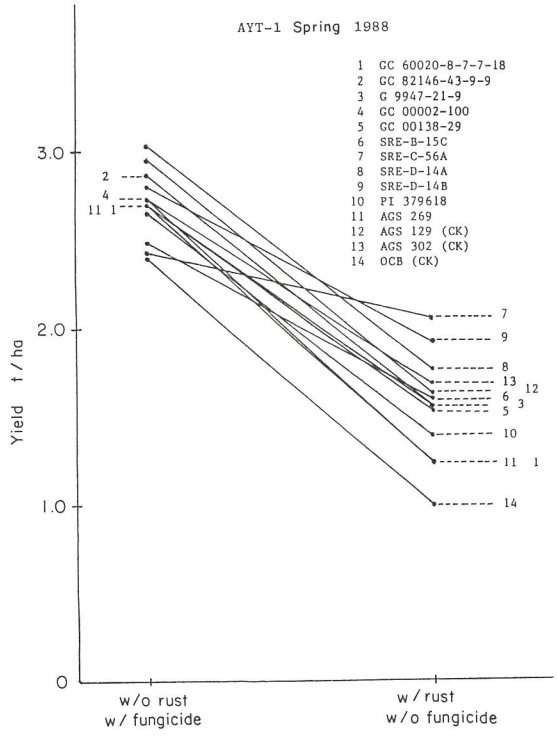

Fig. 11.
Yield differences between genotypes with and without fungicide treatment, AYT-1, spring, 1988.

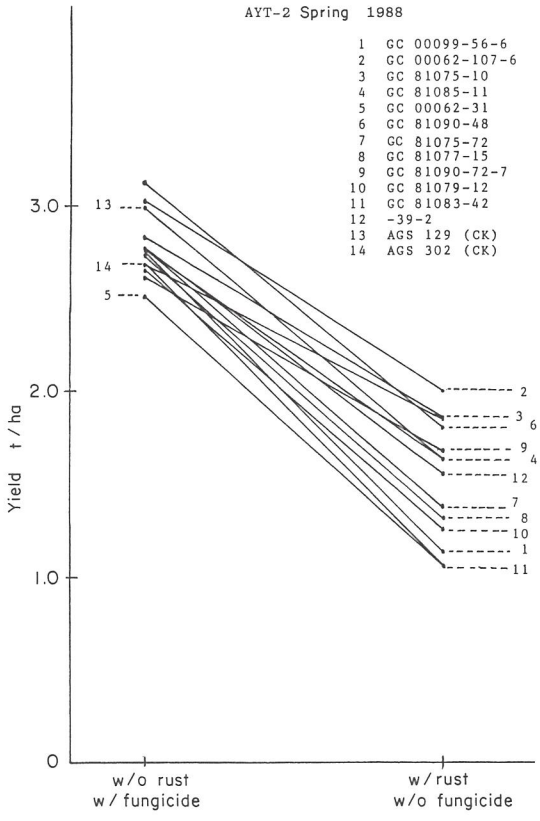

Fig. 12.
Yield differences between gentoypes with and without fungicide treatment, AYT-2, spring, 1988.

Table 25. Percent of soybean rust infection in nine selections in three seasons.

Variety	Percent rust					
	87 SP[z]		87 AU		88 SP	
	WF[y]	WOF	WF	WOF	WF	WOF
GC 60020-8-7-7-18	0.6	27.5	9.4	84.3	18.6	62.0
GC 82146-4-3-9-9	0.7	27.7	6.8	81.0	21.7	53.9
G 9947-21-9	0.5	14.6	5.7	78.2	31.0	64.9
GC 0002-100	0.7	43.1	7.7	89.3	19.1	49.8
GC 00138-29	0.9	33.5	5.7	76.4	18.5	43.6
SRE-B-15C	0.4	36.4	5.4	79.7	16.1	38.6
SRE-C-56A	0.6	22.4	5.7	39.4	17.7	34.7
SRE-D-14A	0.6	27.8	5.8	84.8	18.7	49.7
SRE-D-14B	0.6	17.3	6.1	76.8	26.5	48.5

[z]WF = with fungicide. WOF = without fungicide. [y]SP = spring season. AU = autumn season.

$$\text{Rust tolerance index (RTI)} = \frac{\text{Yield (or) 100-seed weight WOF} \times 100}{\text{Yield (or) 100-seed weight WF}}$$

The higher the RTI, the better the rust tolerance is.

RTI using 100-seed weight did not give the true picture of the tolerance level (Table 27) but RTI using yield showed the soybean rust-tolerant genotypes rather well. A similar drought-tolerance index was proposed and used in wheat by Fischer and Wood (1979)[4]. Rust-tolerance index for AYT-1 and AYT-2 in spring also indicated a quantitative measure of rust tolerance (Tables 27 and 28).

[4]Fisher, R.A. and J.T. Wood. 1979. Drought resistance in spring wheat cultivars. III Yield association with morpho-physiological traits. Aust. J. Agric. Res. 30:1005-1020.

Table 26. Yield ranking and yield loss due to rust infection in nine selections in three seasons, 1987 and 1988.

Variety	Yield (t/ha) (rank)								
	87 SP			88 SP			87 AU		
	WF	WOF	Yield reduction	WF	WOF	Yield reduction	WF	WOF	Yield reduction
GC 00002-100	3.3	1.5	1.9	2.7	1.2	1.5	2.2	0.7	1.5
	(1)	(9)	(1)	(4)	(9)	(1)	(9)	(9)	(2)
GC 00138-29	3.3	1.9	1.3	2.7	1.5	1.2	2.7	1.6	1.1
	(2)	(5)	(2)	(6)	(7)	(5)	(5)	(5)	(5)
SRE-D-14A	3.1	2.2	0.9	3.0	1.8	1.3	2.7	1.3	1.3
	(3)	(1)	(4)	(1)	(3)	(4)	(4)	(7)	(4)
GC 82146-43-9-9	2.9	1.8	1.0	2.9	1.6	1.3	3.0	1.6	1.4
	(4)	(6)	(3)	(2)	(6)	(3)	(2)	(3)	(3)
GC 60020-8-7-7-16	2.6	1.7	0.9	2.7	1.2	1.5	2.8	1.3	1.5
	(5)	(8)	(5)	(5)	(8)	(2)	(3)	(8)	(1)
SRE-B-15C	2.5	2.0	0.4	2.5	1.6	0.9	2.4	1.4	1.0
	(6)	(4)	(2)	(8)	(4)	(8)	(7)	(6)	(6)
G 997-21-9	2.3	1.7	0.5	2.7	1.6	1.1	2.3	1.6	0.7
	(7)	(&)	(6)	(7)	(5)	(6)	(8)	(2)	(9)
SRE-D-14B	2.2	2.0	0.1	2.8	1.9	0.9	2.5	1.6	0.9
	(8)	(3)	(8)	(3)	(2)	(7)	(6)	(4)	(2)
SRE-C-56A	2.1	2.1	0.0	2.4	2.1	0.4	2.9	2.1	0.8
	(9)	(2)	(9)	(9)	(1)	(9)	(2)	(1)	(8)

WF = with fungicide. WOF = without fungicide.

Table 27. Soybean rust tolerant index using 100-seed weight and yield, AYT-1 spring, 1988.

Entry	RTI (100-seed weight)	RTI (yield)
SRE-D-14A	83.3	58.4
AGS 129	115.7	55.3
GC 82146-43-9-9	108.9	54.1
SRE-D-14B	74.9	68.8
AGS 302	54.5	62.0
GC 00002-100	71.0	45.4
GC 60020-8-7-7-18	52.3	46.1
GC 00138-29	78.3	57.0
G 9947-21-9	92.5	57.9
269	60.1	46.5
PI 379618	92.0	52.9
SRE-B-15C	77.6	64.8
SRE-C-56A	64.8	85.0
OCB	71.0	41.3

Table 28. Soybean rust tolerant index for AYT-2, spring 1988.

Entry	Rust-tolerance index (yield)
AGS 302	69.1
GC 00062-107-6	66.5
GC 81075-10	65.8
GC 81090-72-7	64.7
GC 81085-11	59.5
GC 81090-48	57.8
-39-2	56.3
AGS 129	54.6
GC 81075-72	49.9
GC 81083-42	48.3
GC 81079-12	47.5
GC 00062-31	42.5
GC 00097-56-6	41.7
GC 81083-42	39.7

Breeding for Bacterial Pustule and Downy Mildew Resistance

Summary

From 795 pedigrees selected in summer 1987, 116 were screened based on bacterial pustule resistance, seed yield and downy mildew resistance. Screening during the 1988 summer confirmed that of the 116, 11 were highly resistant to bacterial pustule while the rest were moderately resistant. Among highly resistant selections GC 86026-48, (AGS 29 × AGS 269) yielded 4.1 t/ha. These 11 selections will be further evaluated in various locations.

Introduction

Bacterial pustule caused by *Xanthomonas phaseoli* var. *sojensis* is a serious disease during the warm and rainy season, whereas downy mildew whose causal agent is *Peronospora manshurica* is severe during the cool dry season. Resistance to bacterial pustule has been reported to be governed by a recessive gene 'rxp', while resistance to downy mildew has been reported to be governed by a dominant gene 'Rpm'. Several races of downy mildew pathogen have been reported.

The AVRDC soybean program aims to incorporate the genes for resistance to all diseases wherever possible. A number of AGS lines with high yield potential lack resistance to bacterial pustule, downy mildew or both. Therefore, a series of crosses were made with selected high yielding AGS lines and the resistant germplasm and selections for resistance were made in the inbreeding generations.

Materials and Methods

All yield trial entries were planted separately in 1-m long rows with two replications. Entries were inoculated artificially with bacterial suspension in summer. Downy mildew infection was allowed to occur naturally in spring. The check cultivars, Shih Shih (resistant to downy mildew but susceptible to bacterial pustule), AGS 129 (susceptible to downy mildew but resistant to bacterial pustule), G8190 and CNS (resistant to bacterial pustule) were planted on every fifth row for comparison. Details of bacterial pustule inoculation and the rating system are presented in the plant pathology section of the report.

Out of 795 pedigrees obtained from 20 crosses in summer 1987, 116 were selected based on their yield and planted during spring. These 116 entries were again planted in summer 1988 in a preliminary yield trial. These were also independently planted in a disease screening field and artificially inoculated with bacterial suspension. The disease screening procedure and results are discussed in the plant pathology section. Along with the selections, AGS 129, AGS 302, G 8190, CNS and Shih Shih were planted as checks for comparison. An 11 × 11 lattice design with two replicates was used; plot size was 3 × 2 m^2.

Results and Discussion

Results of the yield trial are reported in the yield trial section.

Of the 795 pedigrees selected in summer 1987 based on single plant yield, 116 were selected from 20 crosses (Table 29). The selection differences varied from 9.2 to 22.7 g.

Among 116 pedigrees evaluated, 12 were confirmed highly resistant to bacterial pustule in summer. The mean yield of 121 entries evaluated was 2.4 t/ha while that for 11 selections highly resistant to bacterial pustule is also 2.4 ± 0.7 t/ha. Among them, GC 86026-48 (AGS 29 × AGS 269) had the highest yield of 4.1 t/ha in 97 days. The yield, days to maturity and 100-seed weight of 11 selections are given in Table 30.

Table 29. Selection of bacterial pustule-resistant superior pedigrees from 20 crosses.

Cross no.	Pedigree	No. of pedigrees	Mean SW/ plant (g)	Mean + 1SD	Selections No.	Selections Mean	Selection differential
86021	AGS 8 × AGS 129	23	37.26	45.30	4	50.8 ± 3.3	13.5
86022	AGS 8 × AGS 269	29	31.79	43.85	4	54.5 ± 8.7	22.7
86023	AGS 17 × AGS 129	51	30.55	38.80	6	44.5 ± 4.3	13.9
86024	AGS 17 × AGS 269	26	33.81	47.16	6	53.1 ± 6.5	19.3
86025	AGS 29 × AGS 129	50	29.20	39.19	6	45.3 ± 8.2	16.1
86026	AGS 29 × AGS 269	51	31.86	41.64	8	49.9 ± 5.4	18.0
86027	AGS 66 × AGS 129	63	28.97	37.09	7	41.4 ± 4.8	12.4
86028	AGS 66 × AGS 269	57	28.46	36.37	10	41.2 ± 4.0	12.7
86029	AGS 85 × AGS 129	40	31.00	38.84	8	42.5 ± 2.9	11.5
86030	AGS 85 × AGS 269	21	30.95	43.19	3	53.7 ± 8.3	22.7
86031	AGS 95 × AGS 129	31	34.74	42.37	8	44.0 ± -0.9	9.2
86032	AGS 95 × AGS 269	27	30.37	39.52	5	46.0 ± 5.2	15.6
86033	AGS 121 × AGS 129	33	36.03	47.64	7	54.4 ± 6.3	18.4
86034	AGS 121 × AGS 269	34	34.91	44.57	6	49.7 ± 3.0	14.8
86035	AGS 144 × AGS 129	28	37.29	47.74	4	56.8 ± 7.6	19.3
86036	AGS 144 × AGS 269	20	30.15	42.74	4	49.0 ± 4.2	18.8
86037	AGS 157 × AGS 129	17	32.65	41.44	4	46.3 ± 6.0	13.6
86038	AGS 157 × AGS 269	29	34.03	42.48	5	46.5 ± 3.5	12.5
86039	AGS 162 × AGS 129	32	39.00	48.96	5	53.6 ± 7.6	14.5
86040	AGS 162 × AGS 269	19	43.47	57.36	6	61.0 ± 9.2	17.5

Table 30. Yield, days to maturity and 100-seed weight of highly bacterial pustule-resistant selections in summer, 1988.

Entry	Yield (t/ha)	Days to maturity	100-seed weight (g)	Bacterial[z] pustule resistance
GC 86026-48	4.1	97	15.9	HR
GC 86026-23	2.7	97	18.8	HR
GC 86022-17	2.6	97	17.0	HR
GC 86029-30	2.6	96	15.6	HR
GC 86032-18	2.5	97	16.8	HR
GC 86040-1	2.4	97	15.9	HR
GC 86028-4	2.3	93	18.1	HR
GC 86026-51	2.3	98	16.2	HR
GC 86040-9	2.3	98	15.9	HR
GC 86028-14	1.8	97	17.5	HR
GC 86032-17	1.7	97	16.5	HR
GC 86022-12	1.3	96	15.2	HR
CNS (check)	1.9	88	12.4	MRG
8190 (check)	1.4	92	13.5	HR
AGS 302 (check)	0.9	98	20.7	MS
Mean	2.2	95.7	16.4	
CV	26.71	1.42	6.14	
LSD (0.05)	1.25	2.91	2.15	

[z]MR = moderately resistant; MS = moderately susceptible; HR = highly resistant.

International Cooperation

Summary

A total of 13 ASETs and 1,924 seed packets were distributed to 105 cooperators in 45 different countries. Fifty-six scientists from 29 countries expressed interest in the AVRDC vegetable soybean. AVRDC breeding lines appeared promising in Burma, Ethiopia, Liberia, Malaysia, Nepal, the Philippines and Zaire. Seeds of several AVRDC vegetable soybeans are multiplied in Sri Lanka for farmers' adoption. AVRDC assisted Korea in its soybean generation advance and seed multiplication. Newly released vegetable soybean, KS #1, is planted to 51% of the vegetable soybean area and grain soybean KS #10 and Tainan No. 1 together occupy 50% of the total grain soybean area in Taiwan.

Introduction

AVRDC research results and genetic materials reach the small farmers through collaboration with the national programs. At the request of the national program scientists, AVRDC provides the improved elite germplasm and breeding lines for evaluation by the national program. The results and comments of the scientists on the evaluation of breeding lines are presented here.

Germplasm Distribution and Evaluation Trials

Scientists from 10 countries requested 13 ASETs. A total of 999 AGS lines, 694 pedigrees or populations and 231 accessions were sent to 103 cooperators in 45 countries (Table 31). Since INTSOY terminated its production research and discontinued distribution of soybean trials and IITA confined its research activities to Africa, requests for research materials from AVRDC increased significantly.

The announcement of the release of vegetable soybean variety Kaohsiung No.1 (AVRDC AGS 292) by Kaohsiung DAIS created significant interest among soybean scientists around the world. A total of 56 scientists from 29 countries requested seeds of Kaohsiung No. 1. Sixteen scientists from 21 countries were also sent the two local vegetable soybeans, Acc. G 9053 and G 10134.

ASET Results

Although the ASETs are sent yearly, due to different planting dates in different countries, the results are received at different times. During 1988, results of two trials conducted in 1985, four in 1986 and seven in 1987 ASET were received from nine cooperators in eight countries.

Brazil

In Brazil at 25°S latitude, AGS 124 (Clark × CH#3), AGS 217 (Clark 63 × PI 248407) and AGS 270 (Selection from PK 7394) did well as the local check varieties. However, maturity duration was more than 120 days for all entries, including the local checks. AGS 124, AGS 217 and AGS 324 appeared resistant to *Pseudomonas syringae* and *Septoria* leaf spot. AGS 160, AGS 208 and AGS 217 had no purple seed stain while AGS 124 had some disease.

AVRDC released the seeds to scientists one year later from the quarantine office in Brazil. The cooperator noted that the germination and plant stand were not satisfactory.

Burma

From the trial planted on 26 January in Burma, AGS 268 (selection from Siatsa 194) and AGS 147 (Shih Shih × SRF 400) yielded 1.6 and 1.4 t/ha compared to the local check's 0.5 t/ha. All matured in 82 days. OCB from Thailand matured 18 days earlier than the check variety and yielded 0.9 t/ha which was at par with the local check.

The coefficient of variation for yield was 51.5%, 65.7% and the R^2 was only 0.36, 0.79 for the January and May crop, respectively. The major problem in this trial was plant population density. There were significant differences between varieties on the number of plants harvested. Another problem reported was rat damage.

Ethiopia

AGS 129 (Shih Shih × SRF 400) was at par with one of the local checks, 'Celeste', but yielded significantly by higher than the other check, 'Williams'. AGS 160, AGS 162 and AGS 217 were susceptible to shattering.

Table 31. Distribution of AVRDC Soybean Evaluation Trial (ASET) and other enhanced germplasm to national programs in different countries, 1988.

Country	No. of cooperators	Type of seed sent			
		ASET	AGS lines	GC pedigrees	Accessions
Australia	3		4		2
Belgium		1	3		2
Brazil	1		1		
Brunei	2	1	3	1	4
Burundi	1		10		
Colombia	1		1		
Costa Rica	2		4	2	2
Dominican Rep.	1		1		
Ecuador	3	2	12		
Ethiopia	1		3		
France	3		13		4
Gambia	1	1			
Ghana	1	1			
Guatemala	1		2		
India	10		105	5	25
Indonesia	4		90	7	17
Iran	2	1	1	2	
Iraq	1		9		1
Japan	1		24		6
Korea	4		6	193	24
Lesotho	1		2		2
Madagascar	1	2	3	45	
Malawi	1	7		1	
Malaysia	4		3		6
Maldives	1		2		
Mauritius	1		2		2
Mexico	1	1		1	3
Nepal	1		4	3	29
Nigeria	3		10		2
Pakistan	3	2	146	4	2
Papua New Guinea	1		5		
Philippines	9	2	17	2	4
Saipan	1		2		2
El Salvador	1		8		
Saudi Arabia	2	1	3		
Singapore	1		18		2
Solomon Islands	1		14	6	
South Africa	1		1		
Sri Lanka	2		10		
Sudan	1		1		
Swaziland	1	1			
Taiwan	6	114	14	7	
Thailand	4	264	9	13	
U.S.A.	9	31	448	10	
United Kingdom	1		2	6	
Vanuatu	1		4		
Yugoslavia	1		30		
Total	105	13	999	694	231

Iraq

AGS 275 (selection from Duocrop) was comparable in yield to the local check Lee. AGS 242 (Shinsei × PI 248407) and G 2261 (Tainung #15) were susceptible to shattering.

Japan

Dr. T. Yoshida evaluated 16 AVRDC breeding lines for possible adoption in Japan. Among them, 10 lines gave 4.0 to 5.2 t/ha grain yield. However, only six lines had 100-seed weight of more

than 35 g. The yields of those with large seeds were not as high as the others. GC 84144-P-1-2-11 with 37.5 g (100-seed weight) gave the highest yield of 2.32 t/ha. Japan requires large seeds and high yield.

Korea

AVRDC assisted in advancing the generation of Korean breeding lines and multiplied the seed of advanced lines in spring. A total of 353 entries with seeds weighing 54 kg were shipped to Korea in May-June 1988.

Liberia

Of nine AVRDC entries tested, six significantly outyielded the two local check varieties. Compared to 2.0 t/ha yield of local varieties, six entries gave 2.9 to 3.5 t/ha. The results implied that Liberia has very good potential to produce soybean.

Malaysia

Mr. Tan Teo Soon and Mr. Yeong Chin Sheong evaluated four vegetable soybean varieties which were harvested as dry soybean. AGS 190 gave 3 t/ha with a 100-seed weight of 35 g. The next highest yielder was G 9053 with 1.8 t/ha and 100-seed weight of 37 g. G 10134 produced the largest seed with a 100-seed weight of 43 g. Since harvesting coincided with rainfall seed quality was poor. These varieties will be reevaluated in 1988-89. AGS 190 appeared promising.

Nepal

AVRDC entries were included for evaluation in a number of trials conducted in Nepal.

The cooperator, Dr. M.P. Bharati reported the results of soybean rust screening at Khumaltar. Among 11 lines examined, PI 230971, TN #4, PI 200492 and PI 459025 did not show any soybean rust symptoms. PI 339771B and PI 459024 had RB type rust lesion while others had TAN type rust lesion. Results suggested that at least three races that attack PI 200492, PI 230971 and PI 459025 are not present in Nepal. The Indian race which attacked Ankur is present in Nepal.

Mrs. S. Joshi screened 34 AVRDC entries and two check varieties, Wayne and Wills, for soybean rust, bacterial pustule and frog eye leaf spot in June, 1988. Results showed that PI 200490 and PI 200492 were resistant to soybean rust. None of the diseases was observed on Wayne, PI 200488 and PI 224268.

Philippines

AGS 29 (Clark 63 × 64-64) yielded significantly higher than the check IPB SY2 138-29. G 2261 matured 13 days earlier than the check but attained similar yield. However, in another trial conducted by the same cooperator in Ilagan, Isabela during the same planting date there was no significant difference in yield between the entries. In one trial, the check yielded 1.6 t/ha. In another trial it gave 2.6 t/ha.

In a trial conducted at Mindanao State University in General Santos city, AGS 304 & [(G2120 M_8 (37-1)], AGS 208 (KS 473 × Unknown), OCB, AGS 299 (Clark 63 × TN #4) and AGS 129 outyielded the two local check varieties. The first three varieties also matured 20 days earlier than the checks.

At Los Baños, Laguna, POP conducted wet and dry season trials. During the wet season, AGS 208, AGS 147 and AGS 129 outyielded the check UPL SY 4 but only AGS 208 outyielded BPI SY 4. Among them, AGS 147 and AGS 129 were free from bacterial pustule; AGS 208 was susceptible. During the dry season, there were no significant differences between entries. Also, leaf rollers and mites were serious problems. The problem of plant stand was more severe during the dry season than wet season and there were significant differences in the number of plants harvested between varieties.

Preliminary results from Nestle Co. in Manila showed that AGS 217 and AGS 270 outyielded 14 other entries and checks UPL Sy-2 and SJ-4.

Data from four sites were used to determine the stability of different genotypes. The mean yield per site was regressed over the yield of individual varieties. Results suggested that AGS 208 and AGS 269 were above the population mean in both low and high yielding environments. AGS 269 and AGS 208 are well adapted to all environments. OCB appeared to have above average stability and is adapted to low yielding environment. However, OCB's yield potential under high yielding environment appeared to be lower.

Sri Lanka

About 80 kg seeds of six vegetable soybean entries were provided to Plenty Canada in Sri Lanka. M/S Wasantha Chithral[5] (1988) reported that AGS 164, AGS 165, AGS 184, AGS 190, AGS 191 and AGS 185 were most promising. Green bean yield varied from 4.1 to 9.4 t/ha in Maha season. Maturity ranged from 69 to 72 days.

Syria

AGS 242, AGS 29 and AGS 129 yielded 2.4 to 2.9 t/ha in about 154 to 168 days. AGS 129, AGS 245, AGS 275, G 2261 and AGS 261 shattered badly. The maturity of AVRDC entries was too long for Syria at 36°67'N latitude. AVRDC will instead provide early maturing selections.

Taiwan

Kaohsiung No. 10 (AGS 129) released in 1985 is planted in 3,690 ha (41% of the total soybean area). Tainan No.1 released in 1986 is planted in 800 ha which is 9% of the total area. Kaohsiung No. 1 vegetable soybean (AGS 292) released in 1987 occupies 51% (3,919 ha) of the total area planted to vegetable soybean.

Zaire

Yields in general for all entries were low. The seeds sent in October 1986 were planted in September 1987. As a result, germination was poor and plant stand was irregular. Sandy soil could not conserve the sparse rains during the trial, thus resulting in poor yield. Yield varied from 0.2 t/ha for the IITA lines (check) to 0.4 t/ha for AGS 65 (66-D-20 × CH #2) but the differences were not significant.

[5]Chithral, G.M.W. 1988. Green soya beans. Soyanews 10(2):3.

Soybean Entomology

Screening of Breeding Lines for Beanfly Resistance

Summary

Three hundred and six advanced soybean breeding lines (AGS lines) were screened in the greenhouse for resistance to beanfly, *Ophiomyia phaseoli*. Twenty-six least damaged lines were tested in the field by planting them under a large cage and releasing a large number of laboratory-reared beanfly adults. AGS 120 and AGS 122 were least damaged. AGS lines will be screened again and their resistance mechanism will be further studied.

Introduction

The beanfly, *Ophiomyia phaseoli* (Tryon) (Diptera: Agromyzidae), is a destructive and widely distributed insect pest of economically important food legumes in tropical and subtropical Asia, Africa, Australia and Oceania. In soybean, the insect larva bores into the stems of young plants which results in plant mortality or severe reduction in growth and yield like in Indonesia and the southern part of Vietnam. This insect causes serious damage to mungbean and snapbean in Taiwan, but does not infest soybean at seedling stage. In late 1987, however, a mass rearing technique was developed in AVRDC which enabled the screening of soybean germplasm for resistance to *O. phaseoli*. In 1988, all AVRDC AGS lines were screened.

Materials and Methods

All 306 AGS lines were given a preliminary screening in the greenhouse. Seeds of 9 to 10 AGS lines and one susceptible check, TK-5, were planted in clay pots with four pots per entry. Ten plants were raised in each pot. Pots were placed randomly in the greenhouse and covered with a nylon net cage. Soon after emergence, 800 laboratory-reared *O. phaseoli* adults were released inside the cage. Four days later, the number of eggs laid in cotyledons and unifoliate leaves were recorded. Mortality rate was recorded after three weeks. Each plant was cut open and the number of pupae in every plant was recorded.

In second screening, 26 least damaged AGS lines were selected from the preliminary screening and planted in the field under a large walk-in screen cage. Seeds of each AGS line were sown as a single row on a 0.75 m wide bed. Soon after germination, twice or thrice a week, a large number of laboratory reared *O. phaseoli* adults were released. At 24 and 35 days after emergence, 25 plants from each plot were cut open and the number of beanfly larvae and pupae and plants with beanfly damage were recorded. Using a statistical procedure, these entries were classified highly resistant, moderately resistant, having low resistance, susceptible and highly susceptible.

Results and Discussion

Eight hundred beanfly adults were released in each test. Nine or ten entries and one standard susceptible check were used. Insect infestation and plant mortality varied among individual tests. This

prompted the selection of 26 AGS lines, for further testing in the field. In the preliminary tests, only 10 showed significant positive correlation between the number of eggs laid in each plant and plant mortality rate. Thus, although number of eggs laid per plant seems the easiest and most time-saving criterion, it cannot be reliably used in selecting beanfly resistant cultivars. Therefore, plant mortality rate was used as the sole criterion in the selection of resistant entry.

The purpose of the second test was to determine the stability of resistance and select the most promising lines under field conditions. The reactions of the AGS lines varied considerably. Many entries that were least infested in the greenhouse were damaged considerably in the field. However, AGS 120 and AGS 122 which had a low count of eggs laid in the greenhouse, had the least larvae + pupae in their stems and least number of plants damaged by beanfly in both observations. Their performance is summarized in Table 1.

AGS 120 and 122 have good agronomic characters. Their resistance mechanism will be investigated further in the greenhouse and in the field.

Table 1. Infestation of selected AGS lines by *O. phaseoli* under a net cage.

AGS lines	No. beanfly larvae + pupae/25 plants		Damaged plants (%)	
	1st observ.	2nd observ.	1st observ.	2nd observ.
AGS120	1	1	27.8	27.3
AGS122	2	1	22.2	20.8
AGS3[z]	11	9	85.7	88.9
AGS210[z]	12	19	82.4	87.5

[z]Susceptible check lines.

Screening of Germplasm for Beanfly Resistance

Summary

In autumn-winter 1987-1988, 2,106 AVRDC soybean accessions during the past two to three years were screened for resistance to beanfly, *Melanagromyza sojae*. Three hundred accessions were planted weekly in a nonreplicated trial and one-month old seedlings were evaluated for *M. sojae* infestation. Based on the number of beanfly larvae + pupae lodged inside the plant, 80 accessions were considered promising and will be screened again in the field in a replicated trial in 1989.

Introduction

Agromyzid flies, mainly *Ophiomyia phaseoli* (Tryon), *O. centrosematis* (de Meijere), and *Melanagromyza sojae* (Zehntner) (Diptera: Agromyzidae) are major pests in soybean and several other economically important legumes in tropical and subtropical Asia, Africa and the Oceania. Flies lay eggs in the foliage or stem and the larvae feed inside the stem and weaken the plant. In certain cases, plant mortality may result. AVRDC aims to develop an integrated pest control based on host-plant resistance. Toward this end, screening of soybean germplasm for resistance to beanflies, mainly *M. sojae*, was conducted. However, no useful source of resistance was found.

Materials and Methods

A one-hectare field was alternately divided into 1.5-m wide insect source and 6-m wide varietal test blocks. Two weeks ahead of planting the test accessions, soybean cultivar TK-5 was planted in two rows of insect source block. In test blocks, 300 accessions were sown once a week, with 20 to 30 accessions per block. Seeds were planted on top of 2 m long and 0.75 m wide single row plots.

Planting was done on schedule to test the first week's accessions in each block seeded adjacent to the insect source block followed by each subsequent week's planting in the neighboring row. This planting arrangement facilitated easy movement of beanflies from older to younger plants in close vicinity.

Four weeks after germination, 10 plants from each plot were uprooted and dissected. The number of *M. sojae* larvae and pupae found in each plant was recorded. Plants with visible insect damage but no trace of immature insect were also recorded.

Each week, the mean number of insects (larvae + pupae) found per 10 plant sample (or % damaged plants) was subjected to statistical analysis based on mean and standard deviation (SD). The accessions that had insect count (or % damaged plants) less than mean−2 SD were considered highly resistant (HR); between mean−1 SD and mean−2SD, moderately resistant (MR); between mean and mean−1SD, low resistance (LR); between mean and mean+2SD, susceptible (S); and more than mean+2SD, highly susceptible (HS).

Results and Discussion

Considering the significant positive correlation between the number of larvae + pupae/plant and percentage of damaged plants in past screenings, this time only the number of larvae + pupae/ plant was used in evaluating the germplasm. Distribution of germplasm into various resistance categories is shown in Figure 1. Among the 2,148 soybean accessions screened, 80 were considered as HR, 283, MR; 669, LR; 815, S; and 301 HS. This was based on a nonreplicated one-season test. In 1988 to 1989, the 80 HR accessions will be screened in a multireplicate test in the open field for resistance to *M. sojae* and *O. phaseoli*.

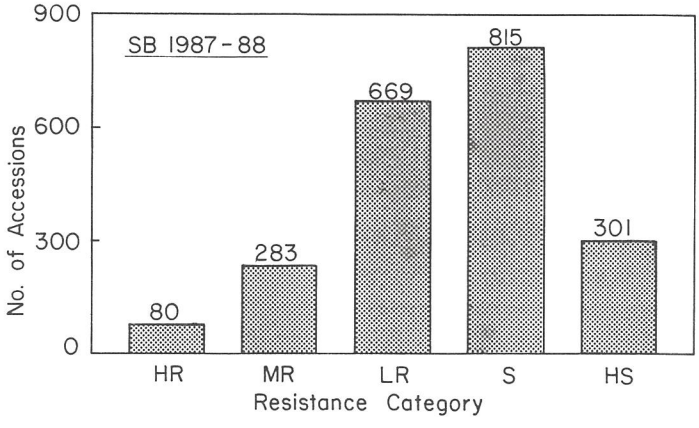

Fig. 1.
Distribution of soybean germplasm into various resistance categories.

Insecticide Screening for Beanfly Control

Summary

Among three insect growth regulators tested for their efficacy against *M. sojae* on soybean, cyromazine at the rates of 75 to 150 g AI/ha gave good control of the pest as the standard insecticide, omethoate, at 500 g AI/ha. Cyromazine at 100, 125, and 150 g AI/ha gave significantly higher yield than the control plot where no insecticide was applied. In a related but separate test, pyrazophos gave practically complete control of *M. sojae* on soybean when the chemical was sprayed at the rate of 0.5 kg AI/ha per week during seedling stage.

Introduction

In tropical to subtropical regions of Asia, Africa, Australia and Oceania, agromyzid flies (*Ophiomyia phaseoli* [Tryon], *O. centrosematis* [De Meijere] and *Melanagromyza sojae* [Zehntner]) (Diptera: Agromyzidae) cause serious damage and considerable yield loss in soybean and other similar legumes. Depending on the species, female adults lay eggs in hypocotyls or cotyledons or unifoliate and early trifoliate leaflets of soybean seedlings and larvae mine the stem. As a result of larval feeding, the plants die or if they survive, their yield is considerably reduced.

Presently, insecticides are frequently used to control these pests. However, most insecticides used are the broad spectrum type which kill pests as well as parasites. Moreover, some of the frequently used chemicals, such as dimethoate and monocrotophos, are becoming less effective against beanflies but remain toxic to parasites. Recently a new class of chemicals which appears more toxic to pests but less to parasites has been synthesized. These chemicals, commonly called insect growth regulators (IGRs), have potential in the integrated control of beanfly. Some had been tested in a screening trial to determine their effectiveness against beanflies.

In a related but separate experiment, an organophosphorus fungicide, pyrazophos, which has a structural similarity to an effective insecticide against beanflies showed potential in agromyzid control.

Materials and Methods

A parcel of land was rototilled and worked into 1-m wide raised beds. The beds were further divided into 3.3 m × 3 m plots. Seeds of soybean breeding line AGS 66 were sown in two parallel rows set 40 cm apart on each bed. Within each row, a distance of 10 cm was maintained between two adjacent planting spots (hill). Weeding, irrigation, fertilizer application and disease control were observed to achieve high yield.

There were 10 treatments including a control, arranged in a randomized complete block design and replicated four times. Predetermined quantities of insecticide formulations were diluted in water and sprayed on each plot with a 10-liter air-pressure sprayer charged to 2.7 kg/cm^2 (40 psi). About 0.5 liter (50% of the designated quantity of the active ingredient & AIé) was sprayed in every plot during the first four applications and 1 liter per plot (1000 liters/ha) at the succeeding three applications. Each sprayer was individually calibrated with a stopwatch to ensure that a specific volume of spray solution could be accurately and uniformly delivered to each plot. Cone-type nozzles were used. Sprayings were done at 3, 7, 10, 14, 21, 28 and 36 days after emergence (DAE).

Effectiveness of insecticide was evaluated at 21 and 35 DAE. Thirty plants were randomly uprooted from each plot. Each plant was cut open and the number of larvae and pupae found within the stems were recorded. Likewise, the number of plants with visible beanfly damage including those without larvae or pupae was also recorded.

Starting 35 DAE, the entire experiment was occasionally sprayed with fenvalerate. At harvest, seed yield from each plot was recorded. All data were analyzed by ANOVA and means were compared by DMRT.

There were only two treatments in the pyrazophos experiment. The plot consisted of two rows of soybean planted on two 4 m long and 0.75 m wide beds (plot size, 4 m × 1.5 m). Evaluation of pyrazophos application and its effectiveness was done in a similar manner as stated above. Due to heavy rains and flooding, the experiment was abandoned after second observation before harvest.

Results and Discussion

Results of the insecticide screening are summarized in Table 2.

Cyromazine (N1-cyclopropyl-1, 3, 5-triazin-2, 4, 6-triyl-triamine), a new IGR, at four dosages ranging from 75 to 150 g AI/ha, gave better control of *M. sojae* than the standard check, omethoate. In both observation intervals, the number of beanfly larvae and pupae found inside cyromazine treated soybean plants were the lowest among all treatments. Two other IGRs, BAS 206538 and BAS 166801, with or without adjuvant, did not give any control of the insect and obviously were not suitable for the control of dipterous insects like agromyzids. In the cyromazine treated plot, yield was comparable

to plots treated with omethoate. Cyromazine was not effective in controlling *Hedylepta indicata*, a leaf roller, whereas omethoate was effective. As a result, the yield under omethoate treatment was comparable to that of cyromazine treatment despite relatively inferior beanfly control by omethoate. Among four rates of cyromazine application, the lowest dose of 75 g AI/ha gave as good control as the higher rates and the yield of the treatments was comparable. This dose, therefore, is suitable for field use.

Results of the pyrazophos application in controlling beanfly are summarized in Table 3. This fungicide gave excellent control of *M. sojae* in soybean. In the first observation at 26 DAE, all plants in pyrazophos-treated plots were free of beanflies, whereas in untreated plots 22.25 larvae + pupae per 30 plants were found. Similar efficacy was noted in the second observation, 12 days later. The mechanism of action of this fungicide against beanflies, including the appropriate dosage required to get an optimum control of beanflies will be studied in 1988-89.

Table 2. Evaluation of insect growth regulators in controlling beanflies in soybean.[z-w]

Insecticides	Rate kg a.i./ha	No. beanfly maggots + pupae/30 plants		Damaged plants (%)		Yield t/ha
		87/10/27	87/11/17	87/10/27	87/11/17	
Cyromazine 10SL	0.1	1.0 d	1.7 c	78.2 bc	52.5 c	2.5 abc
Cyromazine 10SL	0.1	2.5 d	2.0 c	71.7 c	39.1 d	2.5 ab
Cyromazine 10SL	0.1	1.2 d	1.7 c	72.5 c	38.3 d	2.7 a
Cyromazine 10SL	0.1	0.7 d	0.7 c	65.0 c	35.0 d	2.7 a
BAS 206538 + BAS 0902Sv	0.06 + 1.0	24.7 b	42.2 a	98.3 a	100.0 a	2.2 bc
BAS 206538 10EC	0.1	28.2 ab	46.5 a	98.3 a	98.3 a	2.2 bc
BAS 166801 + BAS 0902S	0.06 + 1.0	13.2 c	19.2 b	90.8 ab	75.8 b	2.2 bc
BAS 166801 10EC	0.1	31.5 a	46.2 a	92.5 a	100.0 a	2.4 abc
Omethoate 50EC	0.5	9.5 c	16.0 b	57.5 d	65.0 b	2.7 a
Control		29.5 ab	45.0 a	98.3 a	100.0 a	2.1 c

[z]Cultivar: AGS 66. [y]Planting date: 87/10/2. [x]Insecticide sprayed: 87/10/8, 10/12, 10/14, 10/21, 10/28, 11/4, 11/11. [w]Harvest date: 88/1/11. Data shown are means of four replicates. Means within columns are not significantly different at 5% probability level according to DMRT. Design: RCBD. [w]Plot size: 10 m^2. [v]An adjuvant.

Table 3. Effect of pyrazophos on beanfly infestation in soybean by beanflies.[z]

Treatment	Rate kg a.i./ha	No. beanfly larvae + pupae/30 plants		Damaged plants (%)	
		88/8/5	88/8/17	88/8/5	88/8/17
Pyrazophos 30EC	0.5	0.0 b	1.2 b	1.6 b	14.1 b
Control		22.2 a	22.0 a	88.3 a	82.5 a

[z]Cultivar: KS 9, Planting date: 88/7/1. Insecticides sprayed: 11, 15, 18, 22, 29 July, 5 August 1988. Plot size: 6 m^2 (1.5 × 4 m). Design: RCBD. Data are means of four replicates. Means within columns are not significantly different at 5% probability level according to DMRT.

Biological Studies on Stink Bug, *Riptortus clavatus*

Summary

Certain biological studies were conducted to understand the life cycle, feeding and reproductive behavior of a stink bug species, *Riptortus clavatus*. Duration of egg stage was reduced from 12.75 to 4.13 days and nymphal stage from 35.47 to 11.52 days both at 20°C and 35°C, respectively. Most eggs were laid on lower leaf surface. The first instar larva did not feed but the next four instars fed on soybean pods. The number of eggs laid was 28.67/female when the eggs were allowed to remain and hatch on the plant but the number increased to 72.67/female when the eggs were removed every day. Adults died in one week but lived for three weeks on soybean plants and four weeks when reared on dry soybean seeds in the laboratory.

Introduction

A stink bug species, *Riptortus clavatus* Thunberg (Heteroptera: Coreidae) is a serious pest in economically important legumes, such as soybean and mungbean. It is a pantropical insect and there are very few biological studies about it. Information on its biology is helpful in developing a rational control of the pest. Several biological studies were conducted in the past two summers at AVRDC. A research study that was essential but could not be done in 1986 and 1987 was conducted in 1988. The study covered the life cycle, oviposition, nymphal feeding habit and adult longevity of the insect.

Materials and Methods

Life cycle study. One-day-old eggs were collected from mass rearing. Fifty eggs were placed in each of 20 petri dishes lined with moist filter paper. The paper was kept moist by adding water whenever necessary. When collection of all eggs was not possible at one time, the researcher collected whatever was available every day and placed an equal number of each day's eggs in five petri dishes; one petridish represented a replicate. Each group of five petri dishes was placed at 20°C, 25°C, 30°C or 35°C.

Eggs were observed once every six hours. Soon after eggs were hatched, the insects were collected and placed in breeding cups. A green soybean pod of R_4 to R_5 stage was placed in each cup. Eggs that failed to hatch were considered dead and recorded. Hatching of eggs and mortality rates were calculated.

All first instar nymphs were reared in the breeding cups. Several insects in each cup were furnished with green soybean pod. Each cup was marked clearly on top and the insects were bred at each temperature until all nymphs became adults. The status of each instar was recorded once every six hours. Duration of development stage and mortality of nymphs of each instar were calculated. When all nymphs turned into adults, the percentage of adult emergence and sex ratio was recorded.

Oviposition study. Six potted soybean plants in R_3 to R_5 growth stage were used for this study. Each plant was placed on an acrylic cylinder and newly emerged male and female adults were released on each plant. The cylinder was covered with transparent net and a small cup with cotton dipped in syrup was hung inside to serve as the insects' source of food. Each potted plant was considered as one replicate. From the first three plants, eggs were removed every day but not thereafter. When egg laying stopped, the total number of eggs was recorded. In plants where eggs were not removed, the nymphs started emerging from the eggs.

Nymphal feeding habit. Newly emerged nymphs of each instar were kept (one nymph per petri dish) at 30°C. Each petri dish was lined inside with a filter paper kept moist by adding water. A fresh green soybean pod which had no insect damage at all was provided. To keep the pod fresh, the petiole was wrapped in a moist cotton plug. The insect was observed frequently, and molting was recorded. The old pods were replaced with fresh ones.

All pods were opened and the pericarps were placed in a staining solution overnight. The pericarps were removed, rinsed in tap water and dipped in acetic acid for fixing. The stained pod covers were counted. The number of stained feeding sheaths of each instar was recorded.

Adult longevity. Twenty-four medium sized cages were divided into three groups. The influence of three factors on adult longevity was studied. One soybean plant was placed in each of the first eight cages. In another eight cages, soybean seeds were placed. In the remaining eight, food source was not provided. Each group of cages was divided equally into two subgroups. In each subgroup, five males were released and in the other, five females. The number of alive insects and mortality rate were recorded every day until all adults died.

Results and Discussion

Life-cycle study Duration of egg stage decreased from 12.75 days at 20°C to 4.13 days at 35°C (Table 4). At lower rearing temperature, the development time was prolonged. The nymphal

stage took more than thrice longer to become adults at 20°C. The sex ratio was not consistent, but at 20°C the females outnumbered males by a ratio of about 2:1. Most females molted into adults earlier than the males. Mortality of *R. clavatus* eggs varied considerably from 20° to 35°C (Table 5). Mortality higher than 25% was observed in the fifth instar at all temperatures, and it was especially high at 35°C where it reached almost 70%. At 30°C, mortality was lower than in other temperatures. Cumulative mortality was higher at both the lowest and highest temperatures. Thus, temperature seemed not to influence insect mortality.

Oviposition study. When eggs were removed daily, a single female laid an average of 72.67 eggs. However, when eggs were allowed to remain and hatch on the plant, a single female laid an average of 28.67 eggs. The substantial reduction in the number of eggs when these were allowed to remain appeared to be the mechanism developed by the insect to avoid competition among its offsprings. It was found that a female can lay eggs all the time and males died earlier. Before egg laying, females would secrete some slimy material from the anal end and paint on selected surfaces where they laid eggs. Egg color changed from bright blue, blue green, then to deep tan. The first instar nymph did not eat its egg shell. The insects laid eggs mainly on foliage, to some extent randomly on other plant parts and on the cage wall (Table 6). The distribution of eggs was erratic and statistically no significant difference in the preference for oviposition sites was found.

Nymphal feeding habit. As *R. clavatus* grew older, the more it fed on the soybean pods (Table 7). The first instar nymphs did not puncture in the pod pericarp and pierced only the syrup soaked cotton. They remained still and raised their abdomen all the time. In older nymphs, the range of stylet sheaths was considerable. This may be the result of probing or unsuccessful attempts at feeding. Each pod punctured by the insect became rotten easily, and there were spots on the pod surface.

Adult longevity. The influence of various food on mean longevity of adults after emergence is summarized in Table 8. Without food, the insects died in about a week. The females lived longer than the males. Providing food increased the insect's life span. Insects survived longer on dry seeds than on soybean plant with pods. Females survived longer on green pods while males did on dry seeds.

Germplasm Screening for Limabean Podborer Resistance

Summary

Among 1,000 soybean accessions screened for resistance to limabean pod borer, *Etiella zinckenella*, five accessions were least damaged and found promising for future tests. Three accessions were less damaged in the second test of 15 accessions monthly planted from July to October. There was a significant positive correlation between seed size or trichome density on pods and podborer damage. Similar results were obtained when 24 entries from *G. max* and *G. soya* cross progenies were tested along with certain *G. max* accessions. Among four insect resistant plant introduction (PI) accessions, PI 227687 was consistently least damaged in four plantings. The higher the trichome density (between 200 to 320/6.25 mm^2 on pod) the greater was the podborer damage. Among accessions with varying trichome densities on pods, the higher the trichome density (between 100 to 600/6.25 mm^2 pod surface), the greater the podborer damage.

Introduction

In tropical to subtropical Asia, limabean podborer, *Etiella zinckenella* (Trietsche) (Lepidoptera: Pyralidae), causes serious damage to soybean. It is a polyphagous insect and attacks other legumes including mungbean, cowpea and lentil. The insect lays eggs mainly on the developing pods and larvae bore inside and feed on developing seeds. Thus, soybean yield is reduced. Past resistance screening at AVRDC identified seven soybean accessions which had significantly less pod damage. Investigation of the resistance revealed that these accessions were late maturing and escaped podborer infestation

Table 4. Duration of various growth stages of *R. clavatus* reared at different temperatures.

Temperature	Duration (days)[z]							Sex ratio
	Egg	Nymphal stages					Total nymphal period	F:M
		1	2	3	4	5		
20°C	12.75 ± 0.54	4.23 ± 0.45	6.37 ± 0.61	5.31 ± 0.53	7.32 ± 0.62	12.29 ± 1.17	35.47 ± 0.99	1:0.52
25°C	7.88 ± 0.32	2.41 ± 0.27	3.69 ± 0.07	3.38 ± 0.13	4.44 ± 0.42	8.16 ± 0.48	22.01 ± 1.69	1:0.86
30°C	5.25 ± 0.54	1.64 ± 0.26	2.47 ± 0.15	2.45 ± 0.15	2.67 ± 0.23	5.01 ± 0.78	13.78 ± 0.56	1:0.80
35°C	4.13 ± 0.61	1.45 ± 0.26	1.83 ± 0.09	1.77 ± 0.19	2.32 ± 0.35	4.33 ± 0.89	11.52 ± 1.27	1:0.92

[z]Data are means of 50 eggs and varying number of nymphs in different instars.

Table 5. Mortality of *R. clavatus* at different life stages at various temperatures.

Temperature	Egg stage (days)	Mortality (%)[z]					Adult	Cumulative
		Nymphal instars						
		1	2	3	4	5		
20°C	4.40 a	8.46 a	25.22 a	13.90 ab	15.88 b	54.48 a	8.00 a	80.40 b
25°C	3.32 ab	10.35 a	3.78 b	2.03 b	6.71 c	41.05 bc	5.26 a	56.08 c
30°C	0.84 b	3.29 a	7.75 b	13.98 ab	5.91 c	26.17 c	3.03 a	46.33 d
35°C	2.90 ab	7.25 a	23.01 a	14.97 a	33.60 a	69.87 a	10.19 a	89.60 a

[z]Mean separation in each vertical column by DMRT at 5% probability level.

Table 6. Distribution of *R. clavatus* eggs on various surfaces.[z]

Oviposition surface	Distribution of eggs (%)
Upper leaf surface	11.0 a
Lower leaf surface	31.4 a
Other plant parts	14.6 a
Container wall	43.0 a

[z]Data are mean of 3 replicates. Mean separation by DMRT at 5% probability level.

Table 7. Number of feeding sheaths formed at different nymphal stages of *R. clavatus*.

Nymphal stages	No. of pods	Mean no. of stylet sheaths/pod	Range
1	30	0	0
2	11	8.2 ± 3.79	3-15
3	14	10.35 ± 7.68	1-27
4	13	22.38 ± 7.68	6-40
5	16	41.75 ± 7.05	12-59

Table 8. Influence of various food on average longevity of adults.[z]

Food source	Longevity (days)	
	Male	Female
Green pods	17.1 b	24.0 a
Dry seeds	30.8 a	27.5 a
None	6.7 c	7.5 b

[z]Rearing temperature 25 ± 1°C. Mean separation by DMRT at 5% probability level.

which is seasonal in Taiwan. In other locations, seasonality is either different than Taiwan's or pest population is high throughout the year, as in Indonesia. In such places these apparently resistant accessions are susceptible. To select a resistant soybean accession irrespective of seasonality, the screening procedure was modified five years ago. In the new screening (preliminary), the same set of 1,000 accessions were planted twice, once in September and October. For confirmation, the same set of soybean accessions were planted four times; once each in July, August, September and October. This arrangement minimized the chances of avoiding podborer infestation due to difference in time of pod setting and peak of podborer population.

In a preliminary screening in 1987-88, 1,000 soybean accessions were screened. In addition, a population of *Glycine max* × *G. soja* crosses were screened. In one experiment, soybean accessions with varying levels of trichome density on their pods were also screened.

Materials and Methods

Preliminary screening A 0.8 ha parcel of land was rototilled, applied with basal fertilizers and worked into 0.75-m wide raised beds which were further divided into 5-m long plots. Seeds of each accession were sown as a single row on each bed. The first set of 1,000 accessions was planted in September 1987. The second set was planted a month later in an identical manner. The crop was raised following the standard cultural practices including irrigation, weeding, fertilizer application and disease control to achieve high yields. No insecticide was applied.

At flowering of the earliest-maturing accession and at about 10-day intervals thereafter, a large number of pupae of laboratory reared limabean podborers were released at a regular distance throughout the field. All plants were harvested and their pods examined for limabean podborer damage. The number of healthy and podborer damaged pods was recorded and percentage of damaged pods was calculated.

Data were analyzed by a statistical procedure based on the mean and standard deviation (SD) of percent damaged pods. This enabled the classification of the germplasm into: highly resistant (HR), with percent pod damage less than mean−2SD; moderately resistant (MR), with percent damage

between mean−2SD and mean−1SD, low resistance (LR), with percent damage was between mean and mean−1SD; susceptible (S), with percent pod damage between mean and mean+2SD; and highly susceptible (HS), with pod damage greater than mean+2SD.

Confirmation screening. In the first screening, podborer infestation and damage observation procedures used were identical with the preliminary screening except that 15 accessions were planted four times (once each in July, August, September and October). At every screening, each accession was planted in three randomly selected plots, each plot representing one replicate. Percent of pod damage was analyzed by ANOVA and means were separated by DMRT. At harvest, the diameter of each pod between two points on the flattened seed surfaces was also measured. Trichomes at four 2.5 mm × 2.5 mm points on the pods were also counted. Podborer damage, pod size and trichome density were analyzed for linear regression to determine the correlation between pod size or trichome density and podborer damage.

In the second screening, four defoliator resistant PI accessions were evaluated along with two susceptible checks in four plantings (once each in July, August, September, and October). The field design, growth of crop, podborer observation, pod character observation and statistical analysis used in this test were identical to that of the first one.

Screening of progenies from a wide cross. Twenty populations from crosses between *G. max* and *G. soya* were screened with four *G. max* susceptible checks. The field design, growth of crop, podborer damage observation, pod character observation and statistical analysis procedure used were identical to the confirmatory test except that the crop was planted once in September 1987.

Screening of accessions with varying trichome density. Soybean accessions with density range of 115 to 663 trichomes/4 mm^2 pod surface were screened. The field design, growth of crop, podborer damage evaluation, pod morphology study and statistical analysis used were similar to the confirmatory test, except that the crop was planted once in September.

Results and Discussion

Preliminary screening Results of podborer damage and resistance reaction of soybean germplasm are summarized in Table 9. In both screenings, the number of accessions damaged by the podborer followed normal distribution. The mean as well as range of damage was considerably higher in September than in October. As in the past tests, there was a considerable variation in the extent of podborer damage between two screenings. Certain accessions that were least damaged in one test were not necessarily least damaged in the other. Such variation in podborer damage of selected accessions (Table 10) was probably due to the difference in days to flowering and pod setting among various accessions and the peak of podborer infestation. As a result, pods were the same in certain late pod-setting accessions in the first planting with those in early maturing accessions in the second planting, when podborer population was high. These entries suffered greater damage, while early pod-setting accessions in the first planting and late ones in the second escaped podborer damage. Despite this variation, G 6359, G 6455, G 6497, and G 7180 were considerably less damaged in both plantings. Their performance along with that of certain susceptibles is summarized in Table 11. Their resistance reaction was not influenced by date of pod-setting implying that they might possess veritable resistance. As the experiment was conducted on a single replicate, these accessions will be screened in 1988-89 in a multireplicate test to assess the morphological characters of the plants and study the mechanism of resistance.

Confirmation screening Results of the first screening are summarized in Table 12. Although 10 test entries were screened because these were less damaged in previous tests, only G 3469, G 3543, and G 3574 were least damaged in four plantings. Considerable variation was observed in podborer infestation among four screenings. For example, accession G 3266 was the least damaged in the first screening but most damaged in subsequent three screenings. Similar, but less conspicuous

variations were observed in other accessions. However, G 3469, G 3543, and G 3574 were relatively damaged in four screenings.

Except in the first planting, a significant positive correlation was observed between pod diameter and pod damage (Fig. 2). This raises the possibility that resistance of these accessions was due to their smaller pods rather than to the resistance they possess. A similar phenomenon was observed in all screenings conducted in the past.

Table 9. Distribution of soybean germplasm for limabean podborer resistance in various resistance categories in two screenings, AVRDC 1988.

Resistance category[z]	First screening[y]		Second screening[x]	
	Pod damage (%)	No. of Accessions	Pod damage (%)	No. of Accessions
HR	<8.89	11	<0.86	1
MR	8.90 to 15.23	119	0.87 to 5.24	137
LR	15.24 to 21.57	386	5.25 to 9.62	389
S	21.58 to 34.25	307	9.63 to 18.38	288
HS	>34.26	132	>18.39	140
		955		955
Damage range	3.45 to 49.33%		0 to 28.57%	
Mean	21.57%		9.62%	
S.D.	6.34		4.38	

[z]HR = highly resistant, MR = moderately resistant, LR = has low resistance, S = susceptible, HS = highly susceptible. [y]Planting date = 87/9/23. [x]Planting date = 87/10/15.

Table 10. Variability in podborer damage in certain soybean accessions in two screenings, AVRDC 1988.

Accession no.	First screening[z]		Second screening[y]	
	Pod damage (%)	Resistance rating[x]	Pod damage (%)	Resistance rating
G 6230	8.3	HR	17.6	HS
G 6285	29.1	HS	3.8	MR
G 6308	30.2	HS	5.2	MR
G 6401	28.7	HS	5.1	MR
G 6526	35.9	HS	2.7	MR
G 6656	28.7	HS	2.5	MR
G 6843	29.8	HS	4.9	MR

[z]Planting date: 87/9/23. [y]Planting date: 87/10/15. [x]HR: highly resistant, MR = moderately resistant, HS: highly susceptible.

Table 11. Resistance of selected soybean accessions to podborer infestation in two screenings, AVRDC 1988.

Accession no.	First screening[z]		Second screening[y]	
	Pod damage (%)	Resistance rating[x]	Pod damage (%)	Resistance rating
G 6359	8.3	HR	5.15	MR
G 6455	7.3	HR	4.68	MR
G 6497	3.4	HR	2.07	MR
G 7180	7.8	MR	2.54	MR
G 6988	42.5	HS	24.28	HS
G 7272	32.7	HS	28.13	HS

[z]Planting date: 87/9/23. [y]Planting date: 87/10/15. [x]HR = highly resistant, MR = moderately resistant, HS = highly susceptible.

Table 12. Resistance to limabean podborer of selected soybean accessions and breeding lines.

Entry designation	Damaged pods (%) in various screenings[z]			
	I screening	II screening	III screening	IV screening
G 3469	10.0 bcd	13.4 g	4.3 h	5.5 b
G 3472	10.1 bcd	21.8 efg	8.2 fgh	6.9 b
G 3515	13.1 a	31.7 cde	15.2 d	10.1 b
G 3543	9.7 cd	18.9 fg	12.5 def	5.5 b
G 3574	9.4 cd	16.2 fg	5.9 gh	6.3 b
G 3638	9.9 bcd	25.4 def	12.3 def	6.1 b
G 3681	12.6 ab	30.5 cde	9.2 efgh	6.4 b
G 3755	11.9 abc	23.0 efg	10.2 defg	9.7 b
AGS 99	10.0 bcd	30.4 cde	14.5 de	7.3 b
AGS 169	9.7 bcd	25.5 def	12.7 def	8.3 b
G 74 (S)[y]	8.9 d	38.3 bc	24.9 c	9.7 b
G 298 (S)	10.5 abcd	21.5 efg	41.9 a	11.3 b
G 488 (S)	12.9 a	35.4 cd	25.5 c	16.8 a
G 1269 (S)	13.1 a	47.9 ab	26.0 bc	8.8 b
G 3266 (S)	9.3 cd	52.1 a	31.0 b	19.0 a
Mean damage	10.7	28.8	17.1	10.0
S.D.	1.5	5.8	3.1	3.0

[z]Planting dates: 1 screening: 87/7/16, II screening: 87/8/14, III screening: 87/9/23, IV screening: 87/10/14. [y](S) = susceptible check.

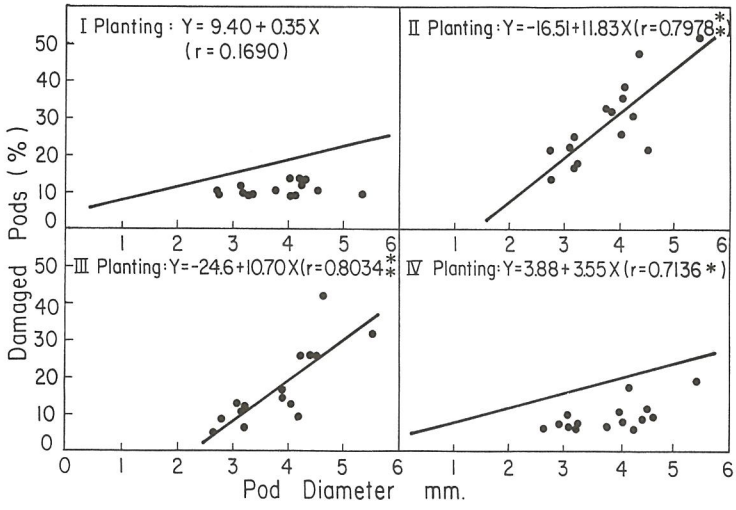

Fig. 2.
Correlation between pod size and limabean podborer infestation in selected soybean accessions in four plantings, summer-autumn 1988.

No significant correlation was observed between trichome density on pods and podborer damage (Fig. 3) within the range of 150 to 300 trichomes/6.25 mm^2. Within this range, plant constituents did not seem to influence podborer infestation.

In the second test, podborer infestation of four defoliators (resistant PI accessions) is summarized in Table 13. PI 227687 was consistently less damaged than other PI accessions in four tests except the first, when PI 229358 had slightly less damage. Other PI accessions, particularly PI 171451, was susceptible as the checks. There was also a significant positive correlation between pod size and pod damage (Fig. 4). This phenomenon was similar to observations in other tests.The resistance of PI accessions seemed to be associated with smaller pods which presumably made the plant parts less acceptable for oviposition. It is also possible that small pods did not provide the insects with enough food to survive. Oviposition appeared to be more important. This aspect will be evaluated in 1988.

A significant positive correlation was observed between trichome density and podborer infestation (Fig. 5) except in the third screening. No such relationship was observed in previous tests. PI

Table 13. Infestation of selected defoliator-resistant PI accessions by limabean podborer.

Entry designation	Damaged pods (%) in various screenings[z]			
	I screening	II screening	III screening	IV screening
PI 171444	8.7 b[x]	9.5 b	28.1 b	23.4 bc
PI 171451	12.7 b	9.8 b	44.1 a	30.0 b
PI 227687	6.8 b	8.7 b	12.5 c	13.7 c
PI 229358	6.7 b	9.5 b	37.6 ab	14.5 c
G 6(S)[y]	12.7 b	13.6 b	32.2 ab	31.3 b
G 3166(S)	28.8 a	23.4 a	47.7 a	46.4 a
Mean	12.5	14.4	34.5	26.6
S.D.	10.0	25.9	7.1	6.5

[z]Planting dates: I screening:87/6/17, II screening: 87/7/16, III screening: 87/8/14, IV screening: 87/9/23. [y](S)= susceptible check. [x]Mean separation within columns by DMRT at 5% probability level.

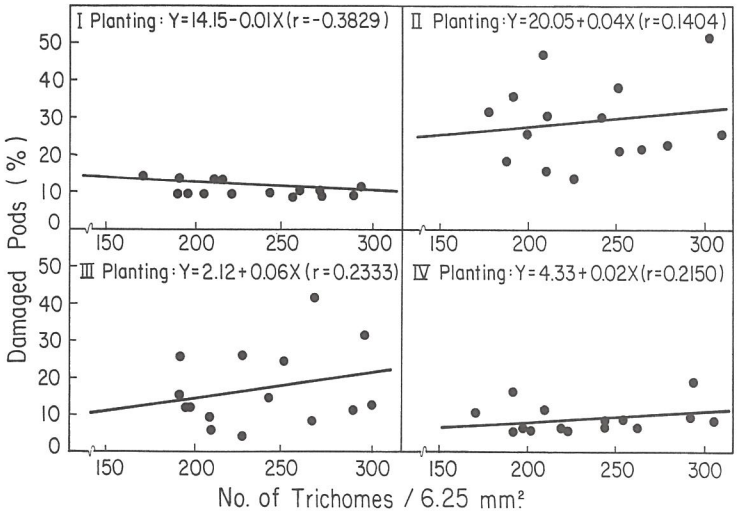

Fig. 3.
Correlation between trichome density on pods and limabean podborer infestation in selected soybean accessions in four plantings, summer-autumn 1988.

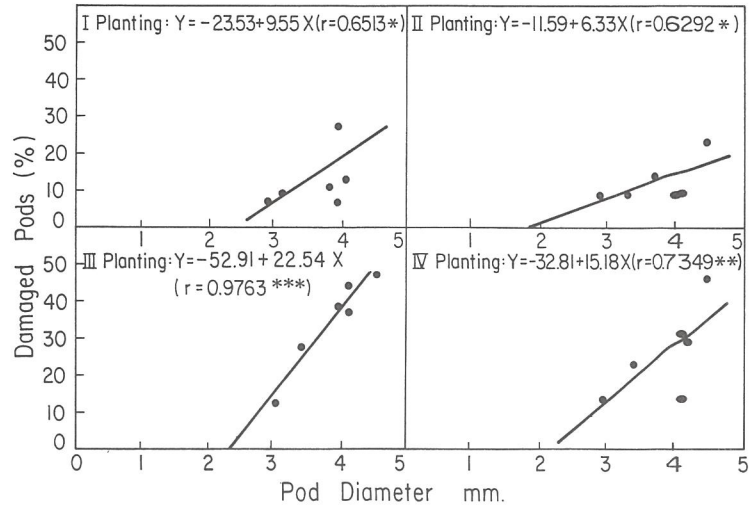

Fig. 4.
Correlation between pod size and limabean podborer infestation in selected insect-resistant PI accessions.

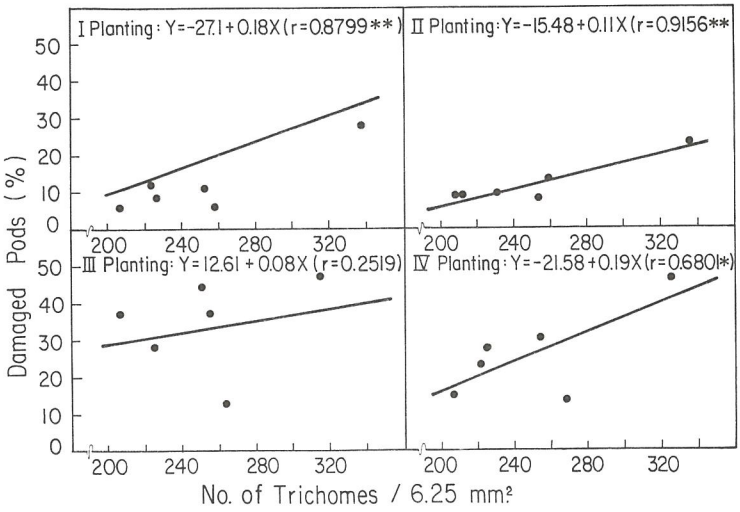

Fig. 5.
Correlation between trichome density on pods of selected insect-resistant PI accession and limabean podborer damage.

accessions included in the present test had higher trichomes than the accessions in the previous test. Within the range of 200 to 340 trichomes/6.25 mm^2 pod surface, the relationship was positive. It was possible that higher trichome density favored oviposition as the eggs were laid on the pods. The trichome presumably provided hooks for the insects to move about and lay eggs on which in turn were protected by trichomes. This phenomenon needs further investigation in 1988 to deduce a criterion for selecting podborer-resistant germplasm.

Screening of widecross progeny This screening aimed to determine if *G. soya* parents have high trichome density and hard pod covers and find out if interspecific progeny might have retained some of these characters, hence increasing chances of being resistant to the limabean podborer. Most interspecific cross populations have small pods. So, G 2120, a small seeded *G. max* accession was included as a check.

Results of podborer infestation of interspecific crosses and certain susceptible accessions are summarized in Table 14. All interspecific crosses were significantly less damaged than the three *G. max* entries. G 2120, on the other hand, had less damage than the certain interspecific crosses. Pod size appeared as a dominant factor in insect infestation as a highly significant correlation was found between pod size and podborer damage. The bigger the pod, the greater was the podborer damage (Figure 6). This observation was identical to findings in the past. Similarly, the greater the trichome density within the range of 90 to 370 trichomes/6.25 mm^2 pod surface, the greater was the podborer damage (Figure 7). This phenomenon was also observed in all previous tests.

Table 14. Infestation of *G. max* × *G. soja* cross progeny by limabean podborer.

Entry designation	Pod damage (%)	Entry designation	Pod damage (%)
KS 9	41.3 a	GC 90012-2-2-9B-YB-B	11.1 def
TK 5	29.4 b	GC 90012-2-18-9B-B	11.0 def
AGS 66	18.6 c	GC 90012-2-10-8B-B	10.9 def
GC 90012-2-8-4B-B	14.5 cd	GC 90012-2-24-1B-B	10.8 def
GC 90012-2-8-5B-B	13.6 d	GC 90012-2-7-7B-XB-B	10.4 defg
GC 90012-2-25-1B-B	13.1 de	GC 90012-2-18-5B-B	10.3 defg
GC 90012-2-8-6B-B	12.9 def	GC 90012-2-16-2B-B	10.3 defg
GC 90012-2-7-1B-B	12.1 def	GC 90012-2-2-8B-YB-B	9.7 defg
GC 90012-2-16-5B-YB-B	11.8 def	GC 90012-2-10-7B-B	8.3 efg
GC 90012-2-19-4B-B	11.8 def	GC 90012-2-11-5B-B	8.2 efg
GC 90012-2-16-1B-YB-B	11.2 def	GC 90012-2-7-2B-YB-B	7.8 fg
GC 90012-2-26-1B-XB-B	11.1 def	G 2120	5.4 g

Mean separation by DMRT.

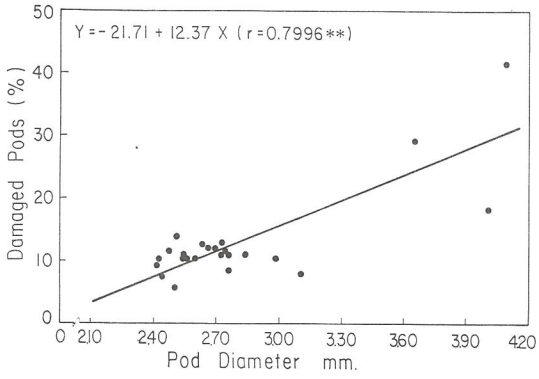

Fig. 6. Correlation between pod size and limabean podborer infestation in *Glycine max* × *G. soya* cross progeny.

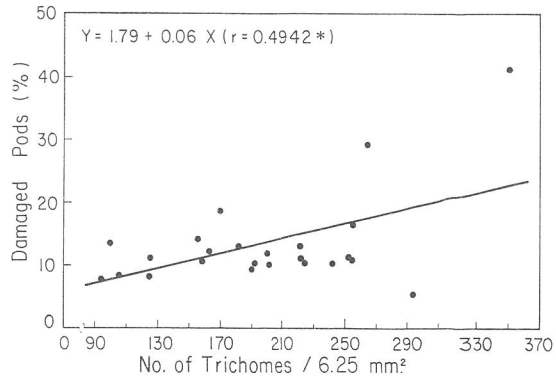

Fig. 7. Correlation between trichome density on pods and infestation of limabean podborer in *G. max* × *G. soya* cross progeny.

Screening of different trichome density accessions. The soybean entries included in this test were selected based on trichome density on their pods ranging from 128 to 522 trichomes per 6.25 mm^2 pod surface. The purpose was to gain insights on the role of these plant parts in podborer infestation. A significant correlation between trichome density and podborer infestation was also found. Within the range of 128 to 522 trichomes/6.25 mm^2 pod surface, the greater the trichome density, the greater was the insect infestation (Figure 8). These results and those of previous experiments imply the need to develop an almost glabrous cultivar to protect the crop from podborer infestation.

Pod size of all entries was also measured to correlate it with podborer damage. A significant positive correlation was observed between pod size and podborer damage (Figure 9). The bigger the pod, the greater was the insect infestation.

Findings from four tests expressed the need to develop a soybean cultivar which has glabrous pods and small seeds. Although small-seeded cultivars have, in addition to apparent podborer resistance, other desirable characters such as seed quality, their yield potential is low. Therefore, research efforts need to be continued to seek a resistant soybean accession with bigger seeds. This accession, if it ever exists, will be truly resistant to podborers.

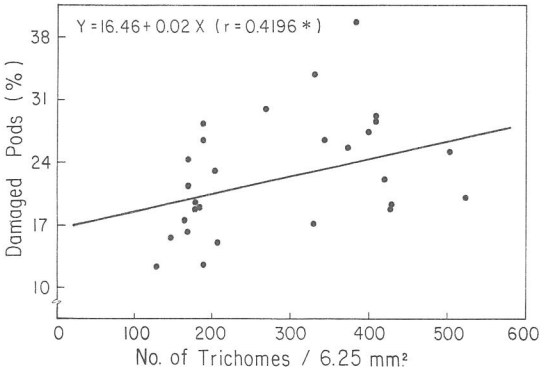

Fig. 8. Relationship of trichome density on pods and limabean podborer infestation of soybean.

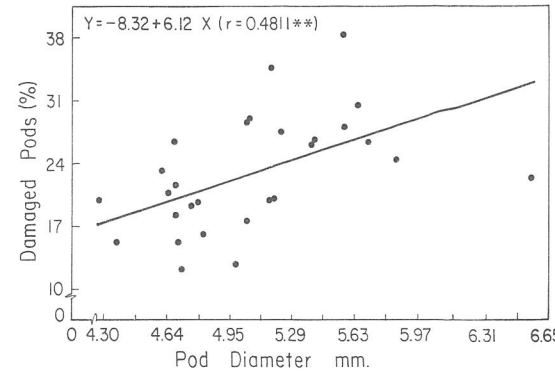

Fig. 9. Relationship between pod size and limabean podborer infestation in soybean.

Soybean Pathology

Advanced Soybean Rust Tolerance Trials

Summary

Eight lines tested had good yield potential similar to fungicide-treated and high-yielding check cultivar G 38. Six lines yielded significantly higher than AGS 181 (highly tolerant check) when not treated with fungicide. Two lines, SRE-D-14C and SRE-D-14D, had the most outstanding yield, regardless of the presence or absence of soybean rust.

Introduction

Previous research indicated that considerable variation in rust tolerance level is found in soybean. The utilization of a tolerant cultivar is the most practical control method in developing countries in Southeast Asia where soybean rust is a serious disease. An advanced soybean rust tolerance trial was conducted in the spring of 1988 to evaluate and select lines with improved level of rust tolerance and high yield. The best selections will be tested in countries where soybean rust is prevalent.

Materials and Methods

The experiment was conducted in the spring of 1988. Two SRE-B lines, three SRE-C lines and two SRE-D lines, selected from advanced trials were planted together with four check cultivars, G 38 (high yielding check), AGS 129 (high yielding check), AGS 181 (highly tolerant check) and Kaohsiung No. 8 (local high yielding check). These lines were selected based on uniform morphology, resistance to lodging in rainy season, and tolerance to rust as well as high-yielding potential under severe rust stress. The plot size for each cultivar was 3×6 m^2 (2×5 m^2 harvested area), and the plant density was equivalent to 400,000 plants per hectare. A split-plot design with four replicates was used. The main plots had fungicide- and nonfungicide-protected treatments. Subplots were planted to advanced lines and check cultivars. Planting was on 2 March 1988. All nonfungicide-treated plots were artificially inoculated four times with rust spore suspension (2,000 uredospores/ml) starting at R1 stage and twice a week to induce severe rust infection. The fungicide-treated plots were sprayed with Dithane M-45 every two weeks. AVRDC cultural practices were followed.

Data collection included yield, 100-seed weight and days to maturity. Data on yield were converted to 13% moisture content before evaluation and yield loss was expressed as percent of fungicide-treated yield.

Results and Discussion

The yield of lines tested was similar to G38 (high yield check) with fungicide treatment (Table 1). Except for the two SRE-B lines, six lines also yielded significantly higher than AGS 181 (highly tolerant check) without fungicide application. SRE-D-14C and SRE-D-14D yielded 2.2 and 2.5/ha, respectively under very severe rust infection. The yield loss of eight lines, except SRE-B-15A and SRE-B-15C, was much lower than the highly tolerant check, AGS 181.

An analysis of the 100-seed weight (Table 1) showed that SRE-D-14C and SRE-D-14D had the largest seed in both with fungicide and without fungicide treatments. The percent of yield loss was highly correlated to the percent of loss of 100-seed weight (r^2 = 0.8816) due to rust.

SRE-D-14C and SRE-D-14D yielded similar to high-yielding check cultivars G38 and KS-8 with fungicide treatment and significantly better than the highly tolerant check cultivar, AGS 181, without fungicide application. These two lines have good yield potential in spring, regardless of the presence or absence of rust.

Table 1. Yield and percent yield loss, 100-seed weight and percent of loss of lines grown under fungicide- and nonfungicide-protected conditions against soybean rust, spring 1988.

Entry	Yield (t/ha)		% yield loss	100-seed wt. (g)		% yield loss
	F[z]	NF[y]		F	NF	
SRE-B-15A	2.5	1.4	42.2	18.3	14.7	19.8
SRE-C-56A	2.8	1.9+	30.6	26.9+	24.0+	10.5
SRE-C-56C	2.8	1.9+	30.7	25.7+	23.5+	8.6
SRE-C-56E	2.9	1.9+	32.9	19.8	17.6+	11.2
SRE-D-14B	2.6	1.8+	30.1	23.3+	20.1+	13.3
SRE-D-14C	2.9	2.2+	22.0	25.4+	24.6+	2.8
SRE-D-14D	3.0	2.5+	15.5	25.7+	25.0+	3.0
SRE-B-15C	2.7	1.6	39.7	18.6	15.5+	16.5
G 38 (CK)	2.7	1.4	48.8	19.2	13.3	30.5
AGS 129 (CK)	3.6+	1.9+	47.4	17.0−	11.5−	32.2
AGS 181 (CK)	2.4	1.4	39.5	18.2	13.3	26.1
KS 8 (CK)	3.0+	1.4	53.7	25.6+	17.8	29.9
LSD 0.05	0.3			1.56		

[z]Fungicide protected, + = significantly ($P < 0.05$) greater than yield check cultivar, G38; − = significantly less than G38. [y]No fungicide protection, + = significantly ($P < 0.05$) greater than highly tolerant check cultivar, AGS 181; − = significantly less than AGS 181.

Advanced Rust Tolerance Trial in Hualien

Summary

Lines GC 82021A, AGS 216, AGS 217 and AGS 299 yielded significantly greater than the local check Hualien No. 1, with fungicide application. These lines, however, were very susceptible to rust. Two lines, SRE-C-56E and SRE-D-11A, had higher yield than the local checks either with or without fungicide treatment. The percent of loss of 100-seed weight due to rust was very highly correlated to percent of yield loss (r^2 = 0.8168). The 1987 and 1988 trials indicated that line SRE-D-11A had a very high level of rust tolerance and high yield under Hualien environment.

Introduction

In previous studies, significant variation in relative yielding potential under rust stress was found among soybean cultivars. Soybean rust spread rapidly in Hualien in spring. Therefore, rust tolerance trials had been established at AVRDC and at Hualien DAIS to evaluate and select soybean lines with improved level of rust tolerance, high yield and early maturity under severe rust stress. More tolerant lines (determined by percent yield loss and yield in the rust-stressed treatment) with higher yield than the checks were selected for regional yield trials.

Materials and Methods

Sixteen tolerant lines were selected from last year's trials at AVRDC and Hualien DAIS and were planted in a 3 × 6m^2 plot. Plant density was equivalent to 200,000 plants/ha. The check cultivars were AGS 129 (high-yielding check), AGS 181 (SRE-E-11A, highly rust tolerant check), Hualien #1 (local check) and Hualien 70-40 (local check). A split-plot design with three replicates was used.

The main plots consisted of the fungicide and nonfungcide-treated plants, and advanced lines and checks were used in the subplots. Sowing was on 7 March 1988. The protective fungicide, 80% Dithane M-45 w.p., was sprayed every two weeks beginning on 1 April. Local cultural practices were followed. Data collected included yield, 100-seed weight and yield loss as expressed in percent of fungicide-treated yield.

Results and Discussion

Lines SRE-C-22A, C-56A, C-56B, C-56C, C-56D and SRE-D-14B, D-14C, D-14D showed low tolerance to cold temperatures of early spring in Hualien and gave a poor yield. GC 82021A, AGS 216, AGS 217 and AGS 299 yielded significantly higher than the local check cultivar, Hualien No.1, under fungicide-treatment (Table 2). However, due to soybean rust infection, these lines only yielded equal to the local check cultivar, Hualien 70-40, without fungicide treatment.

Lines, SRE-C-56E and SRE-D-11A, yielded similarly as the high-yielding check cultivar, AGS 129 and the local check cultivars, Hualien #1 and Hualien 70-40, under fungicide treatment. Without fungicide, the yield of SRE-C-56E and SRE-D-11A was also significantly higher than the local checks, Hualien #1 and Hualien 70-40. SRE-C-56E also showed a yield loss less than the highly tolerant check, AGS 181.

The 100-seed weight of SRE-C-56E and SRE-D-11A with fungicide was also similar to the local check cultivars, Hualien #1 and Hualien 70-40. However, under severe rust outbreak SRE-C-56E had a bigger seed than local checks (Table 2). This consideration becomes important when the cultivar is ready for release. In Table 1, a very high correlation was observed between the percent of loss of 100-seed weight and the percent of yield loss ($r^2 = 0.8168$). This high r^2 value indicates that soybean rust affected seed size then substantially reduced the yield under rust severity.

Yield data of six lines in 1987 and 1988 are compared in Table 3. The line SRE-D-11A with fungicide treatment yielded similarly as the local check cultivars, Hualien #1 and Hualien 70-40. Without fungicide, SRE-D-11A did not only yield significantly higher than the local checks but also showed higher tolerance than check cultivar, AGS 181, in both years. It also showed a yield loss of 14.33%

Table 2. Yield, percent yield loss, 100-seed weight and weight loss of advanced breeding lines and commercial cultivars grown with and without fungicide during spring 1988 in Hualien.

Entry	Yield (t/ha)		% yield loss	100-seed wt. (g)		% yield loss
	F[z]	NF[y]		F[z]	NF[y]	
SRE-B-15A	1.6	1.0	37.4	21.3 –	18.2	14.5
SRE-B-15C	1.0 –	0.9	14.7	21.3 –	18.1	15.0
SRE-C-22A	0.8 –	0.9	-9.5	20.3 –	19.5	3.9
SRE-C-56A	0.7 –	0.7	10.1	29.4	27.4 +	6.8
SRE-C-56B	1.0 –	0.7	23.3	28.5	28.3 +	0.7
SRE-C-56C	0.5 –	0.4	18.0	29.4	29.1 +	1.0
SRE-C-56D	0.8 –	0.5	36.3	30.0	24.2 +	19.3
SRE-C-56E	1.8	1.6 +	12.7	25.7	25.4 +	1.2
SRE-D-11A	2.0	1.3 +	36.0	23.5	17.9	23.8
SRE-D-14B	0.8 –	0.6	29.3	25.5	20.1	21.2
SRE-D-14C	0.8 –	0.6	27.8	27.7	25.6 +	7.6
SRE-D-14D	0.8 –	0.7	25.0	30.4 +	25.0 +	17.8
GC 82021A	2.2 +	1.0	51.4	18.8 –	12.4 –	34.0
AGS 216	2.4 +	0.8	66.5	27.8	17.6	36.7
AGS 217	2.6 +	0.9	65.4	22.9	11.9 –	48.0
AGS 299	2.8 +	0.6	78.4	22.3	10.7 –	52.0
AGS 129 (CK)	1.8	1.0	43.5	20.0 –	14.2 –	29.0
AGS 181 (CK)	0.8 –	0.5	33.3	21.1 –	16.4	22.3
Hualien #1 (CK)	1.8	0.6	66.0	26.2	16.6	36.6
Hualien 70-40 (CK)	1.8	0.8	55.4	25.6	19.0	25.8
LSD 0.05	0.4			4.18		

[z]Yield from those with fungicide treatment, + = significantly ($P < 0.05$) greater than the local check cultivar, Hualien #1; – = significantly less than Hualien #1. [y]Yield from those without fungicide, + = significantly ($P < 0.05$) greater than the local check cultivar, Hualien 70-40; – = significantly less than Hualien 70-40.

Table 3. Advanced rust tolerance trials in Hualien DAIS, 1987 and 1988.

Entry	Yield (t/ha) spring 1987			Yield (t/ha) spring 1988		
	F[z]	NF[y]	loss (%)	F[z]	NF[y]	loss (%)
SRE-B-15A	2.2	1.8+	17.0	1.6	1.0	37.4
SRE-B-15C	2.1	1.9+	14.0	1.0-	0.9	14.7
SRE-C-22A	2.4	2.0+	11.3	0.8-	0.9	-9.5
SRE-C-56A	2.4	2.0+	13.9	0.7-	0.7	10.1
SRE-D-11A	2.6	2.2+	14.3	2.0	1.3+	36.0
SRE-D-14B	2.6	2.0+	19.7	0.8-	0.6	29.3
AGS 129 (CK)	2.6	1.7	36.0	1.8	1.0	43.5
AGS 181 (CK)	2.2	1.7+	22.6	0.8-	0.5	33.3
Hualien #1 (CK)	2.0	1.3	36.4	1.8	0.6	66.0
Hualien 70-40 (CK)	2.3	1.3	44.9	1.8	0.8	55.4
LSD 0.05	0.4			393.7		

[z]Yield from those with fungicide treatment. [y]Yield from those without fungicide. + = significantly ($P < 0.05$) greater than the local check cultivar, Hualien #1; - = significantly less than Hualien #1. [x]Yield from those without fungicide. + = significantly ($P < 0.05$) greater than local check cultivar, Hualien 70-40.

and 36.01% in the spring of 1987 and 1988, respectively. The results showed that SRE-D-11A is not only highly rust tolerant but also high yielding under Hualien DAIS environment. This line is suitable for planting in spring in Hualien.

Effects of Soybean Rust Severity and Tolerance Levels on Rust-induced Yield Loss

Summary

Rust-tolerant and susceptible soybean cultivars were evaluated in four trials in fall 1986, spring and fall 1987 and spring 1988. In the susceptible cultivar, TK #5, the loss of green leaf area (GLA) occurred earlier and was higher than that of the tolerant cultivar, SRE-B-15A, in each of the four seasons. Percentage of the estimated total GLA was highly correlated to the yield potential of two cultivars in each season.

The higher estimated total GLA induced higher yield in SRE-B-15A than in the susceptible cultivar, TK #5 in each season, indicating a slower rate of disease development in this cultivar than in TK #5.

The percentage of estimated total GLA loss due to soybean rust was very closely related to the percentage of yield loss ($r^2 = 0.8347$) in two cultivars in all seasons. TK #5 showed a higher percentage of total GLA loss due to rust at each growth stage in each of the four seasons than the tolerant cultivar, SRE-B-15A. Therefore, the yield loss of TK #5 was much higher than that of SRE-B-15A in the same treatment in the same season. The percentage of GLA of tolerant cultivars is the most important factor related to the yield ability under rust infection.

Introduction

Soybean rust, caused by *Phakopsora pachyrhizi*, is one of the major constraints in growing soybean in the tropics and subtropics of the eastern hemisphere. Heavy rust infections reduce the chlorophyll content and the rate of photosynthesis of infected leaves. Soybean rust usually reduces yield by causing premature defoliation and by decreasing the plant's pods and seeds. This experiment aimed to quantify the effect of soybean rust severity and tolerance level on rust-induced yield loss.

Materials and Methods

Two soybean cultivars, SRE-B-15A (tolerant to rust) and Taita Kaohsiung No. 5 (susceptible to rust), were planted on 3 October 1986, 2 March and 21 September 1987, and 3 March 1988. The plot size was 4×6 m^2 with 2 m between cultivars and 2 m between treatments. Plant density was

equivalent to 400,000 plants per hectare, i.e. 10 cm between hills, 2 plants per hill and 50 cm between rows.

A split-plot design with four replicates was used. The main plots consisted of the cultivars. The subplots were made of four treatments: 1) artifical inoculation and induced rust infection starting at R_1 growth stage; 2) artificial inoculation and induced rust infection starting at R_3 growth stage; 3) artificial inoculation and induced rust infection starting at R_5 growth stage; 4) spraying of 80% Dithane M-45 w.p. at weekly intervals to control rust. Standard AVRDC cultural practices were followed. The plots were pipe-irrigated for 10 min three times a week at R1 growth stage to allow the development of rust.

Rust severity was evaluated once a week beginning at R_2 growth stage, using the Horsfall-Barrat rating system. Defoliation was evaluated by counting the number of defoliated leaves of sample plants. Yield was evaluated from a 3 × 5 m^2 area in the center of each plot and calculated at 13% seed moisture content. Yield loss was expressed as percent of yield treated with fungicide. Yield potential was expressed as percent compared with the highest yield in the treatments of the same cultivar in the same season. The percentage of GLA was estimated as: [100% - % of defoliation - % of rust-infected foliage] × (100% - % of defoliation) in the unprotected treatment, but the percentage of GLA in the control treatment = 100% - % of defoliation in the control. The percent of GLA loss was estimated as GLA in protected treatment minus GLA in unprotected treatment in the same cultivar.

Results and Discussion

Since the control plots in each season were treated with fungicide, rust did not affect the foliage. In the nonfungicide-treated plots, rust infection resulted from natural and artificial inoculation and was favored by the pipe irrigation. Soybean rust caused a significantly earlier and higher loss of GLA in TK #5 than in SRE-B-15A in the same treatment of each season (Table 4). In TK #5, all treatments resulted in rapid rust development and caused more serious infection than in SRE-B-15A. The loss of GLA at R_6 stage (Treatment A) in TK #5 was 75.6, 81.7, 93.1 and 89.1% in fall 1986, spring 1987 (Table 5), fall 1987 (Table 6) and spring 1988 (Table 7), respectively. However, in

Table 4. Percentage of GLA loss at different growth stages in soybean, fall 1986.[z]

Vareity	Treatment[y]	% of GLA Loss							
		R_2	R_4	R_5	$R_{5.5}$	R_6	$R_{6.3}$	$R_{6.5}$	R_8
TK #5	A	0.0	19.3	30.5	55.2	75.6	86.8	98.1	99.7
	B	0.0	3.8	18.6	41.6	57.7	67.8	93.0	99.0
	C	0.0	0.0	0.1	6.9	19.1	25.4	51.0	82.0
	D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		R_3	R_4	$R_{5.5}$	$R_{5.8}$	R_6	$R_{6.3}$	$R_{6.5}$	R_7
SRE-B-15A	A	0.0	0.0	1.0	6.7	11.5	25.2	42.4	68.9
	B	0.0	0.0	0.9	6.0	6.1	16.9	28.2	52.8
	C	0.0	0.0	0.0	2.6	5.8	8.5	14.3	11.2
	D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[z]Planted: 3 October 1986. [y]A - Inoculated and induced rust infection at R1 growth stage. B - Inoculated and induced rust infection at R3 growth stage. C - Inoculated and induced rust infection at R5 growth stage. D - Treated with fungicide.

Table 5. Percentage of GLA loss at different growth stages of soybean, spring 1987.[z]

Variety	Treatment[y]	% of GLA Loss						
		R_2	R_3	R_5	$R_{5.5}$	$R_{5.8}$	R_6	R_8
TK #5	A	8.8	20.0	36.3	59.5	81.6	81.7	99.9
	B	2.6	11.3	23.4	39.2	58.3	88.7	99.7
	C	2.5	7.7	9.3	24.4	45.5	78.1	99.0
	D	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		R_3	R_4	R_5	$R_{5.5}$	R_6	$R_{6.5}$	R_7
SRE-B-15A	A	5.0	6.2	10.0	26.6	32.9	58.5	80.0
	B	5.0	5.3	7.5	17.5	17.1	26.3	60.4
	C	0.0	5.2	5.1	13.4	13.9	21.3	46.6
	D	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[z]Planted: 2 March 1987. [y]A - Inoculated and induced rust infection at R1 growth stage. B - Inoculated and induced rust infection at R3 growth stage. C - Inoculated and induced rust infection at R5 growth stage. D - Treated with fungicide.

Table 6. Percentage of GLA loss at different growth stages of soybean, fall 1987.[z]

Variety	Treatment[y]	% of GLA Loss					
		R_2	R_4	R_5	$R_{5.5}$	R_6	$R_{6.8}$
TK #5	A	2.1	9.1	27.5	45.0	93.1	99.3
	B	1.1	3.4	19.2	31.3	81.2	97.4
	C	0	1.9	14.3	11.1	35.3	61.5
	D	0	0	0	0	0	0
		R_3	R_4	R_5	$R_{5.5}$	$R_{6.5}$	$R_{6.8}$
SRE-B-15A	A	1.1	0.1	6.1	15.4	48.8	65.4
	B	0.5	0	5.7	5.4	28.1	46.3
	C	0	0	0.9	1.3	7.4	15.4
	D	0	0	0	0	0	0

[z]Planted: 21 September 1987. [y]A - Inoculated and induced rust infection at R1 growth stage. B - Inoculated and induced rust infection at R3 growth stage. C - Inoculated and induced rust infection at R5 growth stage. D - Treated with fungicide.

Table 7. Percentage of GLA loss at different growth stages of soybean, spring 1988.[z]

Variety	Treatment[y]	% of GLA Loss						
		R_2	R_3	R_5	R_5	R_6	$R_{6.5}$	$R_{7.5}$
TK #5	A	15.1	40.6	57.9	74.2	89.1	97.5	99.2
	B	4.5	12.2	23.1	48.9	70.4	86.7	97.3
	C	1.8	4.4	11.5	17.4	39.4	58.9	92.4
	D	0	0	0	0	0	0	0
		R_3	R_3	R_5	R_6	$R_{6.5}$	$R_{6.8}$	$R_{7.5}$
SRE-B-15A	A	9.1	17.2	30.5	44.9	53.3	67.7	84.3
	B	4.1	8.7	14.1	16.2	32.5	58.2	75.3
	C	2.5	4.3	6.2	9.2	16.5	22.0	52.4
	D	0	0	0	0	0	0	0

[z]Planted: 3 March 1988. [y]A - Inoculated and induced rust infection at R1 growth stage. B - Inoculated and induced rust infection at R3 growth stage. C - Inoculated and induced rust infection at R5 growth stage. D - Treated with fungicide.

SRE-B-15A, loss of GLA was only 11.5, 32.9, 48.8 and 44.9% in fall 1986, spring 1987, fall 1987 and spring 1988, respectively. Results clearly indicated that the disease progressed more rapidly in TK #5 than in SRE-B-15A, confirming the high level of rust tolerance of SRE-B-15A. Furthermore, the disease developed earlier in spring than in fall.

The estimated total GLA in both cultivars was very closely related to the yield potential in each season. The correlation coefficient (r) for TK #5 was 0.95, 0.97, 0.93 and 0.93 in the fall 1986 (Table 8), spring 1987 (Table 9), fall 1987 (Table 10), and spring 1988 (Table 11), respectively. For SRE-B-15A, it was 0.85, 0.91, 0.87 and 0.93 in fall 1986, spring 1987, fall 1987, and spring 1988, respectively. These figures suggested a higher estimated total GLA induced higher yield in the tolerant cultivar SRE-B-15A, than in the susceptible cultivar, TK #5, in four seasons.

The percentage of estimated total GLA loss due to soybean rust in both cultivars is very closely related to the percentage of grain yield loss in four seasons. The correlation coefficient (r^2) is 0.96, 0.99, 0.90, 0.93 in TK #5 and 0.91, 0.96, 0.94, 0.99 in SRE-B-15A in fall 1986 (Table 12), spring 1987 (Table 13), fall 1987 (Table 14), and spring 1988 (Table 15), respectively. Between two cultivars and among four seasons, the correlation coefficient (r^2) was 0.83. The high value of r^2 suggested that soybean rust induced necrosis and yellowing directly affected the chlorophyll content and the rate of photosynthesis of infected leaves in both tolerant and susceptible cultivars and eventually reduced seed number, seed size and grain yield. The susceptible cultivar, TK #5, showed much higher percentage loss of total GLA due to rust at each growth stage than the tolerant cultivar, SRE-B-15A in each of four seasons. Therefore, the yield loss of TK #5 was much higher than SRE-B-15A in the same treatment in the same season.

Soybean rust infection started earlier and was more severe in spring than in fall. Therefore, yield loss was higher in spring than in fall in both tolerant and susceptible cultivars.

Table 8. Correlation between percentage of estimated total GLA and yield, fall 1986.

Treat.	Rep.	TK #5		SRE-B-15A	
		Estimated total GLA (%)	Yield potential (%)	Estimated total GLA (%)	Yield potential (%)
A	I	342.8	48.7	624.7	87.7
	II	329.9	45.2	625.5	86.5
	III	323.1	45.6	564.2	85.3
	IV	331.6	60.3	600.4	85.2
B	I	379.7	54.8	634.9	87.7
	II	383.7	52.4	637.8	84.2
	III	395.9	60.2	628.6	89.4
	IV	425.3	79.8	647.2	87.1
C	I	529.0	78.7	699.8	100.0
	II	526.2	83.4	699.6	98.6
	III	541.0	87.8	675.5	91.3
	IV	571.3	93.8	653.7	92.4
D	I	637.0	96.8	703.4	98.3
	II	621.0	100.0	713.4	95.9
	III	640.9	93.6	720.1	96.7
	IV	630.9	98.0	720.1	93.3
Correlation coefficient		r = 0.95	r = 0.85		
Correlation coefficient (2 varieties)		r = 0.93			

Table 9. Correlation between percentage of estimated total GLA and yield, spring 1987.

Treat.	Rep.	TK #5		SRE-B-15A	
		Estimated total GLA (%)	Yield potential (%)	Estimated total GLA (%)	Yield potential (%)
A	I	231.8	29.4	395.0	70.3
	II	237.3	29.7	383.6	73.5
	III	213.7	25.0	371.3	72.9
	IV	254.9	39.3	401.9	78.6
B	I	275.7	37.2	448.9	87.1
	II	292.7	41.7	424.9	85.7
	III	294.7	46.1	440.2	84.9
	IV	306.2	54.9	457.2	84.4
C	I	329.3	43.2	456.3	85.0
	II	314.0	41.7	447.8	87.4
	III	331.1	49.6	490.3	86.8
	IV	353.0	56.9	472.4	84.4
D	I	445.5	90.4	537.4	98.5
	II	493.9	90.6	523.5	100.0
	III	514.1	94.4	539.4	91.5
	IV	503.0	100.0	533.8	95.2
Correlation coefficient		r = 0.97	r = 0.91		
Correlation coefficient (2 varieties)		r = 0.97			

Table 10. Correlation between percentage of estimated total GLA and yield, fall 1987.

Treat.	Rep.	TK #5		SRE-B-15A	
		Estimated total GLA (%)	Yield potential (%)	Estimated total GLA (%)	Yield potential (%)
A	I	317.4	41.5	422.8	72.3
	II	289.7	37.5	403.8	77.5
	III	292.0	38.4	425.0	76.6
	IV	320.7	44.8	410.0	81.5
B	I	341.3	41.0	444.9	80.7
	II	324.1	42.3	455.3	78.0
	III	337.7	44.1	457.1	80.4
	IV	331.3	52.9	445.4	82.2
C	I	422.6	78.3	516.9	95.6
	II	408.1	88.0	498.5	100.0
	III	405.3	89.5	484.0	95.8
	IV	399.5	88.2	485.7	88.3
D	I	481.5	94.1	520.3	93.7
	II	502.5	93.1	509.5	98.1
	III	486.8	89.8	511.2	90.9
	IV	488.9	100.0	510.9	99.9
Correlation coefficient		r = 0.93		r = 0.87	
Correlation coefficient (2 varieties)		r = 0.93			

Table 11. Correlation between percentage of estimated total GLA and yield, spring 1988.

Treat.	Rep.	TK #5		SRE-B-15A	
		Estimated total GLA (%)	Yield potential (%)	Estimated total GLA (%)	Yield potential (%)
A	I	206.4	19.9	323.0	59.5
	II	189.8	25.6	314.2	62.2
	III	162.8	26.0	321.4	65.3
	IV	175.1	31.0	312.3	65.9
B	I	296.4	28.8	400.6	66.0
	II	269.8	34.5	400.7	71.9
	III	280.6	29.5	386.4	74.0
	IV	277.2	37.1	377.4	73.6
C	I	360.7	45.5	482.5	82.0
	II	345.8	39.9	466.1	82.0
	III	359.9	44.9	446.7	82.5
	IV	362.5	55.4	438.5	88.2
D	I	490.9	91.9	549.8	95.0
	II	482.5	100.0	540.7	96.9
	III	498.8	95.9	526.5	88.5
	IV	489.1	90.0	521.4	100.0
Correlation coefficient		r = 0.93		r = 0.93	
Correlation coefficient (2 varieties)		r = 0.92			

Table 12. Correlation between percentage of estimated total loss of GLA due to soybean rust and percentage of yield loss, fall 1986.

Treatment	TK #5		SRE-B-15A	
	Estimated total GLA loss	Yield loss total GLA	Estimated loss	Yield loss
A	455.2	48.6	155.9	10.2
B	381.5	36.4	110.9	9.4
C	184.7	11.5	42.4	0.5
D	0	0	0	0
	r^2 = 0.96		r^2 = 0.91	
	r^2 (2 var.) = 0.97			

Table 13. Correlation between percentage of estimated total loss of GLA due to soybean rust and percentage of yield loss, spring 1987.

Treatment	TK #5		SRE-B-15A	
	Estimated total GLA loss (%)	Yield loss total GLA (%)	Estimated loss (%)	Yield loss (%)
A	404.4	67.1	219.2	23.4
B	323.1	52.1	139.0	11.2
C	266.6	49.0	105.5	10.8
D	0	0	0	0
	r^2 = 0.99		r^2 = 0.96	
	r^2 (2 var.) = 0.94			

Table 14. Correlation between percentage of estimated total loss of GLA due to soybean rust and percentage of yield loss, fall 1987.

Treatment	TK #5		SRE-B-15A	
	Estimated total GLA loss	Yield loss total GLA	Estimated loss	Yield loss
A	276.1	57.0	136.8	19.5
B	233.5	52.2	86.1	16.0
C	124.1	8.8	25.0	0.8
D	0	0	0	0
	r = 0.90		r = 0.94	
	r^2 (2 var.) = 0.91			

Table 15. Correlation between percentage of estimated total loss of GLA due to soybean rust and percentage of yield loss, spring 1988.

Treatment	TK #5		SRE-B-15A	
	Estimated total GLA loss (%)	Yield loss (%)	Estimated total GLA loss (%)	Yield loss (%)
A	471.8	72.9	307.2	33.5
B	343.1	65.6	209.2	25.0
C	225.9	50.8	113.1	11.8
D	0	0	0	0
	r = 0.93		r = 0.99	
	r^2 (2 var.) = 0.87			

Conclusion

The percentage of GLA in tolerant soybean cultivars is the most important factor related to yield under severe rust conditions.

Screening of Wild Cultivars for Soybean Rust Resistance

Summary

Soybean rust is one of the major constraints to soybean production in Southeast Asia and no highly resistant soybean cultivar has been identified yet. A total of 100 wild *Glycine* accessions from Australia were screened to identify the sources of resistance. In two evaluations, fourteen accessions were rated

highly resistant. These accessions may provide the materials for interspecific soybean hybridization programs geared at improving rust resistance.

Introduction

Soybean rust, caused by *Phakopsora pachyrhizi* is one of the major constraints to soybean production in the lowland tropics and subtropics of the Eastern Hemisphere. Previous reports indicated that soybean and over 30 other genera of cultivated and wild legumes are affected by soybean rust. Despite years of research, no highly resistant soybean cultivar has been found yet. This experiment was designed to screen wild perennial *Glycine* species (received from Dr. J. J. Burdon, CSIRO, Division of Plant Industry, P.O. Box 1600, Canberra City, A.C.T. 2601, Australia) for soybean rust resistance and to identify potential sources for resistance that may be incorporated into soybean through interspecific crosses.

Materials and Methods

One hundred accessions of wild perennial *Glycine* and two checks, AGS 181 (highly tolerant check) and Taita Kaohsiung No. 5 (TK #5) (susceptible check), were planted on 4 March 1988 for preliminary screening for rust resistance in spring. Sixteen accessions rated highly resistant in the preliminary screening were planted on 2 September 1988 for further screening.

Five seeds of each accession were sown in four 15 cm diameter clay pots containing sterilized potting media (5:3:1:1 soil:compost:rice hull:sand). Two weeks later, seedlings in each pot were thinned to three only. The pots were placed outside the greenhouse (replications and per accession) surrounded by the susceptible soybean variety TK #5, also in planted pots.

When most plants reached flowering and pod-setting, these were artificially inoculated three times at 3-4 day intervals with rust spore suspension (2,000 uredospores/ml). Disease resistance was evaluated at least three weeks after the last inoculation. The rating system was based on the percentage of foliage infection: highly resistant (HR) - no or very few lesions; moderately resistant (MR) - less than 20% foliage infection; and, susceptible (S) - more than 20% foliage infection.

Results and Discussion

Sixteen accessions developed only a few lesions, whereas, others did not. These were rated highly resistant in spring 1988 (Table 16). These 16 accessions were reevaluated in fall and 14 accessions were found highly resistant (Table 16). In contrast, two check soybean varieties and even the highly tolerant variety AGS 181, were rated susceptible.

The 14 highly resistant accessions belong to four wild *Glycine* species: *G. argyrea*, *G. clandestina*, *G. tabacina* (2n = 80) and *G. fomentella* (diploid and tetraploid) (Table 17). These accessions may provide excellent materials for interspecific soybean hybridization in the future.

Factors Leading to Soybean Seed Deterioration

Summary

This study aimed to determine the factors that lead to soybean seed deterioration. High temperature and high relative humidity during reproductive stage affected seed deterioration. The percentage of clean seeds which did not germinate and were not infected by microorganisms had higher correlation (r^2 = 0.945) to percentage of seed germination than microorganism infection (r^2 = 0.592). The effect of accumulated precipitation on seed germination was more important than the accumulated daily average temperature. A high percentage of microorganisms, such as *Colletotrichum*, *Phomopsis*, *Macrophomina*, *Fusarium*, *Alternaria*, *Cercospora*, *Penicillium* and some bacteria was found in the seeds.

Table 16. Disease rating and number of *Glycine* accessions screened for resistance to soybean rust in 1988.

Disease rating[z]	No. of entries	
	Spring	Fall
Highly resistant (HR)	16	14
Moderately resistant (MR)	9	2
Susceptible (S)	73	0
Nongermination	2	0
Total	100	16

[z]HR = No or few lesions; MR = Less than 20% foliage infected; S = More than 20% foliage infection.

Table 17. Wild *Glycine* accessions and species which were rated highly resistant to soybean rust in 1988.

Species	No. of accessions	Accessions
Glycine argyrea	4	1626, 2003/9, 2003/13, 2004/1
G. clandestina	3	1664, 1225, 1558
G. tabacina (2n = 80)	4	1226, 1254, 1258, 1262
G. tomentella (diploid)	2	1316, 1366
G. tomentella (tetraploid)	1	1359

Introduction

Soybean seed deterioration is a major constraint to soybean yield in the lowland tropics of Southeast Asia. Soybean seed deterioration is caused by pathological, physiological and varietal factors. The loss of seed viability results in poor stand and is accelerated by high ambient temperatures and high relative humidity. This study was designed to identify the causes of seed deterioration under AVRDC conditions and to determine their importance on seed germination.

Materials and Methods

Soybean cultivar, TK #5, was planted monthly from August 1986 to December 1987. The plot size was 7 × 10 m^2 with four replicates (each 1 × 1 m^2) and plant density was equivalent to 400,000 plants/ha. AVRDC standard cultural practices without fungicide application were followed.

Pods were harvested from each replicate when plants reached the R_8 stage (with 95% mature pods). The pods were then dried and the seeds were threshed until the moisture content was lower than 13%. The seeds were used for the isolation of microorganisms and the germination test. One hundred seeds from each replicate in every harvesting were randomly collected to test the microorganisms present. The seeds were rinsed in two changes of sterile water, surface sterilized in 1% aqueous solution of sodium hypochlorite for 10 minutes and rinsed again with two changes of sterile water.

Ten treated seeds were placed in a petri dish containing 15-20 ml potato dextrose agar, and incubated at 24°C for 5-7 days before identifying the microorganisms and evaluating germination.

Results and Discussion

Percentage of germination in each harvesting from 25 May to 16 December 1987 was lower than 80% (Table 19). This period covered the rainy season. Results indicated that soybean seed was affected by rains which reduced the chance for germination. However, the germination in other harvests (except in 11 November 1986) was quite high — more than 85%. The results indicated that high-quality seed was easily produced during cooler temperature and lower relative humidity.

Clean seeds which had no microorganism infection failed to germinate in the warm humid season (Table 18). This is equal to 62-91% of total seeds which did not germinate (Table 19).

This result indicated that abiotic environmental factors mainly caused seed deterioration and low germination rate during the warm and wet season. The correlation between percentage of clean seed which did not germinate and percentage of germination in each harvesting was very high

Table 18. Deterioration of soybean cultivar TK #5[z] in relation to germination.

Date planted	Date harvested	% of[y] germination	% did not[y] germinate	Nongerminated seed	
				% of seed with clean coat and noninfected by microorganism	% of seed damaged by microorganism
8/1/86	10/30/86	86.0	14.0	5.3	8.8
8/29/86	11/17/86	68.3	31.7	12.0	19.8
9/30/86	12/20/86	90.5	9.5	6.0	3.5
10/30/86	2/2/87	92.3	7.7	3.3	4.5
11/28/86	3/23/87	95.0	5.0	3.0	2.0
12/31/86	4/22/87	88.8	11.2	10.8	0.5
1/27/87	5/1/87	85.3	14.7	13.3	1.5
2/26/87	5/25/87	72.8	27.2	23.5	3.8
4/1/87	7/9/87	51.3	48.7	34.5	14.3
5/1/87	8/12/87	52.8	47.2	38.5	8.8
5/29/87	9/7/87	18.3	81.7	59.3	22.5
7/1/87	9/29/87	40.0	60.0	47.0	13.0
8/3/87	10/22/87	58.8	41.2	37.5	3.8
8/26/87	11/10/87	67.8	32.2	20.0	12.0
10/1/87	12/16/87	74.5	25.5	17.5	8.0
11/2/87	1/29/88	93.0	7.0	2.3	4.8
12/1/87	3/17/88	93.5	6.5	2.8	3.8

[z]100 seeds were collected from each of four replications in each harvesting. [y]Means of four replications.

Table 19. Germination rate of clean and microorganism-noninfected soybean cultivar TK #5.[z]

Date harvested	% did not[y] germinate (A)	% of seed with clean coat and noninfected by microorganism (B)	% of B/A
10/30/86	14.0	5.3	37.9
11/17/86	31.7	12.0	37.9
12/20/86	9.5	6.0	63.2
2/2/87	7.7	3.3	42.9
3/23/87	5.0	3.0	60.0
4/22/87	11.2	10.8	96.4
5/1/87	14.7	13.3	90.5
5/25/87	27.2	23.5	86.4
7/9/87	48.7	34.5	70.8
8/12/87	47.2	38.5	81.6
9/7/87	81.7	59.3	72.6
9/29/87	60.0	47.0	78.3
10/22/87	41.2	37.5	91.0
11/10/87	32.2	20.0	62.1
12/16/87	25.5	17.5	68.6
1/29/88	7.0	2.3	32.9
3/17/88	6.5	2.8	43.1

[z]100 seeds were collected from each of four replications in each harvesting. [y]Mean of four replications.

(r^2 = 0.945), suggesting that percentage of germination coincided very closely with percentage of clean seed that failed to germinate.

However, in May to December 1987, only 3.8% to 22.5% of seeds did not germinate and also showed microorganism infection. The percentage of nongerminated seeds during the other harvesting period was also less than 8.8%, except those harvested on 17 November 1986 (Table 19). This result indicated that the warm and wet season was suitable for the development and infection of seed-borne pathogens which retard seed germination.

There were some pod and seed-inhabiting fungi, such as *Colletotrichum*, *Phomopsis*, *Macrophomina*, *Fusarium*, *Alternaria*, *Cercospora*, *Penicillium* and some bacteria recovered from the seeds (Table 20). A higher percentage of these microorganisms was found at harvest during warm and wet seasons. The correlation between percentage of seeds damaged by seed-borne pathogens and percentage of germination was not high (r^2 = 0.592). This correlation coefficient was much lower

Table 20. Bacterial infection on soybean cultivar TK #5 in each harvesting.

Date harvested	Bacteria	*Alternaria* spp.	*Fusarium* spp.	*Cercospora* spp.	*Colletotrichum* spp.	*Phomopsis* spp.	*Macrophomina* spp.	*Penicillium* spp.	*Rhizoctonia solani*	Others
10/30/86	+[z]	+	+	+	+	+	+			
11/17/86	+	+	+	+	+	+	+		+	+
12/10/86	+	+			+	+	+			+
2/2/87		+	+			+				+
3/23/87		+	+							
4/22/87	+		+							
5/1/87	+	+								
5/25/87	+	+	+				+			+
7/9/87	+	+	+	+		+	+	+		
8/12/87	+		+			+		+		+
9/7/87		+	+		+	+				+
9/29/87	+	+	+		+	+	+			
10/22/87	+		+			+		+	+	
11/10/87	+	+	+	+	+	+		+		+
12/16/87	+	+				+		+		+
1/29/88		+	+							+
3/17/88		+	+			+		+		

[z]400 seeds isolated in each harvesting.

than the former mentioned above (0.592 < 0.945). This indicated that this factor was less important than percentage of clean seeds which germinated but were not infected by microorganisms.

It may be possible that seeds which lost their viability before infection of the pathogens were included. Removal of nonviable seeds therefore, would probably increase the percentage of germination.

Clearly, there was a high negative correlation between the accumulated daily average temperature/precipitation and the percentage of germination from R2 to R8, from the middle of R2-R8 and from R6 to R8. The correlation coefficient during R2 to R8 was the highest (% of accumulated daily temperature vs. % of germination = -0.71110; % of accumulated precipitation vs. % of germination = -0.80765). These data showed that the longer the accumulation of temperatures/precipitation, the higher the negative correlation either in temperature or humidity (-0.71110 < -0.65857 < -0.52064 and -0.80765 < -0.75877 < -0.66871). Results also indicated that correlation between accumulated precipitation and percentage of germination is higher than the accumulated daily average temperature in each of the three growth periods (-0.80765 < -0.71110, -0.75877 < -0.6585), -0.66871 < -0.52064, respectively) suggesting that precipitation affects seed germination more than temperature does.

In brief, soybean seed was greatly affected by the variation of ambient temperature and humidity during the growth period. The next factor related to low germination rate during the warm and wet season was Microorganisms.

Effect of Seed Deterioration on Germination

Summary

Significant differences in germination were observed among TK #5, AGS 129 and PI459025. Seed deterioration by abiotic environmental factors and by seed-borne microorganisms caused the seed's failure to germinate in the first planting. However, high temperature and high humidity were the major causes of the seed's failure to germinate in later planting. Seed-borne microorganisms showed an almost 100% higher percentage of damage on germination. Fungicide application increased the germination rate of TK #5 in both plantings.

Introduction

Diseases are probably the important factors affecting soybean production in Southeast Asia. Plantings during rainy season were affected by lower stand and reduced seed quality. This study aimed to determine if varietal difference affects germination in different environments and evaluates seed deterioration by abiotic factors and microorganisms affecting seed germination.

Materials and Methods

Seeds of TK #5, AGS 129 and PI 459025 were harvested in fall 1987 and planted on 1 and 21 March 1988. The first planting followed the normal planting time for soybean in spring and the second planting delayed the harvesting to July and August. The plot size was 3 × 3 m^2 and plant density was equivalent to 200,000 plants/ha. A randomized complete block design with four replications was used in each planting. Weekly fungicide treatments of 80% Dithane M-45 w.p. mixed with 50% Benomyl w.p., 5% Bayleton w.p. were employed starting at the R_1 stage. A control was used in the experiment. AVRDC's standard cultural practices except the application of fungicide were followed.

Pods in plants at the center (2 × 2 m^2 part of the plot) were harvested when most plants in each plot of every planting reached R8 stage (with 95% mature pods). Seeds were threshed and dried until the moisture content was lower than 13%. The seeds were used for the isolation of microorganisms and germination test. Two hundred seeds were randomly collected from each plot, rinsed twice in sterile water, surface sterilized for 10 minutes in 1% aqueous solution of sodium hypochlorite, and rinsed again twice in sterile water. The treated seeds were placed in a 9-cm diameter petri dish containing 15-20ml potato dextrose agar, 10 seeds per dish. They were then incubated at 24°C for 5-7 days before the microorganisms were identified and the germination test was conducted.

Results and Discussion

There were significant differences in germination among the two varieties and one line in the first planting (Table 21). Seeds of PI 459025 showed 74% nongerminated seeds. This included 39% of the clean seeds that failed to germinate, and 35% of the seeds probably were damaged by microorganisms. Seed deterioration due to abiotic factors and microorganisms influenced the percentage of the germination of PI 459025 in the first planting. TK #5 also showed 11 and 12% damage due to abiotic factors and microorganisms, respectively. And AGS 129 showed 13.3 and 16% damage attributed to abiotic factors and microorganisms, respectively.

In the second planting, 50% of the seeds of TK #5 and AGS 129 germinated. Germination of PI 459025 seeds was almost nil (Table 22), with 96% *Fusarium* spp. infected seeds. This indicated the poor production quality of PI459025 during the hot and wet season. The other two varieties also showed a higher percentage of seed infection by microorganisms in the second planting compared with the first planting. This growth period coincided with the hot and wet season which was previously found unfavorable for the development of soybean seeds but favorable for the infection of seed-borne microorganisms. Infection induced a higher level of damage to seed during the hot and wet season than enviromental abiotic factors.

The application of 80% Dithane M-45 w.p. and 50% Benomyl w.p. significantly increased germination and reduced seed infection by microorganisms in TK #5. The application of fungicide on PI459025 delayed its maturity in the rainy season, thereby decreasing germination. However, in seeds with clean coat and free from microorganism infection, the germination was 44% and 37% with fungicide and without fungicide application, respectively.

Fungicide application affected germination only in TK #5. Seed infection by microorganisms was higher when no fungicide was applied. There was no difference in seed deterioration among seeds of the three varieties with fungicide and no fungicide application. Due to increased temperature and humidity, the percentage of damage either by microorganisms or by abiotic factors increased. Results of the experiment clearly indicated that seed deterioration by abiotic environmental factors and by seed-borne pathogens caused the low germination rate during the hot and wet season. Nevertheless, it is necessary to identify the importance of these factors throughout the year.

Table 21. Effect of abiotic factors and microorganisms on the germination of soybean in the first planting.[z]

Variety/ line	Harvest period	% seeds[y] germinated	% non-germinated seeds	% seeds of abiotic deterioration	% seeds on which microorganisms were detected
TK #5	6/20-7/4	76.7 A	23.3 C	11.2 B	12.1 C
AGS 129	6/30-7/4	70.2 B	29.7 B	13.3 B	16.4 B
PI 459025	6/20-7/18	26.2 C	73.7 A	38.6 A	35.1 A

[z]Planted 1 March 1988. [y]Mean of three replications.

Table 22. Effect of abiotic factors and microorganisms on the germination of soybean in the second planting.[z]

Variety/ Line	Harvest period	% seeds[y] germinated	% non-germinated seeds	% seeds of abiotic deterioration	% seeds on which microorganisms were detected
TK #5	6/30-7/14	50.3 A	49.2 B	18.6 A	31.1 B
AGS 129	7/8-7/14	51.7 A	48.3 B	14.8 B	33.5 B
PI 459025	8/8-8/24	0.5 B	99.5 A	3.6 C	95.9 A

[z]Planted 21 March 1988. [y]Mean of three replications.

Screening for Bacterial Pustule Resistance

Summary

Bacterial pustule is one of the most important diseases of soybean in Southeast Asia during the warm rainy season. A total of 116 AVRDC breeding lines were artificially inoculated in the field

during the 1988 summer to confirm their bacterial pustule resistance. Eleven breeding lines rated highly resistant to bacterial pustule had AGS 269 as one of their parents.

Introduction

Bacterial pustule of soybean (*Glycine max* (L.) Merr.), caused by *Xanthomonas campestris* pv. *glycine* (Nakan Dye), is one of the most important diseases during the warm rainy season in Southeast Asia. The development of resistant varieties is therefore one of the major objectives of the AVRDC soybean improvement program.

Segregating populations from the resistant and susceptible lines and resistant selections were screened in the past. This trial was designed to reassess the bacterial pustule reaction of selected AVRDC breeding lines.

Materials and Methods

One hundred and sixteen progenies screened last year for bacterial pustule resistance were planted in two replications. The plot size was 3 × 1 m^2. Plant density was 500,000 plants/ha. The check cultivars were G 8190 (highly resistant), CNS (moderately resistant) and G38 (highly susceptible). The seedlings were artificially inoculated on 14 September 1988 when they reached R3 growth stage.

The inoculum was prepared by propagating the pathogen isolate (BP-1) on 523[1] medium plates, incubated at 32°C for 24 hr. The culture was washed off with distilled water and the bacterial suspension was filtered through two layers of cheese cloth. The suspension was diluted with tap water to 6.5 × 10^7 cfu/ml (OD absorption 0.30). The concentration of the bacterial suspension was determined by a spectrophotometer (Jasco, UVIDEC-340) at a wave length of 600nm. A sticker-spreader (BASF TOTAL WETT) was added at a dilution of 1:1000. Plants were inoculated by spraying the bacterial suspension on both the top and underneath the leaf with an atomizer at 25 kg/cm^2 pressure.

The disease rating was made 28 and 37 days after inoculation. The rating system followed: highly resistant (HR) = disease resistance similar to or less than G 8190; resistant (R) = disease severity slightly more than G 8190; moderately resistant (MR) = disease severity similar to G 2034 (CNS); (MS) = disease severity distinctly more than G 2034 and less than G 38; and highly susceptible (HS) = disease severity similar to or greater than G 38. The disease ratings made on 28 and 37 days after inoculation were generally similar. However, when ratings differed for a variety, the most severe rating between the two was chosen as the final one for that variety.

Results and Discussion

The highly susceptible cultivar G 38 had more severe pustule symptoms at 28 days after inoculation than the highly resistant G 8190 which had an insignificant amount of lesions at 37 days following inoculation. This suggested that the inoculation technique was uniform and effective.

Among the 116 breeding lines screened, 9.5% were rated highly resistant to bacterial pustule (Table 23). All had AGS 269 (HR) as one of their parents (Table 24). The 55 lines will be screened again to confirm their resistance. The results of the screening indicated that the preliminary screening of large segregating populations by the plant breeder effectively eliminated all the highly susceptible and almost all the moderately susceptible lines.

[1]Kado, C. I., and Heskett, M. G. 1970. Selective media for isolation of *Agrobacterium*, *Corynebacterium*, *Erwinia*, *Pseudomonas*, and *Xanthomonas*. Phytopathology 60:969-976.

Table 23. Disease reaction of AVRDC breeding lines to bacterial pustule, summer 1988.

Disease reaction[z]	No. of entries	%
HR	11	9.5
R	55	47.4
MR	48	41.4
MS	2	1.7
HS	0	0.0
Total	116	100.0

[z]HR: Disease severity similar to or less than G 8190. R: Disease severity slightly more than G 8190. MR: Disease severity similar to G 2034 (CNS). MS: Disease severity distinctly more than G 2034, but less than G 38. HS: Disease severity similar to or greater than G 38.

Table 24. Soybean cultivars and breeding lines highly resistant to bacterial pustule, summer 1988.

Line no.	Disease reaction	Pedigree
GC 86040-19	HR[z]	AGS 162 × AGS 269
GC 86032-18	HR	AGS 95 × AGS 269
GC 86032-17	HR	AGS 95 × AGS 269
GC 86026-48	HR	AGS 29 × AGS 269
GC 86026-23	HR	AGS 29 × AGS 269
GC 86026-51	HR	AGS 29 × AGS 269
GC 86022-12	HR	AGS 8 × AGS 269
GC 86022-17	HR	AGS 8 × AGS 269
GC 86028-4	HR	AGS 66 × AGS 269
GC 86028-14	HR	AGS 66 × AGS 269
GC 86040-1	HR	AGS 162 × AGS 269

[z]HR: Disease severity similar to or less than G 8190.

Soybean Physiology

Water Requirement and Drought Stress on Vegetable Soybean

Summary

Drought stress has influenced vegetable soybean yield and quality especially pod color and blemishes. Drought stress can reduce dry matter production, resulting low vegetable soybean yield and leaf area. The latter possibility, however, requires further investigation, including light effect on chlorophyll degradation, sunburn, or senescence of pods.

Introduction

In selecting a soybean cultivar for vegetable, the seed and pod size, palatability, color, texture, and the ease of gleaning the pods are considered. These criteria of vegetable soybean at immature stage respond to management practices and soil moisture conditions different from that of grain soybeans. This experiment aimed to evaluate the effect of drought stress on growth, and certain quality characteristics of vegetable soybeans.

Materials and Methods

Seeds of vegetable soybean varieties, Tzurunoko (G 9053) and Kaohsiung Sel. No. 1 (AGS 292), were sown on 2 February 1988 in PVC pots (30 cm × 35 cm) containing 6 kg per pot of sand loam soil mixed with sand and compost. At planting, the growing medium contained 830 ppm N, 64 ppm P_2O_5, and 216 ppm K_2O. Side dressing of 0.5 g $(NH_4)_2SO_4$ per pot was applied at R_2 stage. A plant was grown per pot in the plastic house. Eight modes of watering were applied at specific days after sowing (DAS). The range of maximum and minimum watering in the growing medium was as follows:

1. Control, continuous supply of standard amount of water; 10.3-16.5%
2. Water withholding at V_5-R_1 (39 to 47 DAS); 9.0 to 17.0%
3. Water withholding at R_1-R_2 (46 to 54 DAS); 8.1-16.2%
4. Water withholding at R_3 (53 to 61 DAS); 9.4-15.9%
5. Water withholding at R_4-R_5 (60 to 68 DAS); 7.9-15.6%
6. Continuous watering at 2/3 of control; 10.9-13.3%
7. Continuous watering at 1/2 of the control; 9.6-12.6%
8. Continuous watering at 1/3 of the control; 8.8-11.2%

Plants were randomly assigned in three replications (eight pots/replication, four were harvested at 84 DAS and another four at 105 DAS). The plant height and number of leaves monitored weekly, days to first flowering, first fully developed pod and first harvestable pod, pod number with 0, 1, 2, and 3 seeds, immature pod and seed yield, mature seed yield, and fresh and dry weights of plant parts were measured.

In another experiment, a 21-m wide, and 14-m long sloping bed was planted to G 9053 and seeds of AGS 292 were sown (two plants per hill in rows) on 15 March 1988. Parallel with the direction of slope, rows were divided into four sections at 3.5 m/section. Plot size was 1.5 m × 3.5 m, each

with three rows. Spacings were 10 cm × 50 cm and 20 cm × 50 cm. As a reference, drought tolerant and early maturing 'Grant' was also planted in 10 cm × 50 cm spacing. Before sowing 30-50-70 kg/ha of N-P-K fertilizer and 20 t/ha of compost were applied. Side dressing of 30 kg/ha of N fertilizer was applied at R_1-R_2 stage. During this experiment, light interception by the canopy was investigated from R_3 to harvest, and pod abscission potentials were measured. Other growth and quality parameters described above were also determined.

Results and Discussion

Based on plant height and leaf area, a significant drought stress occurred to a level of 70 to 80% of the control at 46 days after sowing. Although water withholding also reduced plant growth, soybean plants tended to recover when these were watered again. There was no significant plant height and leaf number observed between the control and water withholding at generative stages.

Generative stages are expressed in days to initial flowering. The first fully developed and harvestable pods were delayed by various modes of imposed drought stress; the greatest delay occurred with watering of 1/2 or 1/3 amount of the control, 3.5 days of first harvestable pods for both G 9053 and AGS 292. Short-term drought stress at R_1-R_2 stage delayed the development of first pods in both G 9095 and AGS 292. However, plants recovered from drought stress, and those suffering short-term drought stress did not differ in days of development to first harvestable pods from the control. Ratios of graded pods/total pods, i.e. number of pods with more than two seeds/total pod number, immature seed yield, and dry seed yield were reduced as a result of drought stress at generative stages (Table 1). However, great reductions occurred with the watering of 1/2 or 1/3 amount of the control.

Table 1. Effect of drought stress on vegetable soybean.[z]

Entry	Stress treatment	Graded pod no. /Total pod no.	Immature seed yield	Dry seed yield
G 9053	V5-R_1	74	74	83
	R_1-R_2	63	62	71
	R_3	110	96	88
	R_4-R_5	81	83	81
	2/3 of control	69	52	62
	1/2 of control	66	35	38
	1/3 of control	26	10	19
AGS 292	V_5-R_1	76	85	86
	R_1-R_2	63	73	68
	R_3	85	84	89
	R_4-R_5	76	83	76
	2/3 of control	69	60	60
	1/2 of control	37	54	40
	1/3 of control	44	39	35

[z]Expressed as % of the control.

Since continuous drought stress had a pronounced effect on soybean, these two vegetable soybean cultivars were grown in a sloping bed which would constantly provide gradient soil moisture content. In the sloping bed, soil water tension in the 20 cm depth 75-100 cm, 50-75 cm and 25-50 cm sections increased to about 55%, 35% and 20% more of the 0-25 cm section.

On the contrary, there were no significant differences on soybean generative development due to the difference in height in the sloping bed. The drought stress in the sloping bed was not severe enough to affect development. The minimum moisture content measured in the 15-20 cm depth at the 75-100 cm section was 9.5%, which was relatively higher than the previous pot experiment.

On individual plant basis, both total and graded pods were higher in the 0 to 25-cm section than in other sections in the sloping bed (Fig. 1). Both total and graded yields of G 9053 were higher in 20-cm spacing than 10 cm due to an increase in the number of branches (Table 2), but higher in 10 cm than in 20-cm spacing of AGS 292. This trend was also observed in grain seed yield.

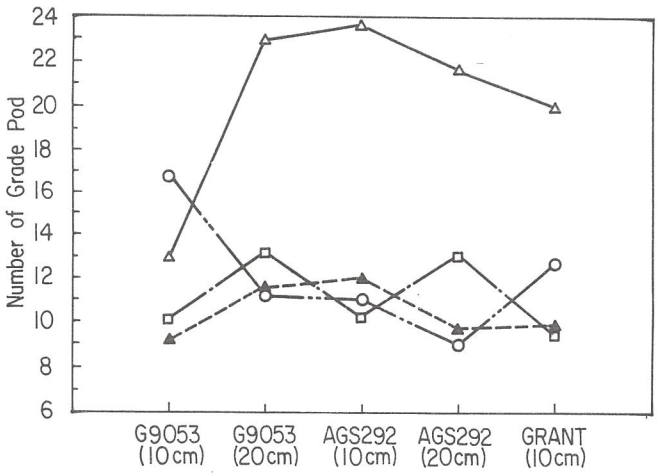

Fig. 1.
Graded pod number/plant of G 9053 and AGS 292 grown in two spacings at the sloping bed (□ - □, 75-100 cm; ▲ - ▲, 50-75 cm; ○ - ○, 25-50 cm; △ - △, 0-25 cm).

Table 2. Plant growth of vegetable soybean as affected by bed height and spacing, May 1988 (R6 stage).

Entry (spacing)	Bed height (cm)	Plant height (cm)	Node no. /plant	Branch no. /plant	Leaf area (cm^2/plant)	Total fresh wt. (g/plant)	Total dry wt. (g/plant)
	75-100	36.6	8.9	3.7 a	847	56.2	15.4 a
	50-75	32.3	8.6	3.2 ab	661	51.1	13.8 ab
G 9053	25-50	32.3	8.9	3.2 ab	793	58.4	15.1 ab
(10 cm)	0-25	35.9	8.8	2.1 b	704	45.5	11.8 b
	"X	34.3	8.8	3.1	751	52.8	14.0
	75-100	24.0	8.4	4.3	818 b	60.1	15.8
	50-75	27.2	8.7	5.6	1111 a	79.0	21.6
G 9053	25-50	26.9	8.3	4.8	1101 a	81.1	22.2
(20 cm)	0-25	25.0	8.1	4.1	747 b	56.7	14.2
	"X	25.8	8.4	4.5	944	69.2	18.4
	75-100	29.7	8.5	3.2	452	41.0	10.4
	50-75	28.1	8.2	1.9	513	45.6	11.3
AGS 292	25-50	29.3	8.9	2.4	503	47.0	11.9
(10 cm)	0-25	28.6	8.6	2.1	479	40.4	10.2
	"X	28.9	8.6	2.4	487	43.5	10.9
	75-100	23.5	8.1	2.5	478 b	48.9	12.5
	50-75	23.3	7.9	2.3	529 b	52.0	13.0
AGS 292	25-50	24.2	8.0	2.1	428 b	47.7	12.2
(20 cm)	0-25	25.0	7.8	3.0	805 a	59.2	14.9
	"X	24.0	7.9	2.5	560	51.9	13.2
	75-100	53.4 b[z]	13.2 ab	3.0	835 b	65.2 b	18.0 b
	50-75	65.7 a	14.2 a	2.0	1058 a	77.1 a	20.9 a
Grant	25-50	61.6 a	12.5 b	1.5	859 b	61.3 b	16.5 b
(10 cm)	0-25	65.3 a	13.0 ab	1.3	933 ab	64.1 b	17.2 b
	"X	61.5	13.2	2.0	921	67.0	18.1

[z]Mean separation within column of same spacing and entry by DMRT at 5% probability level.

Potential pod abscission was higher in AGS 292 than G 9053. But bed height and spacing seemed not to affect potential pod abscission, except with G 9053 at spacings of 20 cm × 50 cm in the sections of 0-25 and 25-50 cm, where pods were difficult to abscise (Figure 2). Pods from high sections of sloping bed tended to have lower chlorophyll content than from low sections; This was reflected in a number of blemished pods (Table 3). Both G 9053 and AGS 292 in 20 cm spacing within rows also had high chlorophyll content. This difference could be attributed to variation in leaf area; both G 9053 and AGS 292 grew in high sections and/or 10 cm intrarow spacing tended to have lesser

leaf area/plant than in low sections and/or 20 cm intrarow spacing (Table 2). It is possible that large leaf prevented direct exposure of pod shell to sunlight, thus decreasing sunburn in the pod shell. Alcoholic insoluble solid in immature seed was high in G 9053 from the high section of the sloping bed, but not in AGS 292 (Table 3). No clear indication of changes in protein, sugar and starch contents in immature seed was observed due to differences in bed height or spacing, except with AGS 292 at 20 cm × 50 cm spacing where seeds from high section had higher sugar contents than the low section.

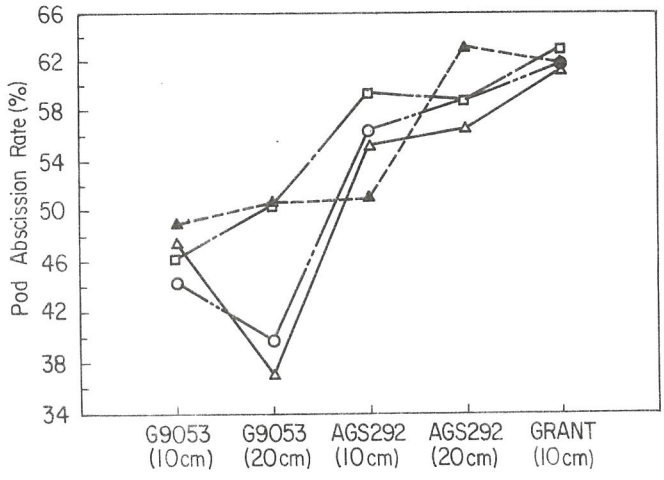

Fig. 2.
Potential pod abscission rate of G 9053 and AGS 292 grown in two spacings in the sloping bed (□-□ , 75-100 cm; ▲-▲, 50-75 cm; ○-○ , 25-50 cm; △-△ , 0-25 cm).

Table 3. Pod quality (%) and seed chemical composition (%) of vegetable soybean as affected by bed height and spacing.

Entry (spacing)	Bed height (cm)	TBP[z]	BP[y]	NBP[x]	Protein	Sugar	Starch	AIS[w]
	75-100	20.9	20.7	56.9	36.4	4.5	9.9	76.0 a
	50-75	24.5	27.5	53.5	39.8	3.6	10.1	75.9 a
G 9053	25-50	19.3	20.7	55.7	41.1	1.8	8.8	73.8 b
(10 cm)	0-25	17.5	37.4	59.6	39.9	3.9	10.0	73.3 b
	"X	20.5	26.6	56.4	39.3	3.5	9.7	74.7
	75-100	30.7 a[v]	35.6 a	42.6	37.2	4.4	9.4	74.8 a
	50-75	30.2 a	36.1 a	49.2	38.4	4.2	8.9	72.3 ab
G 9053	25-50	23.1 a	26.8 ab	46.8	39.6	3.5	7.6	73.8 ab
(20 cm)	0-25	12.3 b	17.9 b	45.4	40.6	4.2	8.1	73.3 b
	"X	24.1	29.1	46.0	39.0	4.1	8.5	73.5
	75-100	19.8	21.0	54.9	37.1	4.0	9.4	75.0
	50-75	24.9	26.8	52.5	38.9	4.8	9.6	75.2
AGS 292	25-50	22.9	42.0	41.2	36.4	3.4	8.2	74.3
(10 cm)	0-25	18.2	20.6	56.6	41.5	4.7	7.2	71.8
	"X	21.5	27.6	51.3	38.5	4.2	8.6	74.1
	75-100	32.4	34.6	48.2	35.7	5.7 a	10.9	74.6
	50-75	33.1	38.5	44.4	36.3	4.9 a	9.0	75.5
AGS 292	25-50	27.4	30.7	50.6	36.0	4.7 a	8.7	73.3
(20 cm)	0-25	22.1	28.7	48.0	36.8	2.8 b	9.7	74.1
	"X	28.7	33.1	47.8	36.2	4.5	9.6	74.4
	75-100	12.4 ab	15.1 ab	58.0	37.0	3.0	6.1 a	73.8
	50-75	12.6 ab	14.8 ab	60.6	37.4	4.1	6.5 b	73.9
GRANT	25-50	19.3 a	22.5 a	58.2	34.3	3.7	7.3 bc	73.2
	0-25	7.2 b	8.3 b	69.9	35.7	3.3	8.3 a	75.3
	"X	12.9	15.2	61.7	36.1	3.5	7.2	74.0

[z]Total blemished pod/total pod per plant × 100 (wt/wt). [y]Blemished pod with 2-3 seeds/2-3 seed pod × 100 (wt/wt). [x]Non-blemished pod with 2-3 seeds/total pod × 100 (wt/wt). [w]Alcoholic insoluble solid. [v]Mean separation within columns of same spacing and entry by DMRT at 5% probability level.

Relationship Between Spacing and Quality of Vegetable Soybean

Summary

Intrarow spacings affected vegetable soybean yield differences. Close spacing at 10 × 50 cm^2 produced highest graded pods of AGS 292, G 9053 and G 10134. However, an increase in pod was not necessarily associated with seed filling. Difference in the number of blemished pods was attributed to variety rather than spacing. Further investigations of the physiological aspects of pod filling could give important information about how to increase vegetable soybean yield and decrease blemish.

Introduction

There is considerable information on the influence of plant spacing to soybean growth and yield. It was observed from previous experiments that spacing in the sloping bed had some effects on the color of and blemish on the pod shell. The present study aimed to examine the effect of intrarow spacing on growth, yield and quality characteristics of vegetable soybean.

Materials and Methods

Seeds of G 9053 (Tzurunoko), AGS 292 (Kaohsiung Sel. No. 1) and G 10134 (Tainung 305, Ryokkoh) were sown in the field previously applied with NPK fertilizer at 30-50-70 kg/ha and 20 ton of compost on 3 March 1988. The soil contained 843 ppm N, 77 ppm P_2O_5, and 135 ppm K_2O at the time of sowing. Seedlings were later thinned to two plants per hill at spacings of 10 cm × 50 cm, 15 cm × 50 cm, 20 cm × 50 cm, and 25 cm × 50 cm. A randomized complete block design with three replicates was employed. Side dressing of 30 kg N/ha was applied at R_1-R_2 stage. The soil's water content at 15-20 cm depth ranged from 14.2 to 22.8% during the experiment.

Characteristics selected for study were plant height, leaf area, node and branch number and dry weights of different plant parts at 27, 48, 69, and 76 (AGS 292) or 82 (G 9053) days after sowing, days to first flowering, first fully developed and first harvestable pods, light interception by the canopy, potential pod abscission, pod number, pod shell color and pod blemishes, and protein, alcohol insoluble solids (AIS) and carbohydrate content in immature seeds.

Results and Discussion

Based on total dry matter accumulation and leaf area, G 10134 seemed to grow early and vigorously. After flowering, G 9053 and AGS 292 had significant amount of dry matter even though leaf area per plant in AGS 292 was lesser. There was a comparable dry matter accumulation at R_5-R_6 stage among three entries at the same spacing. At R_5-R_6 stage, there was a significant difference in height among varieties and spacings (Table 4). Tall plants were spaced at 10 cm × 50 cm for each entry, and short plants at 25 × 50 or 20 × 50 cm^2. There was no significant difference in the number of nodes among treatments. However, more branches and total dry weight per plant were observed at 25 cm × 50 cm in three entries.

Spacing did not influence generative stages, although AGS 292 flowered earlier (i.e. 21.6 to 3.4 days) and pods were ready for harvesting (in 3.5 to 4.6 days). G 9053 attained later flowering and pod maturity. Both G 9053 and AGS 292 had higher pod number than G 10134 (Table 5). The pod number per plant decreased from the close spacing to the sparse spacing. Similar trend was observed in grain seed yield. On the other hand, the number of seeds per pod increased from the close spacing to sparse spacing. The number of culled pods (pods with one seed or none at all) was high from sparse spacing. However, the number of graded pods (pods with 2 or 3 seeds) was not significantly different among three spacings. Among entries, G 10134 had the least graded pod number due to the least total number of pod produced but had comparable number of culled pod from other entries.

Significant yield difference on unit land basis of vegetable soybean was observed among treatments. Both G 9053 and AGS 292 had higher vegetable soybean yields per unit land area than G 10134 of the

Table 4. Effect of spacing on growth of three vegetable soybean cultivars at R_5-R_6 stage, 1988.

	Spacing (cm)	Height (cm)	Node no.	Branch no.	Dry wt. (g/plant)					Leaf area (cm^2/plant)
					Stem	Petiole	Leaf	Pod	Total	
	10 x 50	38.1	9.4	3.2	3.4	2.6	5.3	5.3	16.5	1085
	15 x 50	34.4	8.9	4.3	5.0	3.8	7.6	6.9	23.3	1581
G 9053	20 x 50	29.9	8.7	5.1	7.3	3.9	7.3	7.5	26.0	1444
	25 x 50	30.2	9.3	5.0	4.9	4.2	8.5	8.5	26.1	1675
	"X	33.2	9.1	4.4	5.1	3.6	7.2	7.0	23.0	1446
	10 x 50	33.4	8.7	3.8	2.5	1.2	4.1	9.6	17.4	734
	15 x 50	31.7	8.6	3.4	2.4	1.2	4.3	10.1	18.0	765
AGS 292	20 x 50	29.3	8.8	3.6	2.7	1.5	5.2	9.9	19.3	831
	25 x 50	30.2	9.5	4.8	3.6	1.9	6.9	12.1	24.5	1077
	"X	31.1	8.9	3.9	2.8	1.5	5.1	10.4	19.8	852
	10 x 50	43.9	9.1	2.8	4.2	2.6	5.7	5.3	17.8	933
	15 x 50	41.4	9.2	3.7	5.1	3.2	7.5	6.5	22.3	1209
G 10134	20 x 50	32.9	8.9	3.3	4.0	2.8	7.3	7.0	21.1	1216
	25 x 50	33.7	9.7	4.6	5.2	3.9	10.2	6.4	25.6	1818
	"X	37.9	9.2	3.6	4.6	3.1	7.7	6.3	21.7	1294
Entry	5%	2.38	NS	NS	1.41	0.49	0.99	0.91	NS	153
LSD Spacing	5%	2.75	NS	0.78	NS	0.57	1.14	1.05	3.5	177
E x D	5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5. Effect of spacing on yield and yield components of three vegetable soybean cultivars.

Entry	Spacing (cm)	Pod no. /plant	Culled pod no./plant[z]	Graded pod[y] no./plant	Immature pod wt. (g/plant)	Immature seed wt. (g/plant)	Graded pod wt.[y] (g/plant)	Graded pod yield (t/ha)	Seed yield (g/plant)
	10 x 50	22.0	5.7	16.3	0.56	0.09	34.5	13.8	21.3
	15 x 50	22.5	7.7	14.7	0.99	0.27	35.0	9.3	21.7
	20 x 50	31.3	11.5	19.9	2.14	0.51	46.8	9.4	28.4
G 9053	25 x 50	26.6	11.3	15.3	3.23	0.80	40.0	6.4	24.1
	"x	25.6	9.1	16.5	1.73	0.42	39.1	9.7	23.9
	10 x 50	19.0	7.9	11.1	1.40	0.41	31.1	12.5	19.0
	15 x 50	22.7	9.3	13.4	1.60	0.44	38.0	10.1	22.5
	20 x 50	27.5	12.0	15.5	1.98	0.58	48.8	9.8	30.0
AGS 292	25 x 50	27.7	11.1	16.6	1.65	0.38	54.1	8.7	30.7
	"x	24.2	10.1	14.1	1.66	0.45	43.0	10.3	25.6
	10 x 50	17.3	8.5	8.8	1.00	0.18	26.9	10.8	18.7
	15 x 50	17.9	9.3	8.5	1.19	0.25	28.3	7.5	19.8
	20 x 50	19.7	10.5	9.3	1.18	0.21	30.8	6.2	21.2
G 10134	25 x 50	20.3	11.3	9.1	1.22	0.16	31.5	5.0	20.8
	"x	18.8	9.9	8.9	1.15	0.20	29.4	7.4	20.1
	Entry 5%	3.0	NS	2.7	NS	0.20	6.2	1.7	3.7
L.S.D	Spacing 5%	3.5	1.6	NS	NS	NS	7.2	2.0	4.3
	E x D	NS	NS	NS	NS	NS	NS	NS	NS

[z]Pods with one seed or none at all. [y]Pods with 2 or 3 seeds.

same spacing. Within the same entry, however, highest yields were obtained in closest spacings and lowest yields were at wider spacings.

Small leaf area index in AGS 292 (i.e. 2.94 at 10 × 50 cm^2) at 69 days after sowing was attributed to less light intercepted by the canopy. As expected, on the other hand, close spacings in three entries increased light interception by the canopy due to large leaf area index, i.e. 4.34 and 3.73 at 10 × 50 cm^2 for G 9053 and G 10134, respectively, at 69 days after sowing. On unit land basis, the increased light interception was reflected in increased total dry matter production, but not in vegetable soybean yield.

There was no significant difference in pod abscission among spacings but AGS 292 had higher pod abscission than other entries, indicating that AGS 292 is easier to glean.

Spacings within the same entry did not influence the number of blemished pods. However, AGS 292 had more blemished pods than G 9053 and G 10134 (Table 6). This could be due to the pod's exposure to solar radiation; correlation coefficient between number of blemished pods and light penetration by the canopy was 0.73** at harvest. On the contrary, pod shells from wide spacings tended to have high chlorophyll concentrations, which could also be due to sunlight exposure. Pod shells of G 9053 had lowest chlorophyll concentrations. On chemical constituents in seed, total sugar and AIS content were not influenced by spacing. G 9053 had highest AIS content among three entries, whereas AGS 292 had highest sugar content in immature seed. On the contrary, there were significant differences in protein and starch contents in immature seed among varieties and spacings. AGS 292 had more starch but less protein than other entries. Wide spacing at 25 × 50 cm^2 increased starch content in AGS 292 and G 10134, but decreased protein content in G 10134.

Table 6. Effect of spacing on quality of three vegetable soybean cultivars.

Entry	Spacing (cm)	TBP[z]	BP[y]	Pod shell chlorophyll ($\mu g/cm^2$)	Protein	Sugar	Starch	AIS
		%			(% dry wt. basis)			
	10 × 50	25.4	27.4	6.7	36.8	4.6	8.2	76.0
	15 × 50	20.1	21.0	8.7	37.5	3.8	8.8	78.2
	20 × 50	21.7	27.7	8.0	37.1	4.4	10.7	75.8
G 9053	25 × 50	26.3	30.0	7.3	36.8	4.3	9.1	75.3
	"X	23.4	26.5	7.7	37.0	4.3	9.1	76.3
	10 × 50	35.3	41.5	8.0	34.4	6.6	10.7	73.0
	15 × 50	38.7	42.6	9.0	34.9	6.7	13.8	71.6
	20 × 50	33.4	35.0	9.3	37.5	7.0	12.8	73.8
AGS 292	25 × 50	38.7	41.8	9.3	35.2	6.1	12.7	70.8
	"X	36.5	40.2	8.9	35.5	6.6	12.5	72.3
	10 × 50	16.0	17.6	9.0	39.3	3.3	7.4	72.3
	15 × 50	10.5	12.7	9.0	38.2	4.8	8.8	73.2
	20 × 50	24.7	28.5	9.0	39.4	3.5	8.9	73.1
G 10134	25 × 50	17.0	20.6	10.0	38.3	4.1	8.9	71.1
	"X	17.1	19.8	9.3	38.8	3.9	8.5	72.4
	Entry 5%	6.5	6.8	0.6	0.8	1.1	1.1	1.8
L.S.D	Spacing 5%	NS	NS	0.7	0.9	NS	1.3	NS
	E × D 5%	NS	NS	NS	1.5	NS	NS	NS

[z]Total number of blemished pods/total number of pods per plant × 100 (wt/wt). [y]Blemished pods with 2-3 seeds/total number of pods with 2-3 seeds (wt/wt).

Sweet Potato Breeding

Hybridization

Summary

In the 1987-1988 crossing project, priority was given to improvement of dry matter yield, eating quality, resistance to leaf scab and utilization of new germplasm.

Introduction

In the 1987-1988 crossing project, priority was given to improvement of dry matter yield, eating quality, resistance to leaf scab. A polycross of new promising germplasm accessions from different environments i.e. highlands, dry and wet lowlands was also set up to create a gene pool for wide adaptability.

Results

A total of 92,503 seeds were harvested from four polycrosses. These provided materials for seedling screening in 1988 and selected clones were further screened in an observation yield trial (OYT) in July-December.

Wet Season Yield Trials

Summary

A series of trials were conducted in spring and summer to select clones tolerant to hot wet conditions.

A total of 129 selections were entered in the preliminary yield trials (PYT) and 27 were evaluated in the advanced yield trials (AYT) both in spring and summer. Stable high yield and high dry matter yield in both seasons were the most important criteria for human consumption and feed type. Among promising selections in the advanced trials, CN 1489-89 showed very stable and good performance under hot wet conditions. It had 33% dry matter content.

Introduction

Although sweet potato can be grown year-round in the tropics, ordinarily the yield is adversely affected by flooding in the wet season. The development of clones tolerant to high soil moisture conditions is a promising approach to assure constant supply of the crop, reinforce its traditional role as a survival crop and utilize marginal land which cannot be fully utilized for cropping.

To select promising breeding lines for the lowland tropics, repeated multistage selections are being conducted in spring and summer under hot wet conditions at AVRDC, which has similar environmental conditions to many sweet potato growing areas in Asia and the Pacific.

Materials and Methods

A series of wet season yield trials, PYT and AYT were routinely conducted in two different seasons, spring and summer at AVRDC. Trials in spring were from April to July and trials in summer, from June to September.

Both seasons received around 1,000 mm of rainfall in four months concentrated in June to August. Ordinarily, the trials suffered very wet conditions in spring at root bulking stage and experienced wet conditions at root initiation and early root bulking stages in summer. Temperature conditions were almost the same in both spring and summer except in the first month of spring.

Rainfall and temperature during the wet season trials in 1988 are summarized in Figure 1 and Table 1. Due to heavy rainfall (418 mm) on August 13, the field became flooded and waterlogging occurred for almost a week. All trials were supposed to be harvested at 120 days after planting. However, harvesting of trials in summer was delayed for five to seven days because of continuous rain in September.

Total entries were divided into three groups for AYT (Table 2) and four groups for the second year of the preliminary yield trials (PYT2). AVRDC advanced clones, CN 1108-13 and CN 1510-25 were used as common check cultivars in all groups. Other local checks were also used in trials such as Tainung 66 (TN 66), I 444 (Kinmen), Tainung 67 (TN 67).

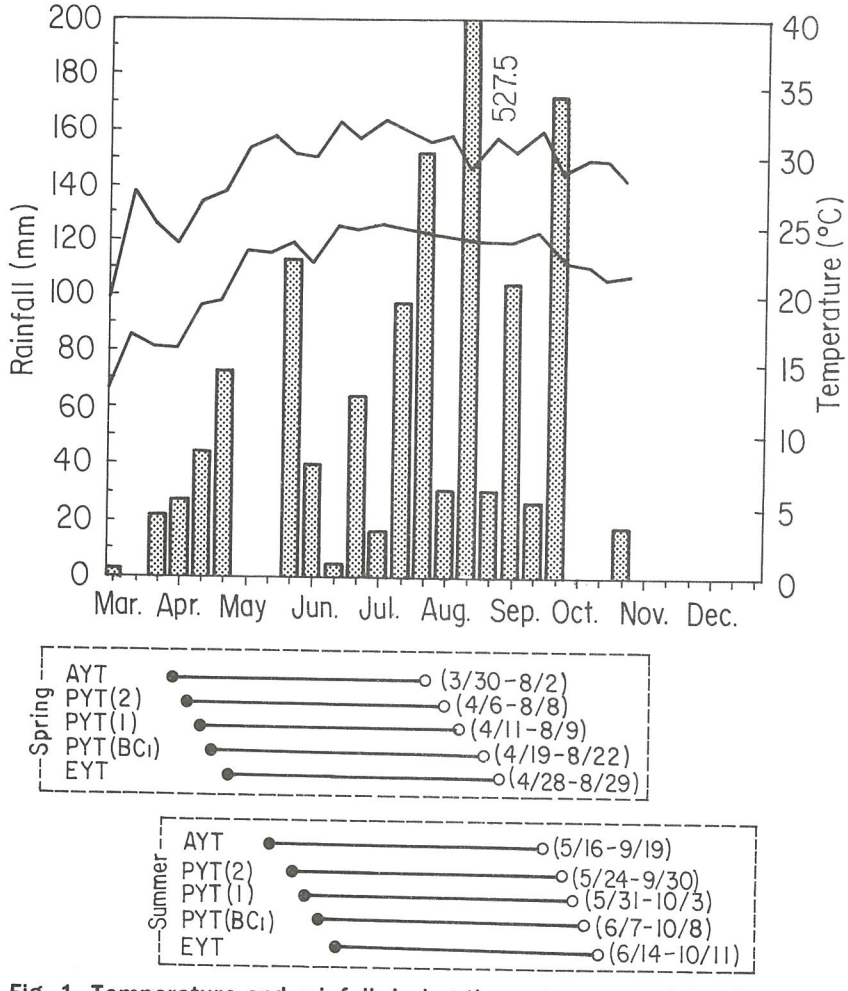

Fig. 1. Temperature and rainfall during the wet season trials of sweet potato AVRDC, 1988.

Table 1. Temperature and rainfall during the AYT and PYT, wet season 1988.

	AYT		PYT 2		PYT 1	
	SP[y] (3/30-8/2)[z]	SU[x] (5/16-9/19)	SP (4/6-8/8)	SU (5/24-9/30)	SP (4/11-8/9)	SU (5/31-9/19)
Rainfall (mm)						
First 2 months	263.5	308.5	281.5	238.0	271.0	379.0
Last 2 months	394.5	889.0	361.0	1046.5	365.0	894.5
Whole planting duration	658.0	1197.5	642.5	1284.5	636.0	1273.5
Maximum temperature (°C)						
First 2 months	27.9 (16.4-33.0)[w]	31.5 (23.8-33.4)	28.8 (17.2-33.0)	31.7 (23.8-33.4)	29.4 (22.2-33.0)	31.7 (23.8-33.4)
Last 2 months	31.7 (23.8-33.4)	31.1 (24.2-33.0)	31.9 (27.0-33.4)	30.7 (24.2-33.0)	32.0 (27.0-33.4)	30.6 (24.2-33.0)
Whole planting duration	29.9 (16.4-33.4)	31.3 (23.8-33.4)	30.4 (17.2-33.4)	31.2 (23.8-33.4)	30.7 (22.2-33.4)	31.2 (23.8-33.4)
Minimum temperature (°C)						
First 2 months	20.4 (13.6-24.8)	24.3 (18.8-26.0)	21.1 (13.6-24.8)	24.4 (18.8-27.0)	21.7 (15.4-24.8)	24.8 (18.8-27.0)
Last 2 months	24.5 (18.8-27.0)	24.3 (22.2-27.0)	24.7 (21.4-27.0)	23.9 (20.8-26.0)	24.8 (23.0-27.0)	23.9 (20.8-26.0)
Whole planting duration	22.5 (13.6-27.0)	24.3 (18.8-27.0)	22.9 (13.6-27.0)	24.2 (18.8-27.0)	23.3 (15.4-27.0)	24.4 (18.8-27.0)

[z]Planting duration. [y]SP = spring trial. [x]SU = summer trial. [w]Range.

Table 2. Sweet potato yield trials conducted in wet season, 1988.

Trial	Group number	No. of entries	Spring		Summer		Remarks
			DP[1]	DH[2]	DP	DH	
PYT(2)[z]	1-3	38	Apr. 6	Aug. 1-3	May 24	Sept. 29[t]	Experimental design; RCBD (2 reps) Unit plot: 2 rows, 5 m long Spacing; 100 cm × 25 cm
	4	13	Apr. 6	Aug. 8	May 24	Sept. 30[t]	
Sub-total: 4 groups, 51 entries							
PYT(1)[y]	1	78	Apr. 11	Aug. 9	May 31	Oct. 3[t]	Experimental design; RCBD (2 reps) Unit plot; 1 row, 5 m long Spacing; 100 cm × 25 cm
PYT (BCF_1)[x]	1	64	Apr. 19	Aug. 22	June 7	Oct. 8[t]	
Sub-total: 2 groups, 142 entries							
Total: 6 groups, 193 entries							
AYT[w]	1	9	Mar. 30	July 25	May 16	Sept. 12	Experimental design; RCBD (4 reps) Unit plot: 4 rows[v], 5m long Spacing: 100 cm × 25 cm
	2	9	Mar. 30	July 25, 28	May 16	Sept. 14	
	3	9	Mar. 30	Aug. 2	May 16	Sept. 19	
Total: 3 groups, 27 entries							

[z]Preliminary yield trial (2nd year). [y]Preliminary yield trial (1st year). [x]Preliminary yield trial (first backcross generation of interspecific hybrids). [w]Advanced yield trial. [v]Yield data was taken only from the middle two rows. [t]The harvest of this trial was postponed for 5-7 days because of heavy rainfall and unfavorable field conditions. [1]Date of planting. [2]Date of harvesting.

Results and Discussion

First Year Preliminary Yield Trial (PYT1) Rainfall during the PYT1 in summer occurred as it did in spring. CN 1108-13 was severely depressed but the other common check line, CN 1510-25 yielded only 12 t/ha in spring whereas the clone gave 24 t/ha in the AYT.

In summer, because of the heavy rains in August and September, many roots became rotten before harvest. Rotten roots were not considered marketable but their number was recorded and rot rate was calculated (Table 3). Variation of rot rate, from 0% to 28.8% between clones was observed. Root rot particularly in CN 1848-77 and CN 1813-149 was one of the main factors of yield reduction in summer. On the other hand, CN 1840-315, CN 1814-124 and CN 1842-236 did not have any rotten roots.

Table 3. Yield and other characteristics of sweet potato selections derived from first year preliminary yield trial, 1988.

Clone no.	Marketable yield (t/ha)		Rotten marketable[x] root (%)	Dry Matter (%)	Dry Matter yield (t/ha)	Flesh[w] color
	SP[z]	SU[y]	SU	SP	SP	
Orange fleshed clones:						
CN 1842-31	33.6*	25.8	13.5	28.8	9.7*	O1
CN 1841-341	28.0	18.8	5.3	23.1	6.5	O3
CN 1842-199	26.6	23.2	2.4	29.7	7.9	O3
CN 1842-203	26.6	29.2	4.3	21.5	5.7	O5
CN 1842-169	23.8	30.4	5.7	23.7	5.6	O3
CN 1842-195	22.8	15.6	11.5	27.1	6.2	O3
CN 1840-284	22.2	28.4	5.6	26.6	5.9	O3
CN 1840-248	20.8	10.8	5.1	28.5	5.9	O5
CN 1844-341	19.0	13.8	5.3	27.6	5.2	O3
CN 1842-78	18.6	28.4	4.2	32.7	6.1	Y3O3
CN 1843-303	16.8	21.8	0.9	29.2	4.9	O3
CN 1840-260	16.8	10.2	7.5	29.0	4.8	O3
CN 1841-225	18.4	21.6	4.3	28.0	5.2	O5
CN 1840-114	14.2	24.4	1.3	26.0	3.7	O3
CN 1840-253	13.6	19.0	4.8	27.1	3.7	O3
Yellow fleshed clones:						
CN 1841-266	27.0	26.0	7.5	30.6	8.3	Y3
CN 1848-77	26.4	16.0	20.0	30.2	8.0	Y1
CN 1840-315	26.0	21.0	0.0	33.3	8.7	Y3
CN 1840-322	19.2	15.6	10.3	33.5	6.4	Y3O1
CN 1813-123	19.0	22.4	0.8	32.8	6.2	Y1
CN 1813-149	15.8	7.2	28.8	39.3	6.2	Y1
CN 1814-124	15.8	6.6	0.0	36.4	5.8	Y1
CN 1842-236	15.8	30.8*	0.0	32.4	5.1	Y3
CN 1843-341	14.4	14.0	17.3	33.5	4.8	Y3
CN 1846-33	12.8	12.2	24.0	35.8	4.6	Y1
CN 1842-72	2.8⁻	20.2	1.0	29.5	0.8	Y1
Check lines:						
CN 1108-13	20.6	9.4	5.6	26.9	5.5 (2.4)	O3Y
CN 1510-25	12.0	16.0	0.0	29.8	3.6 (4.4)	Y3
Mean of 80 entries	**11.0**	**12.5**			**3.3**	
LSD (0.01)	**10.5**	**14.5**			**3.3**	
CV (%)	**35.8**	**43.6**			**37.4**	

[z]Planted April 11 and harvested August 9, 1988. [y]Planted May 31 and harvested October 3, 1988. [x]Rotten marketable root rate = [rotten marketable root no./(rotten marketable root no. + marketable root no.)] × 100. [w]Flesh color: O = orange; Y = yellow; increasing color intensity indicated by number prefix (1 = light to 7 = very intense). *Significantly higher than the superior check. ⁻Significantly lower than the superior check.

Considering these results and the high coefficient of variation in these trials, a relatively higher selection rate of 33 % was given to this group. A total of 26 clones (15 orange-fleshed clones and 11 yellow ones) were selected (Table 3) based on marketable yield, dry matter content and general root appearances.

Preliminary Yield Trials Second Year (PYT2). Fifty one entries were entered into the PYT2. Since there was no statistically significant difference on marketable root number and yield of the common check cultivars, Tainung 66 (TN 66), CN 1108-13 and CN 1510-25 among three groups, the data were combined and analyzed over groups in every season.

The mean yield of all entries in PYT2 in summer was heavily depressed compared with that in spring. The local check cultivar, TN 66, yielded only 2.3 t/ha in summer which was only 10.7% of the yield in spring. Kinmen, which was identified to have an excellent adaptability to flood and drought (AVRDC, 1984), showed least yield reduction in summer. Some PYT2 entries showed even higher yield in summer.

Other characteristics of the selections are also shown in Table 4. In both seasons, clones CN 1823-77, CN 1836-163, CN 1821-8 and 1759-40 attained fairly stable yield. CN 1756-163, CN 1821-39, CN 1821-130 and CN1831-57 were selected for good performance in spring. CN 1836-188, CN 1825-30 and CN 1818-117 were selected for their their high dry matter content, particularly CN 1818-117 (33.4%) which is quite high for deep orange-fleshed clones. In PYT2 many rotten roots were harvested in summer but few in spring. Percentage of the rotten marketable roots in summer varied between clones from 0.0 to 19.6 %. CN 1823-77 did not form rotten roots.

Eleven clones were selected for further testing.

Table 4. Yield and other characteristics of sweet potato selections derived from second year preliminary yield trial, 1988.

Clone no.	Marketable yield (t/ha)		Rotten marketable[x] root (%)	Dry Matter (%)	Dry Matter yield (t/ha)	Flesh[w] color
	SP[z]	SU[y]	SU	SP	SP	
CN 1756-163	27.4	12.7* (46.4)[v]	7.5	28.3	7.6	Y1
CN 1821-39	24.8	9.6 (38.7)	13.8	31.2	7.8	Y3
CN 1821-130	24.3	13.8 (55.7)	19.5	25.1	6.1	03Y1
CN 1823-77	23.2	26.4* (113.8)	0.0	36.8	8.5	Y1
CN 1831-57	21.6	5.5 (25.5)	6.6	34.4	7.4	Y3O
CN 1821-8	20.9	14.3* (68.4)	18.8	34.8	7.3	Y3
CN 1759-40	20.4	13.7* (67.2)	5.4	31.4	6.4	Y3
CN 1836-188	16.9	7.5 (44.4)	16.4	35.4	6.0	Y1
CN 1836-163	16.7	20.8* (124.6)	7.5	35.0	5.8	Y1
CN 1825-30	13.9	11.0 (79.1)	8.1	37.4	5.2	Y3
CN 1818-117	13.8	9.2 (66.7)	13.3	33.4	4.6	O5Y1
Check lines:						
TN 66	21.4	2.3 (10.7)	19.6	26.4	5.6	O5
CN 1510-25	15.6	6.6 (42.3)	19.4	33.3	5.2	Y3
CN 1108-13	13.1	5.8 (44.3)	19.3	26.0	3.4	03Y1
I 444 (Kinmen)	2.6	2.4 (92.3)	2.2	24.7	0.6	Y1
Means of 51 entries	12.3	5.4			4.0	
LSD (0.01)	10.2	6.1			3.4	
CV (%)	31.1	42.5			31.3	

[z]Planted April 6 and harvested August 1-3 and 8, 1988. [y]Planted May 24 and harvested September 29 and 30, 1988. [x]Rotten marketable root (%) = [rotten marketable root no./(rotten marketable root no./marketable root no.)] x 100. [w]Flesh color: O = orange; Y = yellow, increasing color intensity indicated by number prefix (1 = light to 7 = very intense). [v]Yield Summer / Yield Spring (%). *Significantly higher than the superior check line/cultivar. ¯Significantly lower than the superior check line/cultivar.

Advanced Yield Trials (AYT). Seven new entries obtained from the 1987 PYT and 16 selections from the 1987 AYT were entered along with six check lines into the AYT, wet season in 1988. Since there was no statistically significant difference of marketable root number and yield for the common check lines, TN 66, CN 1108-13 and CN 1510-25, the data were combined and analyzed over groups in each season.

The yield difference between the AYT in spring and in summer was clear and no entry showed better yield in summer.

New entries in the AYT. The performance of seven new entries in the AYT is shown in Table 5. In spring, CN 1747-88, CN 1790-42 and CN 1747-20 showed yields equivalent to TN 66, the best yielder among the checks. Reduction in yield of these three clones in summer was relatively lower than that of TN 66.

Dry matter content of new entries was improved and ranged from 31.5 to 40.0 % in spring. CN 1747-88 and CN 1790-42 in particular, had high dry matter content for orange fleshed clones and their beta-carotene content was 6.5 and 6.8 mg/100 g respectively, which was the optimum amount of nutrient and vitamin A source preferred by the Asian consumer.

Promising AYT entries in wet season. A total of 12 advanced clones were selected from the second year entries. Results of evaluation for leaf scab resistance in the field and other horticultural characters of those selections and check cultivars, TN 66 (a leading variety in Taiwan), CN 1108-13 and CN 1232-9 (both AVRDC's elite clones) are presented in Table 6.

Under AVRDC conditions, leaf scab does not exist or occurs slightly unless artificially inoculated susceptible clones are used as source. However, due to heavy rainfall in 1988, severe scab occurred naturally both in spring and summer, and clear clonal differences for the resistance were observed. The severity of infection was recorded one week before harvest using a simple rating system. CN 1108-13, CN 1510-25, CN 1525-11 and TN 66 appeared susceptible whereas CN 1232-9, CN 1489-89, CN 1618-461, CN 1656-101, CN 1656-37, CN 1656-89, CN 1656-97 and CN 1661-62 were rated resistant.

Table 5. Yield and other characteristics of new clones in the advanced yield trial, wet season 1988.

Entries	Marketable yield (t/ha)		Rotten marketable root (%)[x]	SP				Flesh[w] color
	SP[z]	SU[y]	SU	Dry Matter (%)	Dry Matter yield (t/ha)	Starch (% FWB)	Starch yield (t/ha)	
CN 1747-88	29.2	13.2 (45.2)	7.4	33.5	9.8	23.6	6.9	Y5O3
CN 1790-42	27.6	4.7 (17.0)	13.3	31.9	8.9	21.7	6.0	O3
CN 1747-20	18.3	9.4 (51.4)	6.6	39.1	7.1	29.8	5.4	Y1
CN 1732-4	17.6	7.3 (41.5)	3.0	40.0	7.0	29.7	5.2	Y1
CN 1735-1	15.5	3.0 (19.4)	3.4	38.2	5.9	30.1	4.7	Y1
CN 1778-2	12.3	1.9 (15.4)	1.9	31.5	3.9	21.4	2.6	Y3
CN 1795-268	11.0	4.8 (43.7)	6.5	36.9	4.1	27.1	3.0	Y3
Check entries:								
TN 66	27.0	2.4 (8.9)	39.1	26.0	7.0	16.2	4.4	O5
CN 1232-9	26.0	8.1 (31.2)	0.2	27.0	7.0	17.7	4.6	Y1
CN 1510-25	23.9	9.8 (41.0)	10.8	32.0	7.7	24.6	5.9	Y3
CN 1108-13	22.8	6.1 (26.8)	13.7	25.2	5.8	17.7	4.1	O3Y5
TN 67	12.1	5.2 (43.0)	4.6	38.5	4.6	30.0	3.6	Y5
Mean of 29 entries	20.4	6.5			6.4		4.7	
LSD (0.01)	9.7	5.9			3.1		2.4	
CV (%)	24.6	37.7			24.9		26.5	

[z]Planted March 30 and harvested July 25, 1988. [y]Planted May 16 and harvested June 16, 1988. [x]Rotten marketable root (%) = [no. of rotten marketable root/(no. of rotten marketable root + no. of marketable root)] x 100. [w]Y = yellow; O = orange; increasing color intensity indicated by numbers (1 = light to 7 = very intense). Significantly lower than the superior check.

One important objective of the program is to improve the dry matter content. Dry matter content of most promising entries is over 30% (maximum 35%) and even dark orange-fleshed clone, CN 1661-62 has 31% (Table 6).

Most new clones had higher starch content than Tainan 17, a leading variety for starch extraction in Taiwan. Tainan 17, recommended as a wet season variety (PDAF 1981) was reported to have a starch content of 18.3% under summer cropping conditions from June to August.

The marketable yields of 15 lines in 1987 and 1988 wet season trials are shown in Table 7. Mean yield across clones in all trials varied greatly indicating that environmental conditions were widely different although all were conducted in the wet season. There was a favorable environment for yield in

Table 6. Horticultural characters of promising advanced yield trial entries, wet season 1987-1988.

Entries	Leaf scab[z] score		Dry[y] matter	Protein[y]	Sugar[y]	Starch[y]	Root characters[x]				
	88SP	88SU	(%)	(DWB %)	(DWB %)	(FWB %)	unif	size	shape	skc	flc
CN 1108-13	4.0 a	6.9 a	23.1	4.7	14.0	16.1	F	M	MS	O5	O3
CN 1232-9	0.0 c	1.0 d	25.3	5.1	12.9	16.7	F	M	SS	Y3	Y1
CN 1489-89	0.0 c	1.0 d	32.7	4.1	9.5	25.1	G	M	LS	Y3	Y3
CN 1510-25	2.3 b	7.0 a	30.6	3.9	10.3	23.4	F	M-L	LS	R3	Y3
CN 1525-11	1.3 bc	5.8 ab	28.2	4.0	13.9	19.7	F	S-M	O	Y3	Y3
CN 1618-461	0.3 c	2.0 c	28.3	3.8	13.4	19.7	F	M	LS	Y3	Y3
CN 1656-101	0.0 c	2.3 d	30.3	4.2	10.0	21.7	F	M-L	SS/O	Y1R1	Y1
CN 1656-37	0.0 c	2.3 d	32.3	4.2	8.3	25.6	G	M	LS	R5	Y5
CN 1656-89	0.0 c	2.3 d	32.2	4.5	8.7	24.3	F	M-L	LS	B5	Y3O3
CN 1656-97	0.3 c	2.3 d	29.9	4.2	10.9	21.0	F	M-L	SS	R3	Y1
CN 1661-15	0.0 c	3.8 c	35.0	4.6	7.7	27.5	F	S-M	SS/O	R5	Y3
CN 1661-62	0.0 c	2.0 d	31.1	4.1	11.0	22.6	G	M-L	LS	R5	O5
CN 1683-18	0.0 c	4.8 bc	31.3	4.3	9.8	23.3	F	S-M	LS/O	R5	Y5
CN 1688-116	0.0 c	4.3 c	32.4	3.8	9.6	24.4	G	M	LS	R5	Y1
Tainung 66	2.6 ab	6.8 a	24.6	6.2	13.9	15.4	G	M-L	LS	RB5	O5

[z]Increasing scab score indicated by numbers (O = immune, 1 = slight to 7 = very severe). The figure given is mean of four replications. Means within columns are not significantly different at 1% probability level according to DMRT. [y]Mean of four plantings. [x]Root characters. UNIF: uniformity of roots; G = good, F = fair. SIZE: root size; L = large, M = medium, S = small. SHAPE: root shape; MS = massive, SS = short spindle, LS = long spindle, O = ovate, SS/O = short spindle and/or ovate, LS/O = long spindle and or ovate. SKC: skin color; FLC = flesh color, O = orange, Y = yellow, R = red, B = brown, RB = reddish brown, increasing color intensity indicated by numbers (1 = light to 7 = very intense).

Table 7. Yield and environmental sensitivity of promising advanced yield trial entries, wet season 1987-1988.

Entries	Marketable yield (t/ha)				Variety mean	Regression		
	87SP[z]	87SU[y]	88SP[x]	88SU[w]		a[v]	b[t]	r^2
CN 1108-13	32.9	17.2	18.0	7.7	19.0	1.02	0.95	O.90
CN 1232-9	29.1	10.5	23.5	7.7	17.7	-0.04	0.94	O.91
CN 1489-89	34.9	20.7	22.2	20.5	24.6	13.59	0.58	O.68
CN 1510-25	38.3	16.4	26.0	10.6	22.8	1.27	1.14	O.99
CN 1525-11	34.3	13.8	15.4	1.6	16.3	-7.12	1.24	O.91
CN 1618-461	31.0	11.1	22.9	7.6	18.1	-0.84	1.00	O.96
CN 1656-101	33.3	13.1	30.9	5.8	20.7	-1.83	1.19	O.83
CN 1656-37	31.5	16.1	18.1	5.2	17.7	-1.13	1.00	O.93
CN 1656-89	25.7	12.8	18.2	4.1	15.2	-0.91	0.85	O.97
CN 1656-97	37.3	11.4	22.4	7.3	19.4	-4.16	1.25	O.96
CN 1661-15	25.4	13.7	12.7	6.9	14.7	1.77	0.68	O.81
CN 1661-62	35.0	22.9	29.4	6.2	23.3	2.51	1.10	O.81
CN 1683-18	25.3	14.4	19.6	5.6	16.2	1.55	0.78	O.93
CN 1688-116	32.4	15.6	22.9	11.3	20.5	4.07	0.87	O.99
Tainung 66	35.6	4.9	25.0	3.4	17.3	-9.76	1.43	O.89
Environment mean	32.1	14.3	21.8	7.4				

[z]Planted March 24 and harvested August 4, 1987. [y]Planted June 16 and harvested October 14, 1987. [x]Planted March 30 and harvested, July 25, 1988. [w]Planted May 16 and harvested September 12, 1988. [v]Intercept. [t]Regression coefficient (environmental sensitivity index).

spring 1987 (mean yield: 32.1 t/ha), then in spring 1988 (mean yield: 21.8 t/ha), in summer 1987 (mean yield: 14.3 t/ha) and in summer 1988 (mean yield: 7.4 t/ha).

In Table 8, the temperature conditions were quite constant in four environments except in the early stage of planting in spring. On the other hand, the amount and/or pattern of rainfall was quite different. It was considered that different levels of moisture stresses mainly influenced the yields since these trials were conducted under AVRDC conditions.

Simple regression analysis was adapted to determine the stability or environmental sensitivity of the clones (Table 7). The regression coefficient (b) measures the environmental sensitivity and R^2 (coefficient of determination) measures the predictability or reliability of the regression model.

By the environmental sensitivity index (b), genotypes can be classified into three types: Type 1($b = 1$): a regression slope of $b = 1$ indicates the clones which are noninteractive, i.e., sensitive to the environmental changes among entries; Type 2($b < 1$): regardless of the position of the mean, a low slope ($b < 1$) indicates less response from the clones to environmental effects viz. stability of performance under different environments; and Type 3 ($b > 1$): a steep slope ($b > 1$) would indicate the reverse viz. high sensitivity to environmental changes.

Figure 2 shows a graphic representation of mean marketable yield in relation to environmental sensitivity index. Regardless of the marketable yield, most entries fell into Type 1. CN 1489-89, with the highest mean marketable yield, and CN 1661-15, with the lowest mean marketable yield, belonged to Type 2. TN 66, CN 1525-11 and CN 1656-97 appeared to be Type 3. The regression lines of the clones which represent each type are shown in Figure 3 (CN 1108-13 and CN 1232-9 for Type 1, CN 1489-89 for Type 2 and TN 66 for Type 3).

As mentioned earlier, the r^2 indicates the reliability of the regression model. The regression models of 14 entries, except CN 1489-89, had quite high r^2 (Table 7), more than 0.8. The R^2 of CN 1489-89 was 0.68; this reveals that the simple regression model could not detect responses of this clone to environmental changes. CN 1489-89 was stable under the lower-yield environment and showed good response to environment favorable to high yield.

In conclusion, clone CN 1489-89 appeared very stable across a range of environments under AVRDC hot-wet conditions. This clone's response to excessive moisture conditions, considered as the main limiting factor for yield, indicated that the genotype is tolerant to the environment which severely depresses sweet potato yield. This genotype could be suitable for adverse environments in the tropics.

Table 8. Temperature and rainfall during the advanced yield trials in wet season, 1987-1988.

	AYT			
	87SP (3/24-8/3)[z]	87SU (6/16-10/4)	88SP (3/30-8/2)	88SU (5/16-9/19)
Rainfall (mm)				
First 2 months	180.5	479.5	263.5	308.5
Last 2 months	521.5	310.5	394.5	889.0
Whole planting duration	702.0	790.0	658.0	1197.5
Maximum temperature (°C)				
First 2 months	28.0 (17.8-32.2)	31.4 (25.8-34.0)	27.9 (16.4-33.0)	31.5 (23.8-33.4)
Last 2 months	31.2 (26.0-34.0)	30.8 (25.6-33.8)	31.7 (23.8-33.4)	31.1 (24.2-33.0)
Whole planting duration	29.8 (17.8-34.0)	31.1 (25.6-34.0)	29.9 (16.4-33.4)	31.3 (23.8-33.4)
Minimum temperature (°C)				
First 2 months	19.2 (10.4-24.0)	24.5 (22.8-26.6)	20.4 (13.6-24.8)	24.3 (18.8-26.0)
Last 2 months	24.0 (20.6-26.6)	23.1 (20.4-25.4)	24.5 (18.8-27.0)	24.3 (22.2-27.0)
Whole planting duration	21.9 (10.4-26.6)	23.8 (20.4-26.6)	22.5 (13.6-27.0)	24.3 (18.8-27.0)

[z]Planting duration.

Results of this experiment also indicated that TN 66, CN 1108-13, CN 1232-9 and CN 1489-89 could be used as a good set of standards for comparing the sensitivity to hot and wet conditions in the field. Most entries in this experiment were virus-indexed and now ready for distribution to national cooperators.

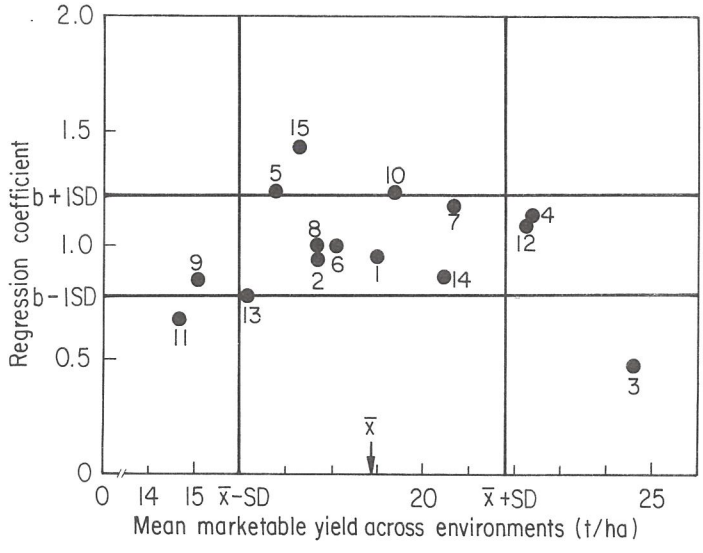

Fig. 2.
Relationship between marketable yield and environmental sensitivity among promising clones in the advanced yield trials, wet season 1987-1988.

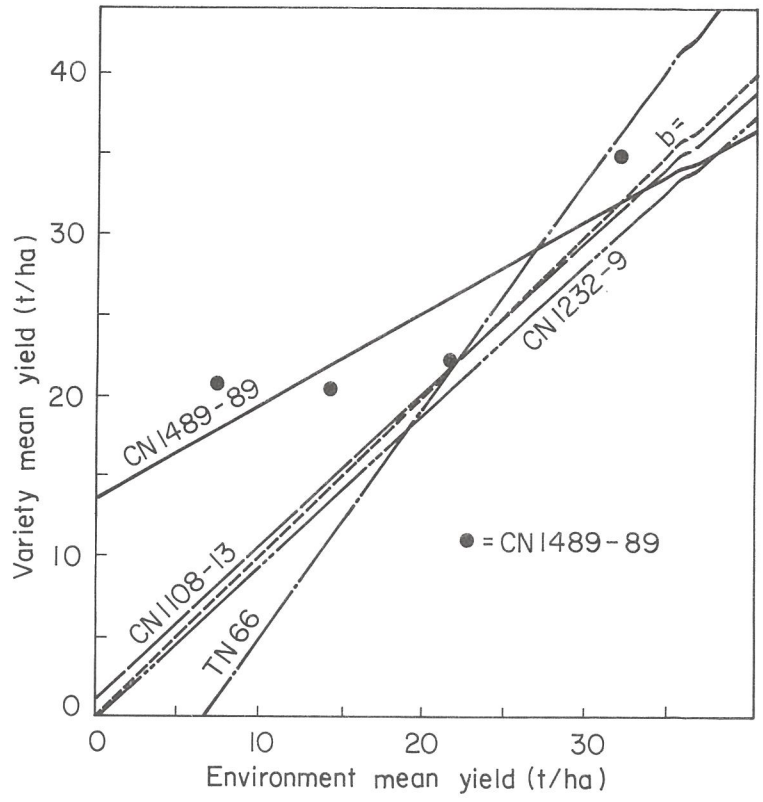

Fig. 3.
Responses of five sweet potato clones to different environments, AVRDC, wet season 1987-1988.

Utilization of Interspecific Hybrids

Summary

To explore the possibility of utilizing wild relatives for practical breeding, 5x hybrids obtained from the cross between 4x *Ipomoea trifida* and sweet potato were evaluated in 1986-87. To improve the yield, the first backcross to the 5x hybrids was conducted in 1986 and the progenies (BCF_1) were evaluated in the OYT, 1987. The selections from the OYT were entered into the PYT in spring and summer 1988.

Under excessive moisture conditions in summer, BCF_1 attained good yield compared with the check cultivars. Initial results indicated that CN 1868-6 and CN 1872-8 would be promising gene sources for excessive moisture tolerance.

Introduction

Genetic introgression from wild relatives has been effectively utilized to introduce specific characters in many crops. The value of wild relatives in sweet potato breeding has been explored since 1930. However, information is still very limited to actively utilize wild relatives for breeding.

On this premise, 5x hybrids obtained from crosses between 4x *Ipomoea trifida* and sweet potato were evaluated in 1985-1986 (AVRDC, 1988). Although the 5x hybrids showed potential for weevil resistance and high dry matter content, they were not recommended for immediate use mainly because of low yield. The first backcross to the 5x hybrids was conducted in 1986 to monitor if the desirable traits of the 5x hybrids could be transferred to the backcross progenies without any reduction and to evaluate how to improve yield. The backcross first generation (BCF_1) were entered into seedling screening and observation yield trial in 1987. Selected clones were evaluated in the preliminary yield trials in wet season 1988.

Materials and Methods

A total of 64 BCF_1 lines, along with their parental lines, nine 5x hybrids and seven sweet potato lines, were planted in the preliminary yield trials in the wet season. Two trials were conducted for the same set of entries, one from April 19 to August 22, and another from June 7 to October 8,1988.

Each trial was planted in a randomized complete block design with two replications, with rows spaced 1 m apart and plants within the row, 25 cm apart.

At harvesting, yield and other agronomic characters were recorded and the root samples of those planted in spring were analyzed for dry matter content. The same set of entries were screened for weevil resistance.

Results and Discussion

Temperature and rainfall during the two trials were quite similar in both spring and summer (Table 9). Performance of the check lines indicated the very poor yielding environment in both spring and summer. Heavy rainfall on August 13 (418 mm) and the resulting waterlogging condition caused severe rotting of roots in spring. This could be the main reason for the extremely high coefficient of variation in this trial.

Figure 4 shows the frequency distribution of yield of BCF_1 and the check lines in spring and summer. All 5x hybrids did not form any storage roots in both seasons, although they showed quite acceptable yield in the preliminary evaluation in cool-dry season in 1986-1987. In both spring and summer, the mean yields of BCF_1 were higher than those of the check cultivars. In summer, 25% of the BCF_1 entries showed better yield than CN 1345-8, the best yielder among the checks with 16.6 t/ha.

Dry matter content varied among BCF_1, from 16.1 to 39.1%. Seventeen entries had higher dry matter content than CN 1501-25 with 33.5%.

Table 9. Temperature and rainfall during the preliminary yield trials (BCF_1), wet season 1988.

	SP (4/19-8/22)[z]	SU (6/7-10/8)
Rainfall (mm)		
First 2 months	276	352
Last 2 months	890.5	879
Whole planting duration	1166.5	1231
Maximum temperature (°C)		
First 2 months	30.2 (22.2-33.0)	32.0 (27.0-33.4)
Last 2 months	31.5 (24.2-33.4)	30.4 (24.2-33.0)
Whole planting duration	30.9 (22.2-33.4)	31.2 (24.2-33.4)
Minimum temperature (°C)		
First 2 months	22.6 (15.4-25.8)	24.8 (23.0-27.0)
Last 2 months	24.6 (22.8-27.0)	23.7 (20.8-26.0)
Whole planting duration	23.6 (15.4-27.0)	24.3 (20.8-27.0)

[z]Planting duration.

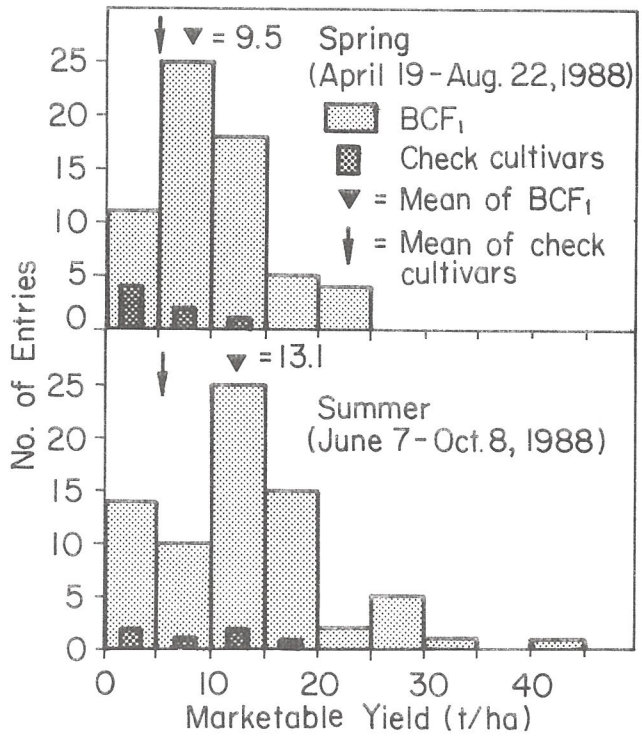

Fig. 4. Frequency distribution of marketable yields among BCF_1 progenies, AVRDC, wet season 1988.

In the observation yield trial of the BCF_1 clones in 1987, the clear difference by crossing directions between sweet potato and 5x hybrids was reported (AVRDC, 1990). Although selected clones with better yield and root appearance were entered in the PYT (BCF_1), the same difference was observed. BCF_1 clones which have sweet potato as female parents showed significantly higher yield than those with 5x hybrids as male parents (Table 10).

Yield and other characteristics of promising BCF_1 clones are listed in Table 11. Although some of them developed stronger and wider root systems than sweet potato, there were no special or inferior morphological traits observed. Due to heavy rainfall in spring, two weeks before harvesting, and

following waterlogging conditions, roots became severely rotten. The variation between entries existed, and rotten marketable roots of the BCF_1 selections ranged 4.0-77.8% and 12.9-77.8% for the check cultivars. Rotting was the main limiting factor of this season's yield for both BCF_1 and check cultivars.

In summer, marketable yields of these BCF_1 selections were generally good compared with the check cultivars. CN 1867-11, CN 1868-6, CN 1872-11, CN 1869-7 and CN 1871-4 in particular, yielded significantly higher than the check cultivar, CN 1345-8. The tendency of BCF_1 to develop stronger and wider root systems might be an indication of good performance under excessive moisture conditions. Performance of these selections under cool-dry conditions will be evaluated in fall.

Table 10. Difference in yield performance of BCF_1 progenies by crossing direction.[z]

	5x hybrids × *I. batatas* (N = 23)	*I. batatas* × 5x hybrids (N = 41)
Mean marketable yield (t/ha)	6.9	16.6
Range (t/ha)	0.8-15.6	0.4-40.8

[z]Two populations are significantly different at $P < 0.001$ [$t(62) = 5.24$].

Table 11. Yield and other characteristics of sweet potato BCF_1 derived from preliminary yield trial, 1988.

Clone no.	Marketable yield (t/ha)		Rotten marketable root(%)[x]		Dry matter (%)	Dry matter yield (t/ha)	Flesh[w]
	SP[z]	SU[y]	SP	SU	SP	SP	
CN 1867-11	24.0	27.2*	9.0	0.0	23.8	5.7	O5
CN 1868-13	22.2	17.0	22.6	7.0	24.4	5.4	Y5
CN 1868-6	20.8	31.0*	39.3	0.0	27.5	5.7	Y1
CN 1867-3	20.6	19.8	4.1	0.0	28.1	5.8	Y3O1
CN 1868-12	17.6	24.0	31.0	8.2	33.0	5.8	Y1
CN 1868-15	17.2	13.0	16.4	0.0	25.8	4.4	Y1
CN 1869-6	15.2	15.8	26.3	0.7	33.9	3.7	Y1
CN 1872-11	14.4	28.4*	39.1	0.0	28.2	4.1	Y1
CN 1872-8	14.2	40.8*	48.6	1.9	24.1	3.4	Y1
CN 1869-13	14.0	18.8	28.8	9.3	26.5	3.7	O3Y3
CN 1867-5	13.8	14.8	28.0	0.0	22.4	3.1	Y1
CN 1869-1	13.4	25.6	47.9	3.0	24.7	3.3	Y1
CN 1867-27	13.2	16.4	26.3	1.6	31.6	4.2	Y5O1
CN 1869-7	12.8	28.8*	37.9	0.0	39.1	5.0	Y1
CN 1868-3	12.6	16.0	39.1	0.0	31.4	4.0	Y3
CN 1871-4	12.0	28.6*	38.1	0.7	24.6	3.0	Y1
CN 1868-4	7.2	17.2	56.1	1.1	29.9	2.2	Y1
CN 1870-9	6.6	17.4	62.4	0.0	33.8	2.2	Y1
CN 1876-3	6.6	22.8	42.9	0.0	28.0	1.8	Y3
CN 1867-17	3.4	17.6	77.8	6.8	28.2	1.3	Y1O1
Check lines:							
TN 57	11.0	3.2	12.9	3.6	26.5	2.9	Y3
TN 66	7.4	7.6	56.8	6.5	27.1	2.0	O5
CN 1108-13	5.4	13.4	53.9	0.0	25.7	1.4	O1Y3
AIS 0122-2	3.8	7.6	38.0	0.0	21.4	0.8	O5
CN 1345-8	3.2	16.6	74.1	2.2	27.6	0.9	Y1
CN 1510-25	3.2	10.6	74.9	10.7	33.5	1.1	Y3
CN 1405-14	0.4	2.2	77.8	0.0	25.2	0.1	Y3
Mean of 80 entries	8.0	11.2				2.5	
LSD (0.01)	13.0	9.6				4.1	
CV (%)	61.0	32.0				61.0	

[z]Planted April 19 and harvested August 22, 1988. [y]Planted June 7 and harvested October 8, 1988. [x]Rotten marketable root (%) = [no. of rotten marketable root /(no. of rotten marketable + no. of marketable root)] × 100. [w]Flesh color: Y = yellow, O = orange; increasing color intensity is indicated by number prefix (1 = pale to 7 = very intense). *Significantly higher than the superior check cultivar. ~Significantly lower than the superior check cultivar.

Germplasm Evaluation in Wet Season

Summary

A total of 215 selections from AVRDC germplasm were evaluated in spring and summer. Thirty-three clones were selected as promising lines for excessive soil moisture tolerance.

Introduction

In the tropics, excessive soil moisture or flooding was reported as one constraint of sweet potato production (Lin et al. 1985). Usually, sweet potato is preferably cultivated under relatively dry conditions or with better drainage since the crop is easily affected by wet or flooded conditions.

AVRDC aims to develop sweet potato cultivars which are more adapted to wet conditions. It aims to explore tolerant gene sources to strengthen the breeding program. In the 1988 wet season, yield trials were conducted to confirm the gene sources which were previously reported tolerant to flooding (AVRDC, 1984) and screen new germplasm as well.

Materials and Methods

A total of 215 entries consisting of 24 AVRDC breeding lines and 191 germplasm accessions were evaluated for yield performance in the wet season. Two trials were conducted in spring, from April 28 to August 29, and in summer, from June 14 to October 11.

A randomized complete block design with two replications was used. A unit plot consisted of 3-m long rows spaced 1 m apart. Plants within the row were planted 25 cm apart. Considering the large number of entries, 12 plants were planted in every plot in two replications. However, check plots were provided for every six plots, and TN 66 and CN 1108-13 were planted in the check plots by turns.

At harvesting, yield and other agronomic characters were recorded. Root samples were analyzed for chemical attributes.

Results and Discussion

Since trials were conducted in late spring and summer, the climatic conditions of two plantings were quite similar (Table 12). The heavy rainfall on August 13 and following extremely wet conditions caused rotting in the spring trial and affected marketable yield. Marketable yield distribution in each trial is shown in Figure 6. In spring, mean marketable yield of all entries was 5.4 t/ha ranging from 0 to 28.7 t/ha (Table 13). About 61.9% of the entries yielded only 0-4.6 t/ha. In summer, mean marketable yield was 1.3 t/ha ranging from 0 to 14.3 t/ha; about 90.7% of the entries had 0-4.3 t/ha.

Root samples of 174 clones were analyzed in spring. Frequency distributions of dry matter, starch, sugar, protein and beta-carotene contents are shown in Figure 7. Compared with the mean chemical analysis of four advanced yield trials (1987-1988) for the check cultivars (TN 66 and CN 1108-13), the dry matter, protein, sugar and starch contents appeared to be 1-3% lower and sugar and beta-carotene, 1-2% higher.

Based on the marketable yield in both seasons, 33 entries were selected for further evaluation (Table 14). Of the selections, 10 were AVRDC clones. In summer the best five yielders were AVRDC clones CN 1345-8, CN 1028-15, CN 1489-89, CN 942-47 and CN 1280-3 with marketable yields of 14.3, 13.7, 11.7, 10.7, 9.7 t/ha, respectively.

Among germplasm accessions, I 938 (K 79; a lowland cultivar in Papua New Guinea) and I 423 (Tainan 17; a summer cultivar for starch extraction in Taiwan) were equal to AVRDC clones.

Among entries previously reported as tolerant to flooding, selections I 392, I 100, I 444, I 423, I 607, I 234 and I 253. I 392, I 100 and I 444 performed relatively well in spring while I 607, I 423, I 234 and I 253 did similarly in summer. All 33 selections will be further evaluated in bigger plot size and more replications in the wet season.

Table 12. Temperature and rainfall during wet season yield trials, 1988.

	EYT 88SP (4/28-8/29)[z]	EYT 88SU (6/14-10/11)
Rainfall (mm)		
First 2 months	256	384
Last 2 months	850.5	847
Whole planting duration	1106.5	1231
Maximum temperature (°C)		
First 2 months	30.9 (23.8-33.4)	31.9 (27.0-33.4)
Last 2 months	31.5 (24.2-33.4)	30.4 (24.2-33.0)
Whole planting duration	31.2 (23.8-33.4)	31.2 (24.2-33.4)
Minimum temperature (°C)		
First 2 months	23.6 (18.8-25.8)	24.8 (23.0-27.0)
Last 2 months	24.5 (22.2-27.0)	23.5 (20.8-26.0)
Whole planting duration	24.1 (18.8-27.0)	24.2 (20.8-27.0)

[z]Planting duration.

Table 13. Marketable yield and other characteristics of selected entries during evaluation of sweet potato germplasm, wet season 1988.

Entries	Origin	Marketable yield (t/ha)		Dry matter (%)	Flesh[x]
		SP[z]	SU[y]	SP	color
CN 1345-8	AVRDC	28.7 (1)[w]	14.3 (1)	29.0	Y1
CN 1232-9	AVRDC	26.3 (2)	6.7 (11)	24.4	Y1
I 392 (Rakwana)	Solomon Is.	25.0 (3)	2.3	26.2	Y3P5
CN 1489-89	AVRDC	23.7 (4)	11.7 (3)	32.5	Y1
I 100 (PI 318848: Kumala Belep)	New Caledonia	22.0 (5)	4.3	24.1	Y1
I 165 (Tainung 57)	Taiwan	20.7 (6)	1.3	20.0	Y3O1
I 136 (OK 6-3-106)	USA	20.3 (7)	0.0	–	O3
I 1175 (V2-30)	Philippines	19.7 (8)	1.7	28.2	O5
I 401 (Salifi)	Solomon Is.	19.3 (9)	0.0	27.0	Y1
I 938 (K 79)	PNG	19.0 (10)	9.3 (7)	31.5	Y3
Tainung 67	Taiwan	19.0 (10)	0.0	32.8	Y5O3
I 1185 (Bali)	Indonesia	18.3 (12)	5.7	27.2	Y3
CN 1280-3	AVRDC	18.3 (12)	9.7 (5)	27.9	Y1
CN 1525-11	AVRDC	18.0 (14)	8.3 (10)	24.9	Y3
CN 1517-139	AVRDC	18.0 (14)	6.7 (11)	32.6	Y3
I 934 (Ilimo 1)	PNG	17.0	1.0	28.4	Y3
I 1188 (Amelika)	Tonga	16.7	3.0	32.6	Y1
I 928 (Koitaki 2)	PNG	16.7	0.0	23.7	Y3
CN 1028-15	AVRDC	16.3	13.7 (2)	21.6	O3Y1
I 381 (Indonesia 321)	Indonesia	16.3	0.0	23.3	O3
I 1174 (V2-3)	Philippines	15.7	3.3	31.0	Y5
CN 942-47	AVRDC	15.7	10.7 (4)	21.5	O3
I 398 (Lukatefou)	Solomon Is.	15.3	1.7	–	Y1
I 444 (Kinmen)	Taiwan	15.3	1.3	20.8	Y1
CN 1510-25	AVRDC	15.0	5.7	26.7	Y3
I 932 (Unu 2)	PNG	15.0	0.3	27.8	Y1
I 423 (Tainan 17)	Taiwan	14.3	9.0 (8)	24.9	Y1
CN 1448-49	AVRDC	12.3	6.0 (15)	31.7	Y5
I 952 (TIB 10)	IITA, Nigeria	8.0	9.5 (6)	27.6	Y3
I 607 (Lae 4)	PNG	9.7	8.7 (9)	21.6	Y1
I 234 (Norin 4)	Japan	7.7	6.7 (11)	29.1	Y1
I 253 (Norin 23)	Japan	7.3	6.5 (14)	25.4	Y1
I 232 (Norin 2)	Japan	8.3	6.0 (15)	34.0	Y1
CN 1108-13	AVRDC	11.6	3.3	21.1	O3
TN 66	Taiwan	8.0	2.2	22.1	O5
Mean of 215 entries		5.4	1.3	27.1	

[z]Planted April 28 and harvested August 29, 1988. [y]Planted June 14 and harvested October 11, 1988. [x]Y = yellow, O = orange, P = purple; increasing color intensity is indicated by number prefix (1 = pale to 7 = very intense). [w]Rank of marketable yield obtained from the trial.

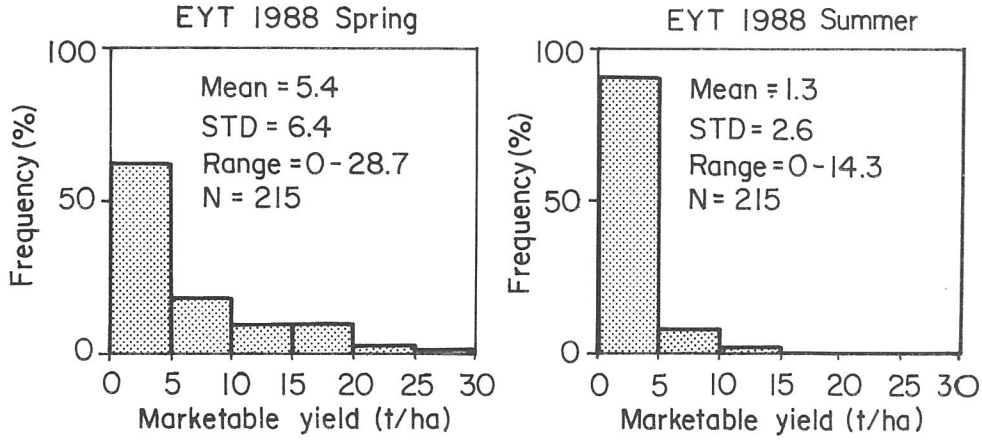

Fig. 5. Marketable yield distribution of sweet potato germplasm in wet season 1988.

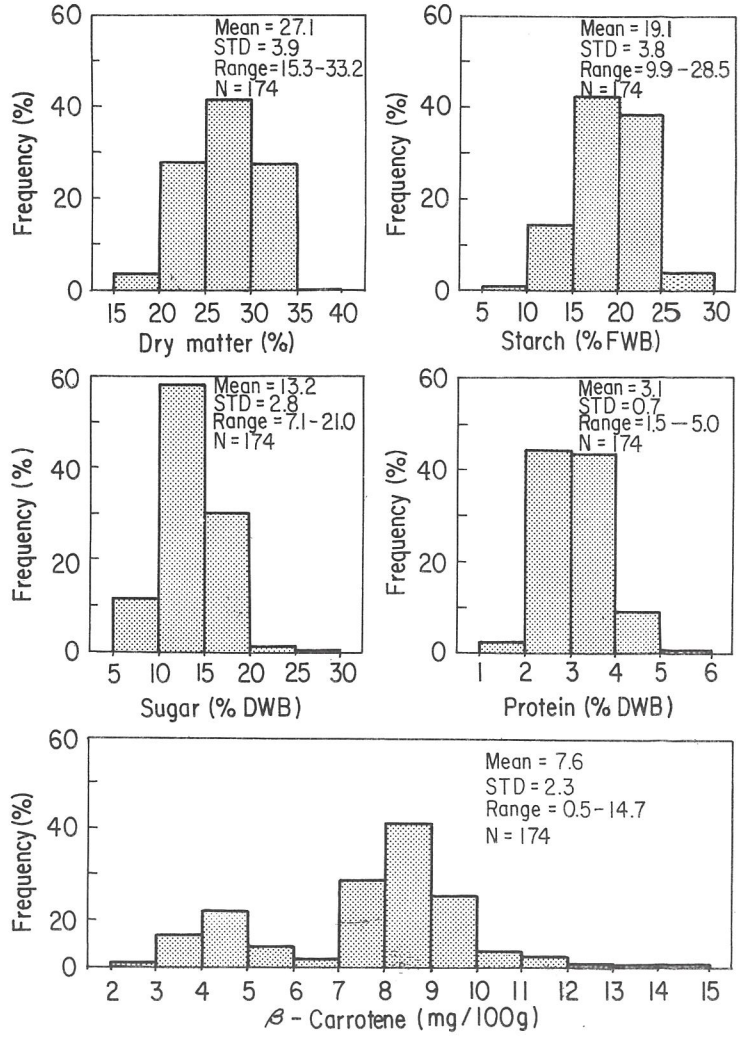

Fig. 6.
Frequency distribution of nutritional attributes of the evaluational yield trial of sweet potato germplasm in wet season 1988.

International Cooperation

Summary

An intensive international distribution of virus-indexed sweet potato materials was resumed. A total of 30 improved materials are now available for international exchange.

International Distribution of Virus-indexed Materials

The international exchange for wide-scale testing of improved sweet potato breeding materials has always been restrained by strict quarantine regulations. To overcome this constraint and distribute only clean materials to cooperators, a virus-indexing scheme was instituted at AVRDC. About 22 AVRDC improved selections from AVRDC germplasm were virus-indexed and became available for international exchange since November 1987. In 1988, the materials were sent out to 25 cooperators (see the section on GRSU in this report for details). In December, 1988, eight more clones went through the procedure and are ready for international distribution.

Feedback from International Cooperators

The international distribution of sweet potato was held back from 1985 to 1987 for virus-indexing. An intensive distribution of virus-indexed materials resumed in 1988. Only limited feedback was received from international cooperators on the performance of the materials distributed.

China. Sweet potato trials were conducted at Jiangsu Xuzhou Institute. AVRDC cooperators tested seven AVRDC clones with the local check Xushu 18. CN 1028-15, a light orange-fleshed clone, yielded 32.2 t/ha, equivalent to the local check cultivar (Table 14).

Kampuchea. A dry season trial was conducted at Kbal Koh Research Station, Phnom Penh, Kampuchea. Tainung 66, CN 1028-15 and CN 1232-9 yielded at the same level as the local check, Loeal (Table 15). Cooperators claimed that roots of AVRDC clones are smaller than the local check, but most roots were found acceptable in the market. CN 1232-9 was not well accepted in the market because of its wet texture. CN 1028-15 was moderately acceptable; TN 66 was the sweetest among entries and CN 1038-16 had powdery texture when cooked.

Table 14. Performance of AVRDC sweet potato clones, Jiangsu Xuzhou Institute, Jiangsu Province, China, 1988.[z]

Entries	Marketable roots		Top wt.	Root color[y]	
	weight (t/ha)	No./'000/ha	(t/ha)	skin	flesh
Xushu 18 (check)	35.0 a**	122 b	57.3 ab**	R6	Y1
CN 1028-15	32.2 ab	178 ab	48.2 bc	R5	O3
AIS 35-2	25.8 bc	228 a	33.1 d	(OY)4	O7
CI 591-51	22.7 cd	230 a	47.1 bc	O5	O6
PC # 9	19.9 cd	228 a	39.5 cd	R7	Y2
PC # 3	17.9 cd	177 ab	44.4 bcd	R5	O4
CI 412-2	15.1 de	181 ab	43.6 bcd	Y2	W(P1)
I 444 (Kinmen)	7.5 e	157 ab	68.9 a	R1	W
Mean of 8 entries	22.0	188	47.8		

[z]Planted June 25, 1988 and harvested October 26, 1988. [y]Skin color: R = red, O = orange, Y = yellow, OY = orange with yellow; Flesh color: Y = yellow, O = orange, W = white, P = purple;increasing color intensity indicated by numbers (1 = light to 7 = very intense). *Mean separation by DMRT at 5% probability level. **Mean separation by DMRT at 1% probability level.

Table 15. Performance of AVRDC sweet potato clones in dry season, Kbal Koh Research Station, Kampuchea, 1987-1988.[z]

Variety name	Marketable roots (t/ha)	Yield of small roots (t/ha)	Roots attacked by insects (t/ha)	Total root yield (t/ha)	Average weight of roots (g)	Skin color	Flesh color	Remarks
Loeal (local check)	29.7	2.5	6.5	38.7	120	Violet	Light yellow	Very vigorous growing, but less sweet than Tainung 66.
Tainung 66	25.5	2.8	3.7	32.0	77	Deep red	Orange	Sweeter than other varieties.
CN 1028-15	24.8	3.0	3.9	31.7	69	Violet	Orange	Sweet enough.
CN 1232-9	24.8	2.6	4.1	31.5	78	White	White	Flesh is very tender after cooking.
CN 1038-16	16.2	2.6	4.0	22.8	77	White	White	Powdery texture after cooking
LSD 5%	6.3	NS	NS	6.7	19.3			
C.V.	16.9%	19%	38%	13.9%	14.9%			

[z]Planted December 8, 1987 and harvested March 9, 1988.

Sweet Potato Entomology

Screening for Sweetpotato Weevil Resistance

Summary

Two sets of sweet potato germplasm accessions were screened in the field for resistance to sweetpotato weevil *Cylas formicarius formicarius*. In the first test, insect infestation varied widely and certain test entries were less damaged than the susceptible checks. However, there was a significant positive correlation between root yield and weevil infestation. Least damage in certain accessions was mainly due to small roots. Least damaged accessions in the second test in 1986-87 had significantly lesser damage than the control but poor yielding entries tended to have lesser weevil damage than high yielding accessions. Despite 15 years of continuous research, a reliable source of resistance to sweetpotato weevil has not been found yet.

Introduction

Sweetpotato weevil, *Cylas formicarius formicarius* F. (Coleoptera: Curculionidae) is the most destructive pest in sweet potato (*Ipomoea batatas* Lam.) in the tropics and subtropics where the crop is grown. The larvae and adults feed on sweet potato roots and crowns while adults feed on the foliage. As a result, the produce becomes unfit for human consumption due to the unpleasant flavor that weevil infestation imparts on the roots. Since 1974, AVRDC has been screening sweet potato germplasm to find an accession resistant to sweet potato weevil. In 1987-88, two screenings were conducted.

Materials and Methods

Land was rototilled, applied with basal fertilizers and worked into 1-m wide beds. Eight weeks before planting of test materials, every third row was planted to a weevil-susceptible cultivar, I 57. A week before planting of test materials, laboratory-reared weevil adults were uniformly released over the planted rows. These weevil-infested rows (spreader rows) later served as source of weevil for the test materials. Sweet potato accessions were planted between rows of weevil source in 5 × 1 m plots. Standard cultural practices were followed, except that no insecticide was applied.

Two screenings were conducted in autumn 1987. In the first screening, 11 least damaged accessions from the preliminary screening in 1986 were evaluated together with three known susceptible checks in three replications. In the second screening, four least damaged accessions in two previous tests were tested along with two susceptibles in six replications.

At harvest, roots were evaluated for weevil infestation by cutting open each root and counting the number of larvae, pupae and adults found inside. The insect count (larvae + pupae + adults) was converted to the number of total insects per kilogram roots and analyzed by ANOVA (analysis of variance). Differences in weevil infestation of various entries were compared by DMRT.

Results and Discussion

First screening. Results of the first screening are summarized in Table 1. No significant differences were observed in either the number of insects found or percent of damaged roots between

Table 1. Resistance sweet potato selection to weevil infestation.[z]

Accession number	Damaged roots (%)	No. of weevils/kg root	Yield t/ha
I 674	29.6 a	73.3 a	8.9 c
I 444[y]	27.9 ab	38.2 ab	17.1 b
I 986	22.1 abc	35.2 ab	12.3 c
I 207[y]	19.3 abcd	48.1 ab	9.0 c
I 57[y]	17.1 abcd	25.3 ab	8.6 cd
I 1000	16.8 abcd	24.5 ab	26.2 a
I 967	12.1 abcd	12.0 b	4.6 de
I 999	12.0 abcd	19.1 ab	10.1 c
I 482	10.1 bcd	8.8 b	3.3 e
I 998	7.9 cd	1.3 b	4.4 de
I 526	5.9 cd	9.1 b	2.8 e
I 991	3.7 cd	3.6 b	8.3 cd
I 636	1.4 d	1.7 b	3.1 e
I 717	1.0 d	6.8 b	3.1 e

[z]Data are means of three replicates. Mean separation by DMRT at 5% probability level. [y]Susceptible check.

susceptible checks and the test accessions. However, five accessions were much less infested than others. Apparently less damaged accessions had low yield potential. There was a significant (r = 0.571*) positive correlation between root yield and weevil damage. This raises the possibility that low yielding accessions, which generally have smaller roots, are least damaged because their roots are not easily exposed to weevil infestation. Conversely, those high yielding ones are damaged more because of bigger roots. This is a disadvantage in breeding of agronomic sweet potato cultivars resistant to sweetpotato weevil. Less weevil damage due to lower yield will be further examined in autumn 1988.

Regression and Correlation

Variable	r	Equation
Yield vs % damage	0.571*	y = 6.347 + 0.804X
Yield vs number of weevils	0.409	y = 10.589 + 1.304X
% damage vs number of weevils	0.897**	y = 5.160 + 2.020X

Second screening. Results of the second screening are summarized in Table 2. All four accessions tested were substantially least infested than the two susceptible checks. Accessions I 974 and I 229 had significantly lesser weevil damage than the susceptible checks. However, there was a strong tendency for low yielding entries to have lower insect infestation than the high yielding ones. Entries will be further investigated in autumn 1988 to determine whether or not low damage in these entries is related to low yield potential.

Regression and Correlation

Variable	r	Equation
Yield vs number of weevils	0.744	y = -13.683 + 4.751X
Yield vs % damage	0.718	y = -3.393 + 2.311X
% damage vs number of weevils	0.938**	y = 3.576 + 0.471X

Table 2. Resistance of sweet potato selections to weevil infestation.[z]

Accession number	No. of weevils/kg root	Damaged roots (%)	Yield t/ha
I 207[y]	24.6 b	17.0 ab	8.3 a
I 229	1.1 c	0.7 c	3.3 b
I 600	7.6 bc	7.0 bc	9.0 a
I 783	6.9 bc	12.4 b	3.7 b
I 974[y]	1.5 c	1.5 c	3.1 b
I 57[y]	52.3 a	26.8 a	9.6 a

[z]Data are means of six replicates. Mean separation by DMRT at 5% probability level. [y]Susceptible check.

Interspecific Cross Progeny Screening

Summary

Twenty entries derived from progenies of crosses between sweet potato and *Ipomoea trifida* which were free of sweetpotato weevil (*Cylas formicarius formicarius*) damage in screenings during 1985-1986, and 1986-1987 were evaluated in the field for sweetpotato weevil resistance. Three entries, WT 57, WT 59, and WT 325 were free of weevil. Lesser damaged entries were those with poor yield. There was a significant positive correlation between root yield and weevil infestation. Roots of poor yielding accessions are not easily exposed to weevil compared to high yielding ones. This association of less weevil damage and poor yield is not favorable in breeding agronomic cultivars for weevil resistance.

Introduction

In 1985, a CIP plant breeder made crosses between sweet potato and *Ipomoea trifida* to develop a sweet potato cultivar resistant to sweetpotato weevil. The progeny was screened in 1985-86 and 1986-87 for weevil resistance. Twenty entries with least weevil damage and good yield potential selected from the 1986-87 screening were tested along with six known susceptible checks in 1987-88.

Materials and Methods

Each entry was planted in randomly selected four 5 m × 1 m plots in a sweetpotato weevil nursery. Each plot was bordered on one side by a weevil-infested row of sweet potato which was planted two months earlier and inoculated with laboratory-reared weevils. The crop was raised following the standard cultural practices except that no insecticide was applied. At harvest, root yield was recorded and roots were cut open to determine weevil infestation and larvae, pupae and adults found inside were counted. The insect count was converted to the number of total insects (larvae + pupae + adults) per kilogram of roots. The data were analyzed by ANOVA and means were compared by DMRT.

Results and Discussion

Among entries, the number of weevils per kilogram of root ranged from 0 to 23.23 and root damage from 0 to 8.25% among the test entries (Table 3). Entries WT 57, WT 59, and WT 325 were free of weevil infestation. WT 57 and WT 59 were also free of weevil damage in two previous tests.

Regression and Correlations

Variable	r	Equation
Yield vs % damage	0.480*	y = -0.202 + 0.839X
Yield vs number of weevils	0.413*	y = 0.213 + 1.264X
% damage vs number of weevils	0.973	y = 0.295 + 1.716X

The lower the root yield, the lower was the weevil infestation. In fact, there was a significant positive correlation between root yield and number of weevils/kg of roots (r = 0.413*) and root damage (0.480*). This raises the possibility that low weevil infestation is due to low yield (small roots) rather than the presence of a resistant gene in these entries. Entries with low weevil damage will be utilized in 1988 for backcrosses to improve the yield and quality of roots.

Table 3. Resistance of wide crosses to sweetpotato weevil.[z]

Entry	Damage (%)	No. of weevils/kg root	Yield t/ha
I 444[y]	29.6 a	51.9 a	11.6 b
I 57[y]	15.8 b	23.5 b	10.5 b
WT 260[y]	10.2 c	11.7 bc	5.5 cdef
WT 129	8.2 cd	23.2 b	5.6 cde
WT 237	7.8 cd	13.6 bc	3.4 efghij
WT 108	4.4 de	8.0 c	2.4 ghij
WT 532	4.1 de	6.0 c	3.8 defghij
WT 279	3.7 de	3.1 c	4.9 cdefgh
Jung Twun[y]	3.0 de	1.6 c	16.7 a
WT 66	2.9 de	7.5 c	5.4 cdef
WT 125	2.7 de	4.8 c	7.0 c
WT 843	2.5 de	4.0 c	2.2 hij
WT 298	2.2 de	2.1 c	6.5 cd
WT 60	1.7 e	2.6 c	4.9 cdefghi
WT 629[y]	1.3 e	1.3 c	1.7 j
WT 700[y]	1.1 e	1.5 c	3.2 efghij
WT 81	0.9 e	0.8 c	7.5 c
WT 452	0.8 e	1.1 c	3.3 efghij
WT 230	0.8 e	0.6 c	9.9 b
WT 262	0.7 e	0.5 c	2.6 ghij
WT 460	0.6 e	1.1 c	5.1 cdefg
WT 578	0.5 e	2.8 c	2.0 j
WT 352	0.4 e	0.9 c	2.9 fghij
WT 59	0.0 e	0.0 c	1.1 j
WT 325	0.0 e	0.0 c	1.4 j
WT 57	0.0 e	0.0 c	2.2 ij

[z]Data are means of four replicates. Mean separation by DMRT at 5% probability level. [y]Susceptible checks.

Correlation Between Root Characters and Sweetpotato Weevil Infestation

Summary

Since it is difficult and time consuming to develop a sweetpotato weevil resistant cultivar, sweet potato accessions with varying levels of dry matter content were evaluated to find out whether this constituent in the sweet potato root has any correlation with weevil infestation. Thirty accessions that differ in dry matter content (ranging from 14.99 to 41.98%) were tested for weevil infestation. There was no significant correlation found between dry matter concentration and weevil infestation. However, entries with higher dry matter tended to have less weevil damage. A similar correlation was observed in past studies with limited number of accessions. Accessions with higher beta-carotene tended to have greater weevil damage.

Introduction

Although sweetpotato weevil infests foliage, stems, crown and roots of sweet potato, the major economic damage results from the insect's feeding on the storage roots. Even slight weevil damage renders the roots unfit for human consumption. To develop an economical control, AVRDC has been screening sweet potato germplasm to come up with a weevil resistant agronomic cultivar. However, despite 14 years of continuous research, the Center has not found a single accession that is consistently resistant to this pest. Other research groups have experienced the same. In 1984, AVRDC initiated basic research to understand the host plant-insect pest relationship of sweetpotato weevil. Relationships among various quantifiable root characters, such as concentration of dry matter, sugar, protein and

beta carotene and weevil infestation was studied. This experiment was based on four or five sweet potato accessions that differed in concentration of root constituents. In 1987-88, 30 accessions with different concentrations of storage root constituents were evaluated.

Materials and Methods

A 0.01 ha of land was rototilled, applied with basal fertilizers, and worked into rows of 1 m wide beds. Every third row was planted to a known weevil-susceptible sweet potato accession, I 57. Six weeks after planting, the entire field was infested with laboratory-reared weevil adults. The weevil-infested sweet potato served as the source of weevil for the test materials.

Thirty accessions that differed in their dry matter, sugar and protein contents were selected for the study. Dry matter content ranged from 14.99 to 41.98%, sugar from 11.07 to 27.04% (dry weight basis) and protein from 1.71% to 8.81% (dry weight basis).

Stem cuttings of each entry were dipped in 0.05% carbofuran solution for 30 minutes before planting. Each accession was planted as a single row on the top of three 5-m long and 1 m wide beds between the rows with the weevil. Plots were arranged in a randomized complete block design.

The crop was raised following the standard cultural practices, except that no insecticide was applied. At harvest, roots from each plot were cut open and the larvae, pupae and adult weevil found inside were counted. Insect count (larvae + pupae + adults) was subjected to a linear regression and correlation analysis to study the relationship between various root constituents and the number of weevils per kilogram of roots.

Results and Discussion

There was no statistically significant correlation between the concentrations of dry matter, sugar or protein in the sweet potato roots and the number of weevils feeding inside.

In the previous three tests, only four or five entries were used to test the correlation of each of the plant constituents and sweetpotato weevil infestation. After getting the results of the 1987-88 trials, previous data were analyzed again. In the analysis, individual plant constituents of all entries were correlated to weevil infestation (Table 4). There was no consistent pattern in the statistical significance of weevil infestation in the root and any of the constituents. Correlation coefficient was relatively higher (though not always significant) and negative for dry matter content.

Based on four tests, there was no statistically significant correlation between plant constituents and sweetpotato weevil infestation in the roots. Correlation with dry matter content was negative. Roots with higher dry matter content seemed to suffer less damage.

Table 4. Correlation of various plant constituents in sweet potato roots and sweetpotato weevil infestation.

Plant constituents	Correlation coefficient[z]		
	1984-85	1985-86	1986-87
Dry matter	-0.613** (16)	-0.429 (18)	-0.308 (18)
Sugar	0.664** (15)	0.423 (17)	-0.174 (17)
Protein	0.021 (15)	-0.286 (17)	0.512* (17)
Beta carotene	0.696 (6)	0.226 (6)	0.233 (6)

[z]Correlation coefficient between the number of weevils per kg roots, significant at 0.05* and 0.01** levels. Numbers in parentheses are degrees of freedom.

Integrated Pest Management of Sweetpotato Weevil

Summary

An integrated pest management technique, based on the control of alternate hosts, use of weevil-free planting material and continuous trapping of male weevils in sex pheromone-baited traps, was utilized to control sweetpotato weevil in farmers' fields in Penghu. Details of the technique were explained to the farmer cooperators. A total of 21,129 male weevils were captured in pheromone traps set in the farmers' field in Jungtwun and 16,348 in Husyi villages. Weevil damage in Jungtwun ranged from 0 to 46.4% root with a mean of 3.65% and 47 out of 55 farms had less than 10% root damage and 31 were weevil-free. Weevil damage in roots at Husyi varied from 0 to 4% and 31 out of 38 farms had no weevil infestation at all.

Introduction

Sweetpotato weevil is a serious pest of sweet potato in tropical to subtropical regions where the crop is grown. The insect larva feeds inside the root making it unfit for human consumption. In the past, AVRDC had been searching for sources of resistance and breeding weevil resistant cultivars. However, due to difficulties in finding a usable level of resistance, AVRDC developed an integrated pest management (IPM) technique using infestation-free planting material, controlling alternate *Ipomoea* hosts from borders and surroundings, hilling up of soil around plants, and using female sex pheromone (from planting to harvest) to trap male weevils. In 1988, this technique was tested in two locations in Taiwan.

Materials and Methods

This experiment was conducted in Jungtwun in Baisa prefecture and Husyi in Husyi prefecture, Penghu Island during summer 1988. Sweet potato, ground nut and sorghum are the principal crops in Penghu Island. All three crops are rainfed and grown mainly between April and September. At harvest of the preceding sweet potato crop in October-November 1987, the sweetpotato weevil damage was surveyed in both locations.

In 1988 cropping season, 39 farmers cultivating 3 ha of sweet potato in 55 parcels in Jungtwun, and 31 farmers cultivating 4 ha in 38 parcels in Husyi participated in this experiment. In both locations, farmers were oriented on the details of the IPM in a public meeting organized for this purpose. The briefing included the control of *Ipomoea* weeds from borders and empty areas, crop rotation, dipping of the vine cuttings in 0.04% carbofuran solution for 30 minutes before planting to eliminate weevil infestation in the cuttings, and regular hilling up of the soil to prevent soil cracks around the plants.

Two weeks after planting, depending upon the size of the field, each farmer was given one to five traps baited with 100 micrograms of sweetpotato weevil sex pheromone. The farmers were advised to change the location of each trap within the field as often as possible to cover the entire field, so that the endemic as well as migrating male weevils can be trapped from the whole area before they could mate. The number of males trapped in each field was recorded.

At harvest, a survey was made in the fields and 5 kg roots from each parcel of land were taken as samples. Several plants were selected at random and just one root from every plant was dug up while it was still standing in the field. Each root was cut in thin slices and the number of SPW larvae, pupae, and adults found inside was recorded. The insect-damaged portion of the root was weighed and percentage of damaged roots was calculated.

Results and Discussion

In both townships, farmers followed crop rotation and sweet potato was planted after either ground nut or sorghum in the previous season. All farmers in Husyi dipped the cuttings in carbofuran solution

but some farmers in Jungtwun failed to do so. Jungtwun farmers' noncompliance with the procedure was still significant because the farmers became aware of the importance of this treatment.

Ipomoea weed species were not a serious problem in Husyi and only minimum effort was required to keep them under control. *Ipomoea* weeds, however, were rampant in Jungtwun and some farmers did not pay much attention despite repeated reminders.

During the season, 21,129 male weevils were trapped in Jungtwun and 16,348 in Husyi. The number of weevils per kilogram of roots ranged from 0 to 69.4 with a mean of 5.10 and insect damage from 0 to 46.4% with a mean of 3.65% (Fig. 1). In 47 out of 55 farms, the damage was less than 10% of the root; 31 farms were weevil free. This compared favorably with mean insect number of 14.5/kg root, damage of 11.6%, and only 10 weevil-free fields out of 62 in 1987.

In Husyi, the number of weevils per kilogram of roots ranged from 0 to 4 with a mean of 0.34 (Fig. 2). The percentage of roots damaged ranged from 0 to 4 with a mean of 0.45%. In this township, 31 out of 38 sweet potato fields were free from weevil infestation. Before the introduction of IPM, 80% of the plants were infested by weevil and about 40% of the roots were damaged.

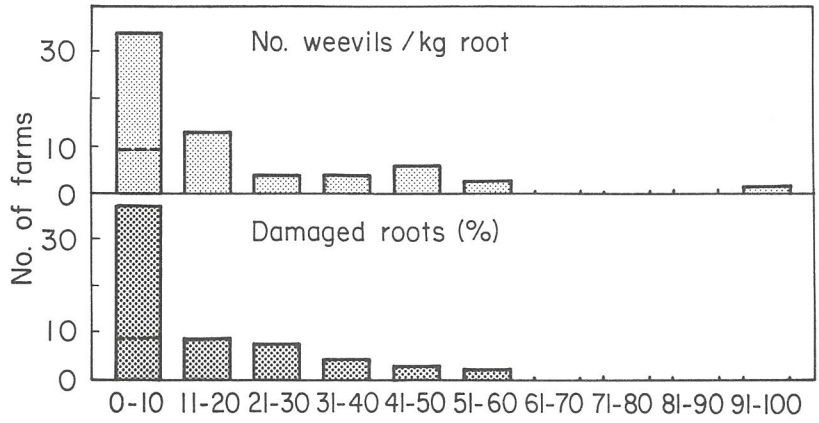

Fig. 1. Sweetpotato weevil infestation on farmers' field in Jungtwun.

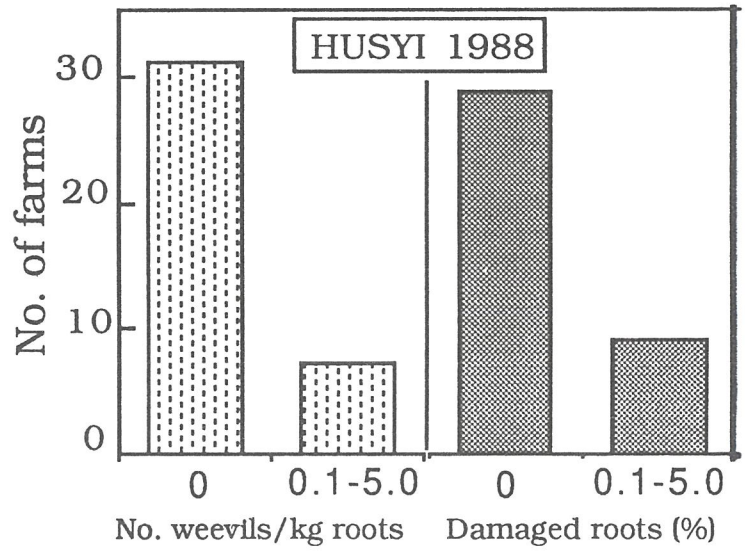

Fig. 2. Sweetpotato weevil infestation on farmers' fields in Husyi.

Although, sweetpotato weevil control in Jungtwun had improved over the 1987 level, it was not as good as expected because some farmers still did not follow the control measures. For example, two fields in this town had 49.3 and 69.4 weevils/kg of root, respectively, which was much higher than

the rest of the field. Fields where no control measures were employed became the source of insects to the rest of the area in this season and potentially in the next. On the other hand, all farmers in Husyi followed the control measure. As a result, this insect did not pose much of a problem in the area.

IPM Technology Transfer

A brochure which describes in detail the IPM of sweetpotato weevil was printed. The brochure and sex pheromone samples were distributed to various research and development organizations in Fiji, Tonga, Western Samoa, Solomon Islands, Vanuatu, Saipan, Tahiti, Caroline Islands, Papua New Guinea, Australia, Japan, China, Taiwan, the Philippines, Vietnam, Thailand, Malaysia, Brunei, Indonesia, India, Bangladesh, Laos, Burma, Korea, Cape Verde, Nigeria, Sierra Leone, Ethiopia, Kenya, Jamaica, Guyana and other islands in the Caribbean via CARDI, Brazil, Venezuela and the United States. Those who responded so far reported an excellent sex pheromone trapping of the weevil. The entomology team plans to continue this development activity and conduct basic research on the transport of the weevil from one location to another, especially through cuttings.

Conclusions

The reduction of sweetpotato weevil infestation to below economically damaging levels seems possible through adoption of IPM using weevil-free planting materials, control of weeds surrounding the planted area, frequent ridging of plants, and use of sex pheromone traps. Success of the IPM, however, depends entirely on the willingness of all farmers in the community to strictly follow it, because failure of one farmer to cooperate will considerably reduce its effectiveness.

Sweetpotato Weevil Alternate Hosts in Taiwan

During the past 15 years, in addition to sweet potato, five species of *Ipomoea* that harbor sweetpotato weevil (*Cylas formicarius formicarius*) had been found. They include *I. acuminata*, *I. aquatica*, *I. hederacea*, *I. obscura*, and *I. sinensis*. Except for *I. hederacea*, all other species are new alternate hosts of sweetpotato weevil.

Alternate hosts of sweetpotato weevil play a very important role in the survival of the weevil during off season when sweet potato is not grown and initiation of infestation of newly planted sweet potato crop. So far 30 Convolvulaceae plant species, including 25 species belonging to the genus *Ipomoea* are reported to be the host of sweetpotato weevil worldwide. In 15 years of occasional surveys in Taiwan and Penghu Island, five species of *Ipomoea* that harbor sweetpotato weevil have been found. They include *Ipomoea acuminata* (Vahl) Roem & Schult, *I. aquatica* Forsk, *I. hederacea* (L.) Jacq., *I. obscura* (L.) Ker-Gawl., and *I. sinensis* (Desr.). All species are perennial and grow along borders and in empty areas. Among them, *I. aquatica*, the water convolvulus, is the only economically important crop. In water convolvulus, weevils were found only in plants growing on bunds and empty areas. None of these new found hosts form storage roots. These plants should not be allowed to grow in the vicinity of the field to control sweetpotato weevil.

Among the five species only *I. hederacea* has been reported as the host of the sweetpotato weevil elsewhere. The remaining species are new records.

Vine Borer Resistance Characterization

Summary

Eight promising progenies from crosses between sweetpotato vine borer (*Omphisa anastomosalis*) resistant accession and high yielding breeding lines were screened together with AVRDC elite clones for resistance to vine borer. Entries CN 1759-47, CN 1759-330 and CN 1759-635 were among the least damaged and had yield potentials substantially higher than the resistant checks but still lower

than the standard agronomic breeding line. One entry showed tolerance to vine borer. Among elite clones, CN 1367-2, was the least damaged, however, damage was substantially higher than the resistant checks.

Introduction

Sweetpotato vine borer (SPVB), *Omphisa anastomosalis* (Gn) (Lepidoptera: Pyralidae), is an important pest of sweet potato in southeast Asia, China and the Pacific, including Hawaii. The insect lays eggs on foliage and stems and freshly emerged larvae bore into vines and feed inside. Pupation takes place in the feeding tunnel. As a result, the plant is weakened and yield is reduced considerably up to 50%.

Screening of the AVRDC sweet potato germplasm had resulted in the identification of two accessions, I 55 and I 92, which are moderately resistant to SPVB. AVRDC used I 55 to breed an SPVB resistant cultivar. In 1986 and 1987, breeding materials were screened and eight least damaged entries were selected. These entries were screened along with three susceptible, three resistant checks and three elite materials for resistance to SPVB in Penghu Island where this pest is endemic and causes considerable damage and yield loss.

In a second test, 21 elite accessions and breeding lines from AVRDC were evaluated. These entries were screened with three resistant and two susceptible checks.

Materials and Methods

After application of basal fertilizers, the land was rototilled and worked into 1-m wide beds. Each entry was planted as a single row on 5-m long beds. The treatment plots were arranged in a randomized complete block design. The first test had five replicates and the second had three. Cultural practices such as application of fertilizers, weeding, banking and others were employed, but no insecticide was applied. At harvest, five months after planting, each plant in every plot was observed and the number of SPVB damaged and healthy ones were recorded. In the first test, roots were harvested and yield per plot was computed. The SPVB damage and yield were analyzed by ANOVA and the treatment means were separated by DMRT.

Results and Discussion

Except for CN 1759-487 and CN 1759-491 all entries that showed least damage in 1987 had significantly less damage than the two susceptible materials (Table 5). The resistance level of CN 1759-47, CN 1759-330, and CN 1759-635 is at par with that of the three resistant checks. These entries are promising. Their yield potential is better than the resistant parent although not high enough.

One elite breeding line, CN 1756-163, had the highest SPVB damage but had high root yield. This indicates that this high yielding breeding line has tolerance to SPVB. The yield of 19 t/ ha is above average for most cultivars grown in Penghu Island. The mechanism of SPVB tolerance in this breeding line will be studied in 1989.

Table 5. SPVB damage and yield of selected resistant breeding materials.[z]

Entry designation	Plant[z] damage (%)	Yield kg/plot[x]	Entry designation	Plant[y] damage (%)	Yield kg/plot[x]
CN 1756-163	83.1 a	9.7 a	CN 1759-465	16.0 efg	0.9 fgh
CN 1757-30	76.3 ab	5.2 b	CN 1759-487	59.1 bc	4.1 bcd
CN 1759-40[w]	67.4 ab	0.5 fgh	CN 1759-491	40.4 cd	1.7 efgh
CN 1759-47	11.0 fg	3.2 cde	CN 1759-635	6.7 g	2.4 def
CN 1759-282[w]	73.5 ab	2.1 efg	I 55[e]	7.0 g	0.4 gh
CN 1759-296	29.7 def	0.4 gh	I 92[e]	9.9 fg	0.3 gh
CN 1759-316	22.8 defg	4.2 bc	I 789[e]	1.4 g	0.1 h
CN 1759-330	11.8 fg	3.1 cde	AIS 35-2[v]	42.2 cd	2.3 def
CN 1759-379	33.7 de	1.5 efgh			

[z]Planting date: 23 May 1988. [y]Observation date: 6 October 1988, [x]Harvest date: 22-23 October 1988; plot size: 5 m × 1 m; Data are means of 5 replicates. Mean separation by DMRT at 5% probability level. [w]Resistant check. [v]Susceptible check.

Results of the screening of elite breeding lines and accessions are summarized in Table 6. CN 1367-2 appears promising as far as SPVB resistance is concerned. The resistance level of this breeding line will be confirmed in 1989.

Table 6. SPVB damage to elite breeding lines and accessions.[z]

Entry designation	Plant damage (%)[y]	Entry designation	Plant damage (%)[y]
I 981	71.4 abc	CN 1421-68	54.4 abcde
I 423	67.6 abcd	CN 1448-49	22.1 fgh
CN 1028-15	45.6 cdef	CN 1448-59	60.7 abcde
CN 1038-16	36.4 defg	CN 1489-43	58.4 abcde
CN 1058-10	68.8 abc	CN 1489-89	80.2 ab
CN 1108-13	78.0 ab	CN 1510-25	57.6 abcde
CN 1216-10	68.9 abc	CN 1517-139	59.3 abcde
CN 1219-1	62.5 abcde	CN 1525-11	50.4 bcdef
CN 1232-9	83.9 a	I 55	35.3 efg[x]
CN 1280-3	23.3 fgh	I 92	2.8 h[x]
CN 1345-8	78.1 ab	I 789	3.0 h[x]
CN 1367-2	13.5 gh	AIS 35-2	21.0 fgh
CN 1421-56	39.6 cdefg	I 57	66.7 abcd

[z]Planting date: 23 May 1988, observation date: 6 October 1988. [y]Data are means of three replicates. Mean separation by DMRT at 5% probability level. [x]Resistant checks.

Vine Borer Response to Sex Pheromones

Summary

Synthetic sex pheromones of eight species of closely related insects were tested to determine the response of sweetpotato vineborer (*Omphisa anastomosalis*) to these chemicals. The sex pheromones of pyralids *Ostrinia nubilalis*, *Chilo suppressalis*, *Galleria mellonella*, and a pheromone common to *Anagusta kuhniella*, *Ephestia elutella*, *E. figuliella*, *E. cautella* and *Plodia interpunctella* were not effective against the sweetpotato vineborer. The sex pheromone of the vineborer appears to be a new compound.

Introduction

Research for the last two years revealed that the classic sex pheromone present in many lepidopterous insects also exists in female moths of sweetpotato vineborer, *Omphisa anastomasalis* (Gn) (Lepidoptera: Pyralidae), a serious pest of sweet potato in Southeast Asia. Because of limited expertise in extracting, isolating, identifying and synthesizing the pheromone chemical, the entomology team failed to obtain pure chemicals for study. This prompted the test on sex pheromones of closely related species against sweetpotato vineborer.

Material and Methods

Sex pheromone chemicals of the following pyralid species were bought from Sigma Chemical Company (USA): *Ostrinia nubilalis*, *Chilo suppressalis*, *Galleria mellonella* and a pheromone common to *Anagusta kuhniella*, *Ephestia elutella*, *E. fiquliella*,*E. cautella* and *Plodia interpunctella*. The chemicals were dispensed individually on rubber septa. Sex pheromone coated septum of each species was placed overnight in a sticky paper trap, one meter above the sweet potato crop in the field. The number of male moths trapped was recorded every morning for several days. Simple laboratory bioassay was performed on 1- to 7-day old males.

Results and Discussion

No sweetpotato vine borer moth was trapped by the pheromones of the above-stated species when male insects could be captured in virgin female-baited traps. Obviously the sex pheromone of sweetpotato vine borer is different, possibly an entirely new chemical. There is a need therefore to isolate this chemical from virgin females.

Vine Borer Alternate Host

In a survey of alternate hosts of the sweetpotato vine borer (*Omphisa anastomasalis*), insect larva was found feeding inside the stems of *Ipomoea pes-caprae*, a convolvulus plant on sandy seashores. A very sturdy plant, it has a hard woody stem, inside of which the vine borer larva feeds.

Having initiated research on sweetpotato vine borer 1979, AVRDC has been searching for alternate hosts of this insect in Taiwan and Penghu Island. In summer 1987, larvae of this insect were found feeding inside the stems of a Convolvulaceae plant, *Ipomoea pes-caprae* (L.) in the vicinity of a sweet potato field in Penghu Island. This perennial plant grows along sandy seashores and has woody stems. This species is present in areas where sweetpotato vine borer occurs. This is a new host for this insect pest. Incidentally, *I. pes-caprae* is also an alternate host of the sweetpotato weevil. Control of this plant will help reduce the damage by both pests.

Sweet Potato Pathology

Virus Elimination and Indexing

Summary

The virus elimination and indexing scheme described in the 1987 Progress Report was modified, using a two-month heat treatment (37°C) followed by meristem tip (0.3 mm) culture for virus elimination. For virus indexing, two ELISA tests were conducted on young plantlets, using antisera to feathery mottle virus (FMV), yellow dwarf virus (YDV), latent virus (LV), sweet potato virus II (SPV II) and mild mottle virus (MMV) produced in AVRDC and two graftings of mature plants to *I. setosa* and *I. nil* (as the graft recipients). Ninety-one lines from Thailand, eight AVRDC breeding lines (set 2) and 18 AVRDC accessions were subjected to this scheme. Thailand lines were heavily infected with virus and only 45 virus-free lines were produced. Similarly only 12 virus-free AVRDC accessions were obtained. However, all AVRDC breeding lines are now virus-free and are ready for distribution in tissue culture.

Introduction

The virus elimination and indexing scheme described in 1987 Progress Report was modified.

Materials and Methods

The method described in the 1987 Progress Report was used for the new batches of sweet potato lines. Antiserum was produced for MMV which enabled testing, with slight modifications and improvements, of this additional virus in ELISA 1 and 2. Initially, graft indexing was done with two indicator species, *Ipomoea setosa* and *I. nil*, and two types of grafting: (1) test plants grafted onto indicator plants; and (2) indicator plants grafted on top of test plants. Past experience showed that only grafting gave reliable results and consequently, the second method was abandoned. The two indicator plants, *I. nil* and *I. setosa*, were used. Two seedlings of each were grafted with scions from mature plants (G1) which were then cut back and allowed to mature. At this stage, the second graft indexing (G2) was performed. Due to lack of seeds of *I. setosa*, grafting was done to only one plant species in G2. Under southern Taiwan conditions, the plant flowers abundantly in the fall season (end of September, October and November). However, most seeds dropped before they attained maturity.

An additional indicator plant, the sweet potato clone TIB8 clone 9 from IITA, preinfected with the aphid-transmitted component of the Nigerian sweet potato virus disease (SPYD) complex was added in this year's indexing. If this clone is grafted with a scion containing the whitefly-transmitted virus, it will show severe leaf deformation and mottle. Using this clone in grafting, the presence of the whitefly component which, so far, has been reported in West Africa was detected. Whenever possible, indicator plants showing virus-like symptoms as a result of grafting were checked by ELISA and by immunosorbent electron microscopy (ISEM) using antisera to five known viruses (FMV, MMV, SPLV, SPV-II and SPYDV).

Heat treatment was also improved (see separate report) and lines now starting the virus elimination and virus indexing scheme were subjected to it.

Ninety-one lines from Thailand, eight AVRDC breeding lines (set 2) and 18 AVRDC accessions were subjected to the above scheme.

Results and Discussion

Results of virus indexing are summarized in Tables 1, 2 and 3.

In the ELISA 1 and 2 tests a large percentage of ELISA positive plants were detected and eliminated. However, this large number may not reflect the presence of virus, because the positive/negative absorbance threshold value was chosen as being twice the healthy threshold. To reduce the number of false positives, the use of a more sensitive serological detection method, such as DOT ELISA on nitrocellulose membranes is being investigated. The graft indexing required careful and constant attention because symptoms were often very mild and frequently appeared only on one or two leaves. During graft

Table 1. Summary of virus elimination and indexing of new introductions from Thailand.

General	
Total No. of lines	91
No. of meristems excised	1345
No. of lines survived (% regeneration)	837 (62.2%) (91 lines)
ELISA I test (E1)	
No. of lines	91
No. of plantlets tested	837
No. ELISA positive plantlets	314 (37.5%) (= 81 lines)
positive for FMV	79 (25.5%) (44 lines)
positive for SPYDV	127 (40.4%) (61 lines)
positive for SPLV	128 (40.8%) (57 lines)
positive for SPV II	51 (16.2%) (25 lines)
positive for MMV	137 (43.6%) (54 lines)
ELISA II test (E2)	
No. of lines	89
No. of plantlets tested	523
No. ELISA positive plantlets	119 (22.8%) (= 64 lines)
positive for FMV	44 (40.0%) (28 lines)
positive for SPYDV	62 (52.1%) (38 lines)
positive for SPLV	25 (21.0%) (18 lines)
positive for SPV II	13 (10.9%) (8 lines)
positive for MMV	40 (33.6%) (32 lines)
Graft indexing I (G1)	
No. of plants indexed	233 (= 89 lines)
No. of plants showing symptoms[1]	80 (34.3%) (= 48 lines)
No. of plants positive for FMV[2]	5 (06.3%) (5 lines)
No. of plants positive for SPYDV	4 (05.0%) (4 lines)
No. of plants positive for SPLV	0
No. of plants positive for SPV II	2 (02.5%) (2 lines)
No. of plants positive for MMV	1 (01.3%) (1 line)
No. of plants with unknown virus	71(88.8%) (42 lines)
No. of plants with symptoms on TIB 8	0
Graft indexing II (G2)	
No. of plants indexed	69 (= 66 lines)
No. of plants showing symptoms[1]	12 (17.4%) (= 7 lines)
No. of plants positive for FMV[2]	0
No. of plants positive for SPYDV	0
No. of plants positive for SPLV	0
No. of plants positive for SPV II	1 (08.3%) (= 1 line)
No. of plants positive for MMV	0
No. of plants with unknown virus	11 (91.7%) (= 6 lines)
No. of plants with symptoms on TIB 8	0
No. of virus-free lines obtained	59

[1]On indicator plants. [2]Virus presence in indicator plants was tested by ELISA and/or ISEM.

Table 2. Summary of ELISA and graft indexing of AVRDC breeding lines Set 2.

General	
Total no. of lines	8
No. of meristems excised	165
No. of meristems survived	108 (65.5%)
ELISA 1 test	
(meristem derived plantlets)	
No. of plantlets tested	108 (8 lines)
ELISA positive plantlets	27 (25.0%) (6 lines)
positive for FMV	7 (25.9%) (3 lines)
positive for YDV	16 (59.3%) (3 lines)
positive for SPVN	12 (44.4%) (5 lines)
positive for SPV II	2 (07.4%) (2 lines)
positive for SPMMV	24 (88.9%) (5 lines)
ELISA 2 test	
(plantlets derived from stem tips of ELISA 1 negative plantlets)	
No. of plantlets indexed	63 (8 lines)
Virus infected plantlets	18 (28.6%) (6 lines)
positive for FMV	6 (22.2%) (3 lines)
positive for YDV	10 (37.0%) (6 lines)
positive for SPVN	7 (25.9%) (5 lines)
positive for SPV II	0
positive for MMV	5 (18.5%) (5 lines)
Graft indexing I (G1)	
No. of plants indexed	18 (8 lines)
No. of plants showing symptoms	2 (11.1%) (2 lines)
No. of plants positive for FMV	1 (05.6%) (1 line)
No. of plants positive for SPYDV	0
No. of plants positive for SPLV	0
No. of plants positive for SPV II	0
No. of plants positive for MMV	0
No. of plants with unknown virus	1 (5.6%)
No. of plants with symptoms on TIB 8 clone 9	0
Graft indexing II (G2)	
No. of plants indexed	14 (8 lines)
No. of plants showing symptoms	0
No. of plants positive for FMV	0
No. of plants positive for SPYDV	0
No. of plants positive for SPLV	0
No. of plants positive for SPV II	0
No. of plants positive for MMV	0
No. of plants with unknown virus	0
No. of plants with symptoms on TIB 8 clone 9	0
No. of virus-free lines obtained	8

indexing, accessions introduced from Thailand developed pronounced leaf curl symptoms on *I. nil* and sometimes on *I. setosa*. These plants were checked in the electron microscope, but in no case could any virus particles be detected nor trapped by immunosorbent electron microscopy (ISEM) using any of the five antisera. These leaf curl symptoms could have been transmitted from *I. nil* to *I. nil* by grafting. It was assumed that a small spherical virus not readily detectable by electron microscopy was involved.

Other researchers have suggested the use of *I. setosa* for graft indexing. At present, AVRDC continues to graft index on *I. nil*, because cases were encountered where only *I. nil* and not *I. setosa* showed symptoms in graft indexing (Table 4). A new unidentified virus may be present and may infect only *I. nil*. This aspect is being investigated.

Table 3. Summary of ELISA and graft indexing of AVRDC accessions.

General		
Total no. of lines	18	
No. of meristems excised	280	
No. of meristems survived	186 (66.2%)	
	ELISA 1 test	ELISA 2 test
No. of plantlets tested	186 (18 lines)	72 (17 lines)
ELISA positive plantlets	70 (37.6%) (15lines)	16 (22.2%) (10 lines)
No. of plants positive for		
FMV	34 (48.6%) (12 lines)	4 (25.0%) (3 lines)
YDV	23 (32.9%) (11 lines)	6 (37.5%) (4 lines)
SPVN	38 (54.3%) (12 lines)	4 (25.0%) (3 lines)
SPV II	5 (07.1%) (4 lines)	2 (12.5%) (1 line)
SPMMV	42 (60.0%) (11 lines)	8 (50.0%) (6 lines)
	Graft indexing 1(G1)	Graft indexing 2(G2)
No. of plants indexed	40 (15 lines)	12 (12 lines)
No. of plants with symptoms	5 (12.5%) (4lines)	1 (8.3%) (1 line)
No. of plants positive for		
FMV	1 (20.0%) (1 line)	1 (100%) (1 line)
YDV	0	0
SPVN	0	0
SPV II	1 (20.0%) (1line)	1 (100%) (1 line)
SPMMV	0	0
unknown	4 (80.0%) (4 lines)	0
Plants with symptoms on TIB 8	0	
No. of virus-free lines obtained	11	

Table 4. Indicator plants recovered from graft indexing which showed conspicuous virus symptoms, yet no virus was found by either ELISA or ISEM.

Origin of lines		Total no. of indicator plants with symptoms but no virus was detected	Symptoms only on *I. nil*	Symptoms only on *I. setosa*	Symptoms on both *I. nil* and *I. setosa*
Thailand	G1	71	18 (25%)	7 (9.9%)	46 (65%)
	G2	11	7 (64%)	0	4 (36%)
AVRDC BL	G1	1	0	0	1 (100%)
AVRDC Acc.	G1	4	4 (100%)	0	0

Comparison between Meristem-derived and Field-propagated Plants

Summary

Stem cuttings of meristem-derived and field-propagated sweet potato were planted in an AVRDC field in a nonreplicated trial to determine the vigor of meristem-derived plants and possible mutation of morphological characters as a result of tissue culturing. The meristem-derived plants did not differ in overall morphology from nonmeristem derived ones and generally had higher yields than the field-propagated plants. A few of the meristem-derived clones were found reinfected with FMV virus in this first planting.

Introduction

Meristem tip culture usually involves the formation of some callus tissue. This may result in mutations and thus genetic variability. Plants which are morphologically or biochemically different from their parental material may develop. Therefore, all lines which have undergone meristem-tip culture were compared with their parental stock in the field for gross morphological characters.

Materials and Methods

Nine AVRDC meristem-derived and virus-indexed breeding lines were compared with field-propagated plants of the same lines. Of each line, 20 stem cuttings (30 - 40 cm long) were planted on 29 August 1988 in 1 × 5 m plots. Distance between plants was 25 cm and between plots, 1 m.

Once during the growing period (10 October 1988), the plots were sprayed with Furadan 3G. On 1 December 1988 the plants were uprooted. The above ground parts were visually compared for morphology, storage root skin and flesh color in cooperation with the plant breeders using the recommended IBPGR sweet potato descriptors. Yield data were taken. Leaf samples were also taken from every other plant of each plot for virus detection by ELISA. Three leaves per plant were collected from the top, middle and bottom part of the individual plants and tested by ELISA for SPFMV, SPYDV, SPLV, SPVII and SPMMV.

Results and Discussion

The meristem-derived plants were identical to non-meristem-derived plants with respect to gross morphological characters (vine habit, leaf morphology, storage root skin and flesh color). However, it was observed that some meristem-derived lines (PI 1656-97, PI 1656-101) had a more pronounced purple root skin, possibly due to an increased anthocyanin production. In meristem-derived lines of 1618-461 and 1656-101 the root flesh also showed an increased purple spotting. In most lines, the yield of meristem-derived plants was higher than that of the field-propagated plants (Table 5). In lines

Table 5. Morphological characters and yield of meristem-derived and field-propagated sweet potato.

Line	Meristem code no.	Meristem-derived virus indexed plants	Non-meristem derived plants
		yield/plant (kg)	yield/plant (kg)
B 1683-18	M3	6.8	–
	M11	8.6	–
		7.7 (ave.)	6.0
B 1517-142	M6	8.3	–
	M8	9.3	–
		8.8 (ave.)	7.6
B 1656-97	M5	8.9	–
	M6	9.3	–
		9.1 (ave.)	9.3
B 1657-5	M3	10.4	–
	M9	9.4	–
		9.9 (ave.)	5.5
B 1656-101	M5	9.8	–
	M7	7.8	–
	M2	8.0	–
		8.5 (ave.)	9.0
B 1618-461	M21	9.8	–
		–	5.7
B 942-47	M4	9.0	–
		–	9.3
B 1656-37	M7	9.0	–
	M3	8.4	–
		8.7 (ave.)	7.2
Total average		8.3	6.5

1656-101, 942-47, the yield of meristem-derived plants was slightly lower than that of the field propagated plants. However, although numerically higher, the average yield of all meristem-derived lines was not statistically different from the average yield of the field-propagated plants.

It was noted that virus reinfection was present in a large number of meristem-derived plants in the first growing season. Virus presence was positively identified by ELISA in seven of the 14 plots with meristem-derived plants (Table 6). This was evident by the appearance of conspicuous red rings and spots on the foliage of some of these meristem-derived plantlets as early as eight weeks after planting in the field.

Table 6. Detection of virus in meristem and field-propagated plants in the first growing season.

Line		No. of plants observed with virus symptoms[z]	No. of virus infected plants[y]	Virus detected				
				F	Y	LV	II	MMV
942-47	FP	6	6 (1)[x]	5(1)	2(4)	0	(1)	0
	M4	2	1 (1)	1	(2)	0	0	0
1656-37	FP	0	(8)	0	(8)	0	0	0
	M7	0	(3)	0	(3)	0	0	0
	M3	0	2 (1)	1	(1)	0	(1)	0
1656-101	F	5	1 (1)	1	0	(1)	0	0
	M5	4	0	0		0	0	0
	M7	1	0	0	0	0	0	0
	M2	1	1	1(2)	1	0	0	0
1618461	FP	9	8	8	6	0	1	0
	M21	5	1	1	0	0	1	0
1656-97	FP	1	1(1)	1(1)	0	0	0	0
	M5	1	1(1)	1(1)	0	0	0	0
	M6	1	0	0	0	0	0	0
1657	FP	0	1	1	0	0	0	0
	M3	0	0	0	0	0	0	0
1683-18	FP	6	4(2)	4(2)	2(1)	(2)	(2)	0
	M3	5	3	3	(1)	0	0	0
	M11	4	1(1)	1(1)	(5)	(1)	0	0
1517-142	FP	0	0	0	0	0	0	0
	M6	1	0	0	0	0	0	0
	M8	0	(3)	(3)	0	0	0	0

[z]Out of 10 plants/plot, from which samples were taken. [y]Samples, consisting of 3 leaves per plant and pooled were taken from 10 alternating plants of each plot. [x]The no. of samples with a clearly positive + or + + ELISA reaction. No. in parentheses reflects the no. of samples where the ELISA reaction was +/−.

Efficiency of DAS ELISA for Virus Detection

Summary

The efficiency of DAS-ELISA test in separating healthy from virus-infected sweet potato plants was examined. The distribution of OD values was not bimodal. Values of healthy sweet potato were generally clustered around 0, tailing off to the right particularly in MMV and SPYDV. OD values of infected sweet potato were scattered over a wide absorbance range possibly indicating different virus concentrations ranging from very low to very high in the host plant. OD values of virus-infected plants overlapped or were very close to the values of healthy plants. A negative/positive threshold of twice the average OD of healthy plants should be adopted. New antisera need to be produced as well as other more sensitive serological tests such as the indirect DOT ELISA.

Introduction

A clear separation of virus-positive and healthy samples is a criterion of reliability of the ELISA test. This is particularly important in virus indexing during detection and subsequent elimination of virus carriers. The clear separation depends on the antiserum titer, the amount of antibodies on healthy plant proteins in the antiserum.

Tests were conducted to determine the absorbance range of healthy and infected plants and to know if the DAS-ELISA test with the presently available antisera would clearly separate virus-infected plants from healthy ones.

Materials and Methods

Healthy and virus-free plant materials which underwent two ELISA and two graft indexing tests were grown. Infected plants consisted of sweet potato artificially infected with individual viruses and showing clear symptoms of infection. Samples consisted of three pooled leaves per plant, extracted with an extraction buffer of 1% egg albumin and 0.01 M Na DIECA.

Results and Discussion

If positive and negative populations are not well separated by a reasonable absorbance interval, problems may arise in applying the ELISA test. Furthermore, the negative individual population in an ELISA histogram may not always be normally distributed, but may tail off to the right instead. This tail area has potential to contain false positives. Similarly, if the positive population is not normally distributed but tails off to the left or is scattered across a wide range of OD values, separation of positive from negative values becomes difficult.

Absorbance values obtained in this study were not bimodally distributed (Table 7). With the exception of MMV, most OD values for healthy plants were clustered near zero, but the OD values of the virus-infected plants were found scattered across a large range of absorbance units (Fig. 1a,b,c,d,e). In MMV and TDV, the lowest OD values of diseased plants were found near the highest OD values of healthy and virus-free plants. This wide OD range of diseased plants with low values near values of healthy plants possibly reflects the previously found uneven concentration of sweet potato viruses (Esbenshade and Moyer 1982[1]: Green et al. 1988[2]).

Therefore, separation of healthy plants by DAS ELISA, used in the present virus indexing scheme, is not easy even with the use of a positive negative threshold of two times the average absorbance value (2X) of the healthy controls. This value had been recommended (Sutula et al. 1986)[3] to prevent false negatives. For SPYDV and MMV, a clear separation may not be possible but false negatives/positives may be possible.

Different purification methods are being tried to obtain antisera with higher titer and fewer antibodies to healthy plant materials for better separation of healthy from infected plants. Sweet potato viruses are difficult to purify because of their generally low concentration in the host and because they usually do not infect hosts from which they can be easily purified. Different serological methods such as DOT ELISA on nitrocellulose membranes known to have higher sensitivity will also be tried.

Table 7. DAS ELISA absorbance values and range of healthy and infected sweet potato plants.

Virus	Healthy plants			Infected plants		
	Range	Mean(x)	2x	Range	Mean	S^z
FMV	0.000-0.025	0.004	0.008	0.282-2.000	1.352	0.257
SPYDV	0.000-0.208	0.027	0.054	0.185-2.000	1.225	-0.123
SPV-II	0.000-0.173	0.009	0.018	0.420-2.000	1.241	0.247
SPLV	0.003-0.077	0.014	0.028	0.394-2.000	1.370	0.317
MMV	0.013-0.203	0.060	0.120	0.084-1.797	0.541	-0.119

[z]Absorbance interval between the highest OD values of healthy plants and the lowest OD value of infected plants.

[1]Esbenshade, P.R. and J.W. Moyer. 1982. Plant Disease 66, 911-913.
[2]Green, S.K., Y.J. Kuo and D.R. Lee. 1988. Tropical Pest Management 34(3): 298-302.
[3]Sutula, C.L., J.U. Gillef, S.M. Morrissey and D.C. Ramsdell. 1986. Interpreting ELISA data and establishing the positive-negative threshold. Plant Disease 70(8):722-726.

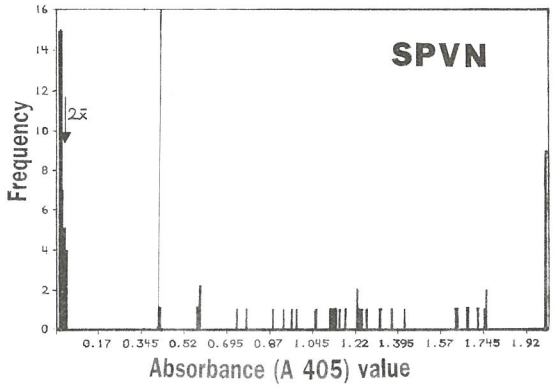

Fig. 1a. SPLV

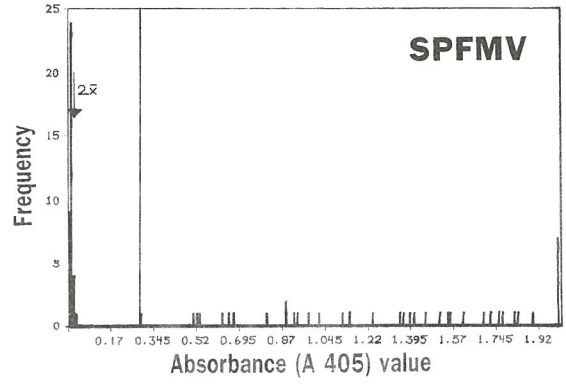

Fig. 1b. SPFMV

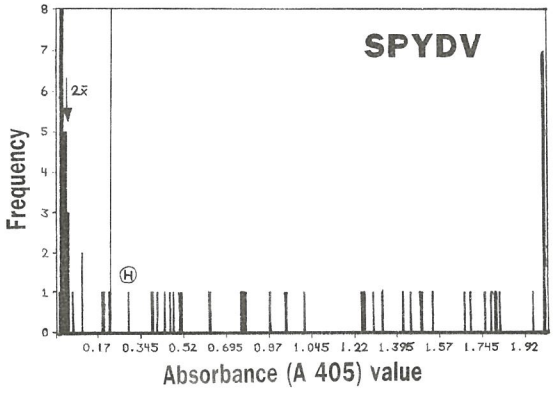

Fig. 1c. SPYDV

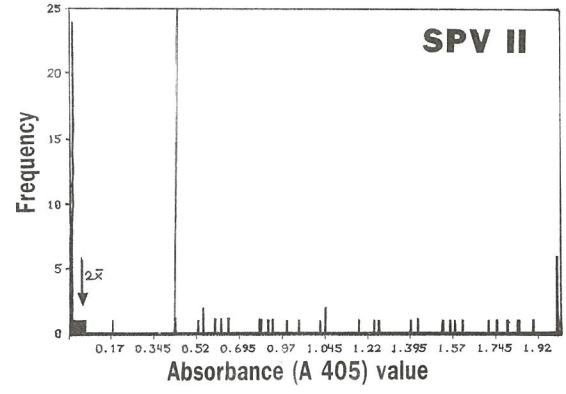

Fig. 1d. SPVII

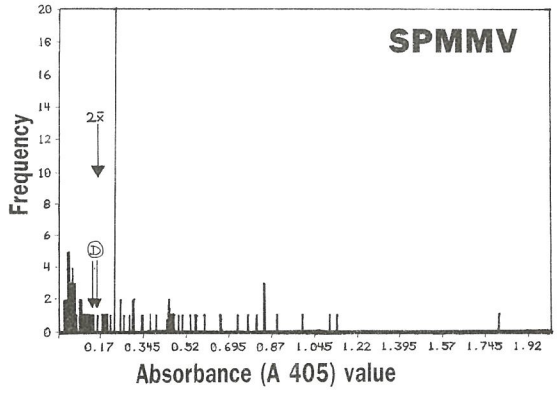

Fig. 1e. SPMMV

Fig. 1. Positive and negative thresholds of five sweet potato viruses measured by DAS ELISA.

Virus Purification for Antiserum Production

Summary

Three sweet potato viruses were purified for antiserum production. About 1.4-3.4 mg of MMV, 1.5-3.5 mg of SPLV and 2.4-2.5 mg of SPYDV were taken per 100 g infected leaves. With the antisera produced, virus-infected plants could be clearly separated by DAS ELISA from healthy plants.

Introduction

In sweet potato virus elimination, AVRDC presently utilizes both serology (ELISA) and grafting to susceptible indicator plants (*I. nil* and *I. setosa*) to verify the absence of virus.The ELISA test is done on meristem-derived plantlets at the 4-5 leaf stage before they are grown out. ELISA eliminates virus-infected plantlets at an early stage, before graft indexing. To have ample supply of antiserum to these viruses for the ELISA tests, AVRDC has produced its own antisera.

Sweet potato viruses are difficult to purify and transmit mechanically because viruses often occur in low concentrations, or are unevenly distributed in the plant and because sweet potato sap contains powerful inhibitors. Different buffers with chelates and antioxidants and liquid nitrogen were tried to transmit the viruses to other hosts from which they might be more easily purified.

Several purification methods used for potyviruses were tried.

Materials and Methods

Purification. SPMM and SPV II were mechanically transmitted to systemic hosts. The viruses were purified by a modification of the method used by Lisa et al. 1981[4], for the purification of zucchini yellow mosaic. Young leaves were harvested two weeks after mechanical inoculation and homogenized (1:2/W:V) in extraction buffer for 4 min at 4°C. After addition of Freon (1,1,2-Trichloro-trifluoroethanol) (1V:1 part original fresh leaves) at 4°C, and low speed centrifugation (5000 rpm, 20 min/4°C), the virus containing aqueous phase was collected and subjected to 2-3 cycles of low speed (5000 rpm, 10 min, 4°C) and high speed (25,000 3.5 hour, 4°C Beckman 45 Ti rotor) centrifugation.The resuspended virus containing pellet was subjected to a quasi-isopycnic centrifugation in CsCl (400 mg CsCl/ml) at 26,000 rpm (Beckman SW 41 rotor 18 hours, 10°C). The virus band was collected from the gradients, diluted with 4-5 volumes of 0.05 M Na-citrate buffer pH 7.5, containing 0.02 M Na_2SO_4 and recentrifuged in CsCl (0.4 g/ml) following the previous conditions.

Following the second CsCl centrifugation, the virus containing band was collected, diluted as before and centrifuged at 30,000 rpm for 4 hr at 4°C.The resulting pellet was resuspended in 0.05 M sodium citrate buffer pH 7.0 and viewed in an electron microscope for purity.

Antiserum production. This purified virus preparation was injected into New Zealand rabbits for antiserum production. At seven-day intervals, rabbits were given two intramuscular injections of purified virus (4 mg/1 ml) emulsified with an equal volume of Freunds incomplete adjuvant and one intramuscular injection emulsified with complete adjuvant. Rabbits were allowed to bleed weekly, starting three weeks after the last injection.

Serology. The serum activity was tested by indirect ELISA using alkaline phosphatase.

Results and Discussion

SPMMV. The virus was purified twice from systemically infected *Nicotiana tabacum*. Concentration was from 1.419 mg/ml to 2.05 mg/ml.Yields were from 1.41 mg to 3.4 mg per 100 g infected leaves. The titer of the antiserum was 510, determined by the ring test. Serological activity

[4]Liso, V, G. Boccardo, G.D'Agostino, G. Dellavalle and M d' Aquilio, 1981, Characterization of a potyvirus that causes zucchini yellow mosaic. Phytopathology 71: 667-672.

is shown in Table 8. The serum was able to clearly differentiate between healthy and infected sweet potato and *N. benthamiana* tissues at a 2000 fold dilution of antiserum and of goat anti-rabbit antibodies. The absorbance value for healthy sweet potato was 0.003 compared to 0.894 for infected sweet potato.

Table 8. Indirect ELISA absorbance (A_{405}) values for sweet potato viruses isolated at AVRDC.[z]

Sample	MMV	SPLV
Healthy *N. benthamiana*	0.016[y]	0.283
Diseased *N. benthamiana*	1.709	1.506
Healthy *I. batatas*	0.003	0.004
Diseased *I. batatas*	0.894	0.989

[x]Dilution of antiserum and goat anti-rabbit 1gG was 2000X for all viruses. [y]Absorbance values are the means of three replicates.

SPLV. The virus was purified twice from systemically infected *N. benthamiana*. Virus concentration was from 3.16 mg/ml to 5.7 mg/ml and yields were from 1.5 mg to 3.5 mg per 100 g infected leaves. Determined by ring precipitation, the titer of the antiserum was 1024. Serological activity is shown in Table 8. The serum was able to clearly differentiate between healthy and infected sweet potato. At a 2000-fold dilution of both antiserum and goat anti-rabbit antibodies, the absorbance value for healthy sweet potato was 0.004 compared to 0.989 for virus-infected sweet potato.

The antiserum contained a large amount of antibodies to healthy *N. benthamiana*, as indicated by high absorbance values of 0.283 compared to 1.506 for virus-infected *N. benthamiana*. However, when sweet potato tissue was tested, very low healthy absorbance values were obtained, making this serum suitable for virus indexing where only *Ipomoea* sp. and not *Nicotiana* sp. are used.

SPYDV. The virus could be mechanically transmitted to *Sesamum indicum*. Purification and antiserum production were the same as those described for MMV.

Virus concentration was from 2.47 mg/ml to 2.56 mg/ml. Virus yield was from 2.9 to 4.1 mg per 100 g infected leaves. Antiserum is presently being produced.

Effect of Virazole and Heat on Leaf Curl Virus

Summary

Sweet potato leaf curl is a disease for which the causal agent or SPLC virus particles have not been found so far. Antiserum is not available and indexing by ELISA is not possible. Several treatments which may reduce the SPLC incidence were investigated. The routine meristem tip culture used in the present scheme was found effective in eliminating SPLC symptoms in 80% of the treated plants. When stem tips were treated with 500 mg/l virazole, 86% of the resulting plantlets did not show SPLC symptoms. However, results of heat treatment were not conclusive.

Introduction

To date, the sweet potato leaf curl disease particles have not been observed but it is known that the disease is whitefly-transmitted and has been reported only in Taiwan. Sweet potato cultivar Tainung 63 is particularly susceptible and reacts with pronounced upward rolling of the leaf lamina. In the present virus indexing scheme, detection of this virus is only possible by grafting the susceptible indicator plants, *I. setosa*, and *I. nil* which both react to leaf curling. The effect of virazole and heat treatment on the incidence of leaf curl in possibly infected sweet potato plants was investigated.

Materials and Methods

Virazole treatment. Leaf curl-infected TN 63 was used. Fifteen stem tips were selected and meristems of 0.3 mm and 1-cm long stems (S_1) immediately below the meristem were excised and

placed on Love and Rhodes (LR) medium. A 1-cm long stem section below S_1 was excised (S_2) and placed on LR medium of 20 mg/l virazole; similarly a 1-cm stem section below S_2 (= S_3) and a 1-cm 17 stem section below S_3 (= S_4) were excised and placed on LR medium supplemented with 30 and 50 mg/l virazole, respectively. When the plantlets had reached 4-5 leaf stage, they were transferred to Jiffy 7 pellets. About 4-6 weeks later, they were planted in 5-inch clay pots where the plants were allowed to grow for nine months. At that stage the plants were visually rated for leaf roll symptoms. About 20-cm long stem sections were cut from plants without clear symptoms, placed in water culture and kept for 1-2 weeks at 37° ±2°C. At this elevated temperature very distinct symptoms developed, thus facilitating the rating.

Heat treatment. TN-66 plants were kept for either one or two months at 37° ±2°C. Following heat-treatment meristems (0.3 mm size), 1-cm stem sections (S_1) below the meristems, and 1-cm stem sections below S_2 were excised and placed on LR medium. At 4-5 leaf stage, the plantlets were removed from the culture medium and placed in Jiffy 7 pellets. Plantlets were transplanted in clay pots and rated as above.

Results and Discussion

Virazole treatment. With an increasing concentration of virazole, the percentage of virus-free plants increased. About 86% of the stem pieces treated with 50 mg/l virazole were found to be SPLCD-free compared to none for the nonvirazole-treated stem tips, and 29% and 57% for the stem tips which were grown in 20 mg/l and 30 mg/l virazole, respectively (Table 9). The roots of virazole-treated plants were short and had the tendency to grow above the agar. Normal growth resumed after plantlets were placed in Jiffy 7 pellets. Virazole-treated mature plants were morphologically indistinguishable from nonvirazole-treated plants.

Meristem tip culture also appears to affect the elimination of SPLC. About 80% of the meristems were virus-free, compared to 0% of the 1-cm stem sections immediately below the meristems.

Table 9. Effect of virazole and meristem-tip culture on sweet potato leaf curl virus excised.

Plant part	Plant no.															% of plants without leaf curl symptoms
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
M (0)[z]	NG[y]	–	–	–	+	–	–	–	+	NG	NG	–	NG	NG	–	80
S_1 (0)	+	+	+ +	+	+ +	+	+	+	+ +	+ +	+ +	NG	+ +	+	+	0
S_2 (20 mg/l)	–	–	+	+	NG	+	+	–	+ +	+ +	+ +	+	+ +	+	–	29
S_3 (30 mg/l)	–	–	–	–	+	+	–	–	+ +	+ +	+	+	–	NG	–	57
S_4 (50 mg/l)	–	–	–	–	–	–	–	–	+ +	–	+	–	–	NG	–	86

[z]Figure in parentheses is virazole concentration. [y]NG: no growth in test tube or plant failed to grow after it was planted in Jiffy 7 pellets. + :leaf curl symptom. + + :severe leaf curl symptom.

Heat treatment. The results of heat treatment were inconclusive (Table 10). The number of virus-free plants resulting from heat-treated meristems was not markedly different from those excised from plants without heat treatment.

Virus elimination was observed in both S_1 and S_2 heat-treated stem sections although no difference was observed in one and two-month heat treatments in S_1. Virus elimination was, however, slightly lower in S_2 than in S_1. It is assumed that a heat treatment longer than two months has to be applied to effectively eliminate SPLC from virus-infected stem tips. This virus seems to be less affected by heat than other sweet potato viruses.

Thus, meristem tip culture was found 75-80% effective in eliminating SPLCD symptoms. Heat treatment prior to meristem excision did not increase elimination efficiency. Virazole at higher concentrations was also effective in SPLCD elimination. It is expected that a combination of meristem tip culture (which is routine in the present scheme) and virazole treatment will be more efficient in producing a high number of leaf-curl-free plants than meristem-tip culture alone. Experiments with higher virazole concentrations are under way.

Table 10. Effect of heat treatment on sweet potato leafcurl virus.

Plant part	Plant no.															% of plants without leaf curl symptoms
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
1 month heat																
M[z]	+[y]	–	+	–	–	+	NG	NG	–	–	–	NG	–	–	NG	72
S_1	+ +	–	+	NG	–	+	+	+ +	–	+	+	–	–	–	NG	46
S_2	+ +	+	+ +	+	–	+	+	+	+ +	–	NG	+	–	+	NG	31
2 month heat																
M	–	+	–	+	–	–	NG	–	–	NG	+	–	NG	–	–	75
S_1	–	+	+	+	–	+	+ +	–	+ +	–	+ +	–	+ +	NG	–	45
S_2	+	+	–	+	NG	+ +	+ +	–	+ +	+	+ +	+	NG	NG	+	17
No heat																
M	–	+	–	–	–	NG	–	+	–	–	NG	+	NG	–	–	75
S_1	+ +	+ +	+	+ +	+	+	+	+	+	+	NG	+	+	+	+	0
S_2	+ +	+ +	+	+ +	+	+	+	+	+	+	+	+	+	+	+	0

[z]Excised plant part: M = meristem; S_1 = 1-cm stem section below the meristem; S_2 = 1-cm stem section 1-cm below S_1. [y]NG: no growth in tissue culture medium or failure of plantlet to grow out in Jiffy pot. +:leaf curl symptoms. + +:very severe leaf curl symptoms.

Improvement of Heat Treatment Method for Virus Elimination

Summary

Heat treatment at 37°C for two months has been recommended for the elimination of certain sweet potato viruses. However, based on AVRDC's experience, potted sweet potato plants (in sand or 1:1:1 sand, soil, vermiculite) showed poor growth, often dried and wilted. The potting substrate used easily became dry.Three different hydroponic systems using 1/2 strength nutrient solution (either pure or combined with hydrocron balls) in lid-covered styrofoam containers or with fitted baskets containing rice husks were used as an alternative for soil or sand potting mixture.The temperature of the nutrient solution covered by baskets containing burned rice hulls averaged 5.4°C lower than the room temperature; since good plant growth was achieved using this medium, it has thus been adopted to improve that treatment for virus elimination at AVRDC.

Introduction

Heat treatment of virus-infected plants at various lengths of time was found effective in eliminating feathery mottle virus (Hildebrand 1961)[5], sweet potato mild mottle virus (Hollings et al. 1976)[6] and sweet potato yellow dwarf virus (Green and Lo, in press)[7]. Duration of heat treatment was found positively correlated with the efficiency of virus elimination. The longer the heat treatment, the more efficient is virus elimination. Treatment at 37°C for two months was found most effective for elimination of sweet potato viruses. AVRDC's experience showed that sweet potato plants kept at this temperature in pots containing sand or sand, soil and vermiculite (1:1:1) grew slowly, had reduced turgor and often wilted. The supporting medium dried out quickly. Hydroponic culture was therefore attempted to improve plant growth under this elevated temperature.

[5]Hildebrand, E.M. 1967. Russet crack — a menace to the sweet potato industry. I. Heat therapy and symptomatology. Phytopathology 57:183-187.

[6]Hollings, M; O.M. Stone and K.R. Bock. 1976. Purification and properties of sweet potato mild mottle, a white-fly borne virus from sweet potato (*Ipomoea batatas*) in East Africa. Ann. Appl. Biol. 82:511-528.

[7]Green, S.K. and C.Y. Lo 1989. Elimination of sweet potato yellow dwarf virus by meristem-tip culture and by heat treatment. Journal of Plant Diseases and Protection 96: 464-469.

Materials and Methods

Three treatments using a half-strength nutrient solution in polystyrene containers (26 × 20 × 14) were tested.

In treatment A, the container was covered with a 1.2-cm thick polystyrene lid with six holes, each containing a 20-cm long stem cutting, protected at the hole with rubber foam (treatment N).

In treatment B, the nutrient solution was combined with a 3-cm thick layer of hydrocron balls floating on the solution. The box was covered with a polystyrene lid as in A (treatment N+H).

In treatment C, the box was covered with a fitted basket (5.5 cm deep) containing burned rice hulls. Rice hulls were kept from falling through the holes by a plastic net. Six stem cuttings were placed vertically into the rice hulls layer (treatment N+BR).

In every treatment, three containers were used. The level of the nutrient solution was initially kept above the bottom of the stem sections. After root emergence, the water level was lowered so that the top part of the root was above the nutrient solution.

The growing conditions of the room were as follows: 12 hours day length, 3.1 klux illumination at 10 cm above plant level, using 400 W fluorescent daylight. The room was heated by an electric heater and temperature was thermostatically controlled at 37°C. An exhaust fan was installed just below the ceiling to allow constant air circulation. An electric humidifier kept the relative humidity at an average of 65%.

The temperature in the room and that of the nutrient solution inside the box were determined daily at 1:00 pm for two weeks, starting three days after the boxes were placed in the heated growth room.

Results and Discussion

Covering the polystyrene containers with a basket of burned rice hulls kept the temperature of the solution inside the container at an average of 31.6°C, i.e. 5.4°C lower than the room temperature (Table 11). After prolonged storage of the container at 37°C, the temperature of the nutrient solution was usually about 5°C lower than the room temperature. In other containers covered by styrofoam lids, the temperature of the nutrient solution was only 2.8° (treatment N) or 1.6°C (treatment N+H) lower than room temperature.

Table 11. Temperature of the growth room and nutrient solution.

Day	Temperature (°C)			
	Room	Liquid growth medium		
		N+H	N	N+BR
1	36.5	34[x]	33.5	30.5
2	37	35	34	31
3	36.5	35	34	29.5
4,5	NM[y]	NM	NM	NM
6	36.5	35.5	34.5	31
7	37	36	35.5	31.5
8	36.5	35	34	31.5
9	38	36	34.5	32
10	37.5	35.5	34.5	32
11,12	NM[y]	NM	NM	NM
13	38	36.5	35	33
14	38.5	36.5	35	31.5
15	36	34.5	34	32
16	37	35.5	34	32
17	36.5	35	33.5	32
18	37	35	34	32
Average	37 a[z]	35.4 b	34.2 c	31.6 d

[z]Average temperature of 3 containers. [y]NM = not measured. [x]Mean separation by DMRT at 5% probability level.

The burned rice hull method has been found very satisfactory for plant growth at this elevated temperature and has now been routinely adopted for heat treatment at AVRDC.

Media for Meristem Tip Culture

Summary

The recently proposed Gamborg B-5 medium was compared with the AVRDC standard medium, i.e. Love and Rhodes medium (1985), in combination with the modified Murashige and Skoog medium. In Gamborg B-5, 27% of the meristems regenerated into plantlets, 55% on the AVRDC standard medium. Callus formed less in Gamborg B-5 medium than in AVRDC standard medium.

Introduction

At AVRDC a modified Murashige and Skoog medium had been initially used (Kuo et al. 1985). It was found in 1987 that regeneration of sweet potato explants was better when they were first placed on Love and Rhodes medium (1985) and then transferred to the modified Murashige and Skoog medium.These two media have now been adopted for routine use at AVRDC. Recently, a new series of tissue culture media for the growth of sweet potato explants was proposed by tissue culture specialists at the International Potato Center (J. Dodds, personal communication, 1988)[8]. These media were compared with the AVRDC standard medium.

Materials and Methods

The composition of the Love and Rhodes and Kuo et al. media was previously described.The proposed Gamborg medium was composed of: Medium for meristems or shoot tips (Stage 1): Gamborg's B-5 salts, or 1/2 strength MS salts with minimal organics; 2 mg/l calcium panthotenate, 20 mg/l gibberellic acid; 100 mg/l ascorbic acid; 100 mg/l calcium nitrate; 20 mg/l putrescine HCl; 100 mg/l L-arginine HCl; 10 ml ascorbic acid; 100 mg/l calcium nitrate; 20 mg/l putrescine HCl; 100 mg/l L-arginine HCl; 10 ml coconut water (or 0.4 mg/l kinetin); 5% sucrose; 0.7% agar; pH 5.6; and medium for meristem or shoot tip transfer (Stage 2): Gamborg's B-5 salts or 1/2 strength MS salts with minimal organics; 2 mg/l calcium panthotenate; 15 mg/l gibberellic acid; 100 mg/l ascorbic acid; 100 mg/l calcium nitrate; 20 mg/l putrescine HCl; 100 mg/l L-arginine HCl; 5% sucrose; 0.7% agar; pH 5.6.

The growth of 152 excised meristems of 17 sweet potato lines in these media was compared to that in the AVRDC standard medium.

Results and Discussion

About 55% of the meristems regenerated into plantlets in the AVRDC standard medium compared with 27% of meristems grown in Gamborg B-5 media (Table 12).

Lesser callus formed in Gamborg B-5 media than in AVRDC standard media. In Gamborg B-5 medium, growth of explants was generally weak and in some cases ceased. Many explants turned brown and became weak with yellowish foliage.

Thus, the standard AVRDC media will be retained for routine use.

[8]Dodds, J. 1988. Personal communication. International Potato Center, Peru.

Table 12. Comparison of sweet potato meristems in AVRDC standard medium with Gamborg B-5 medium.

Sweet potato Line	AVRDC standard media		Gamborg B-5 media	
	No. of meristems excised	No. of plantlets regenerated	No. of meristems excised	No. of plantlets regenerated
L 19	10	6	11	2
L 43	4	0	8	0
L 135	6	3	4	0
L 183	5	2	5	0
L 188	10	9	9	4
L 292	12	5	12	3
L 295	7	3	7	1
L 296	9	7	6	3
L 297	12	5	11	1
L 300	10	7	15	6
L 303	9	9	9	7
L 312	8	2	8	0
L 326	8	4	10	0
L 329	8	2	9	0
L 330	8	4	7	4
L 185	13	3	5	0
L 186	13	12	10	8
Total: 17 lines	152	83 (55%)	146	39 (27%)

Different Media for Growing Out Tissue-cultured Plantlets

Summary

In the present virus elimination and indexing scheme being used, regenerated plantlets are routinely transferred from the test tubes to Jiffy pellets before they are planted in pots containing the standard potting medium (1:1:1 sand soil and vermiculite). Other different growing media such as 1/2 and 1/4 strength nutrient solution with rice hulls (natural or burned), 1:1 sand soil and 1:1:1 sand vermiculite and soil were tested to find a growing medium superior to Jiffy pots. The 1/4 strength nutrient solution with rice as supporting medium and the 1:1 sand:vermiculite medium gave the lowest values for fresh root and whole plant weight. The Jiffy pellets gave the highest values, followed by the 1/2 strength nutrient/burned rice and 1:1:1 sand:vermiculite:soil.

Introduction

The average time needed to regenerate plantlets from meristems varies widely and depends on the genotype. Regeneration of plantlets takes anywhere from six weeks to four months. Regenerated plantlets are often fragile, grow slowly and are sometimes accompanied by a high mortality rate when removed from the protected tissue culture medium and transplanted into soil or other media. In the AVRDC indexing scheme, regenerated plantlets are routinely transferred initially to Jiffy 7 pellets before they are planted in the soil.This study aimed to determine if other initial transplanting media would give better plant growth than that presently obtained from Jiffy 7 pellets.

Materials and Methods

Seven treatments were tested for growing tissue-cultured plantlets.

1) 1/2 strength nutrient solution with burned rice hulls as supporting medium in styrofoam cups (10 cm high, 8 cm upper diameter, 4.5 cm bottom diameter).
2) 1/4 strength nutrient solution with a 4-cm layer of burned rice hulls as supporting medium in styrofoam cups.

3) 1/2 strength nutrient solution with a 4-cm layer of rice hulls as supporting medium in styrofoam cups.
4) 1/4 strength nutrient solution with a 4-cm layer of rice hulls as supporting medium in styrofoam cups.
5) sterilized mixture of sand and vermiculite (1:1) in styrofoam cups.
6) sterilized mixture of sand, vermiculite and soil (1:1:1) in styrofoam cups.
7) Jiffy pots (standard AVRDC practice).

Eight breeding lines were tested in two replicates. Containers were randomly arranged in the screenhouse and data were taken after two months.

The full-strength nutrient solution was composed of:

Constituent	g/l	Constituent	mg
$Ca(NO_3)_2.2H_2O$	0.59	FeEDTA	22.6
KNO	0.22	$MnSO_4.H_2O$	1.54
K_2HPO	0.18	$CuSO_4.5H_2O$	0.079
$CaC1_2.2H_2O$	0.18	$ZnSO_4$	0.220
$MgSO_4.7H_2O$	0.49	H_2BO_3	2.86
		$Na_2MoO_4.2H_2O$	0.025
		$pH^2$6.0	

Results and Discussion

Different cultivars generally behaved differently on each of the growing media tested (Table 13). The 1/4 strength nutrient solution with rice hulls as supporting medium and the 1:1 sand:vermiculite medium generally gave the lowest values for fresh root, and whole plant weight. Based on ranking of the highest numerical values of three parameters tested among nine cultivars (Table 14), the Jiffy pot treatment was ranked first, followed by the 1/2 strength nutrient solution/burned rice culture, 1:1:1 (sand:soil:vermiculite), and 1/2 strength nutrient/solution rice culture.

Based on these findings it was decided that AVRDC will continue the transfer of the regenerated plantlets to Jiffy 7 pellets first before transplanting these to the soil.

Seed Transmission of Viruses in Indicator Hosts

Summary

The absence of seed transmission of sweet potato viruses in indicator hosts used for virus-indexing must be guaranteed. This has never been verified before. Seeds of indicator plants *I. nil* and *I. setosa* infected with the sweet potato viruses by mechanical inoculation or by grafting were collected and grown in an insect-proof screenhouse. Seedlings were visually observed for symptoms and tested by ELISA. Seed transmission could not be detected.

Introduction

Grafting of two susceptible indicators, *I. setosa* and *I. nil* is a major part of virus indexing in sweet potato. Absence of viruses in seedlings of these hosts has to be assured, otherwise, they can not be reliable indicators. Information on seed transmission of sweet potato viruses in these two hosts is not available at present.

Materials and Methods

Plants of *I. setosa* and *I. nil* were grafted on virus-infected sweet potato or infected by mechanical transmission. Plants were allowed to bear flowers and seeds. Seeds were collected only from those

Table 13. Growth of regenerated plantlets from tissue culture medium and transferred to different growing media.

Treatment/ entry	Sweet Potato Cultivar								
	1 1-57	2 I-423	3 CN1028-16	4 CN1038-16	5 CN1058-10	6 CN1216-10	7 CN1219-1	8 CN1345-8	9 CN1421-56
Fresh root weight (g)									
1/2 B	1.8 ab	2.7 a	3.1 ab	1.5 a	1.7 a	2.8 a	1.8 a	2.4 b	3.8 a
1/4 B	1.1 abc	2.3 a	2.5 bc	2.1 a	1.3 a	1.5 bc	1.0 a	0.6 d	1.8 bcd
1/2 R	0.4 c	2.9 a	2.1 c	1.8 a	1.2 a	1.2 bc	0.7 a	4.4 a	3.3 ab
1/4 R	0.8 bc	2.4 a	1.6 cd	0.6 a	1.9 a	0.6 c	1.0 a	0.4 d	2.4 abc
1:1	0.9 abc	0.6 ab	0.8 d	0.9 a	0.9 a	0.8 bc	0.8 a	0.4 d	0.6 d
1:1:1	1.9 a	2.3 a	2.2 c	1.9 a	2.3 a	1.7 abc	1.3 a	1.7 c	1.5 cd
Jiffy-pellet	1.8 ab	2.0 a	3.9 a	2.1 a	1.6 a	1.9 ab	1.9 a	2.1 bc	2.1 abcd
Whole plant weight (g)									
1/2 B	4.1 a	6.7 ab	6.2 ab	3.8 a	4.0 ab	6.3 a	4.6 a	6.2 ab	8.1 a
1/4 B	3.2 b	5.0 b	4.2 bc	4.9 a	3.2 ab	3.7 bc	3.8 a	4.2 bc	4.2 bc
1/2 R	1.8 b	7.7 a	5.1 b	4.7 a	3.4 ab	3.9 abc	2.4 a	5.1 b	7.8 a
1/4 R	2.6 b	5.1 b	3.7 bc	2.1 a	3.9 ab	1.8 c	2.5 a	3.7 bc	5.4 ab
1:1	2.4 b	2.2 c	1.9 c	1.9 a	2.3 b	2.1 c	2.0 a	1.9 c	1.6 c
1:1:1	5.6 a	7.4 a	6.2 ab	4.9 a	6.5 a	5.6 ab	3.9 a	6.2 ab	5.7 ab
Jiffy-pellet	6.0 a	6.4 ab	8.1 a	6.1 a	4.0 ab	5.9 ab	4.4 a	8.1 a	7.3 a
Stem length (cm)									
1/2 B	10.0 a	15.5 ab	15.5 a	12.7 a	8.2 a	13.2 a	9.7 a	10.2 b	8.5 a
1/4 B	13.7 a	13.0 abc	12.0 ab	20.0 a	7.7 a	9.2 a	9.7 a	6.0 b	6.2 a
1/2 R	8.2 a	17.0 a	16.2 a	13.5 a	10.3 a	6.2 a	6.0 a	19.5 a	8.5 a
1/4 R	10.7 a	11.5 bc	10.7 ab	9.2 a	10.2 a	5.7 a	7.7 a	5.7 b	8.5 a
1:1	7.0 a	8.5 c	6.5 c	6.2 a	10.7 a	5.7 a	8.7 a	7.7 b	5.2 a
1:1:1	9.2 a	16.0 ab	15.7 a	9.0 a	12.7 a	9.0 a	7.4 a	12.7 ab	10.0 a
Jiffy-pellet	12.2 a	13.2 ab	9.0 ab	15.5 a	15.9 a	15.9 a	9.0 a	11.0 ab	7.2

1/2 B = half strength nutrient solution, burnt rice husks as supporting medium. 1/2 R = half strength nutrient solution, rice husks as supporting medium. 1:1 = sand:vermiculite 1:1:1 = sand:soil:vermiculite [z]Mean separation within columns for each variable by DMRT at 5% probability level.

plants which showed distinct virus symptoms and where presence of virus was verified by ELISA. Seeds were sown in soil in 3-inch plastic pots in an insect proof screenhouse. Seedlings were observed for five weeks for symptom development. Thereafter the individual plants were tested by indirect ELISA for presence of virus.

Results

None of the seeds collected from virus infected plants was found infected with any of the viruses (Table 15). More seedlings need to be tested to confirm these preliminary findings.

Table 14. Ranking of growing media by highest numerical values.

	Fresh root weight (g)	Whole plant weight (g)	Stem length (cm)	Total
1/2 nutrient, burnt rice	21	23	31	75
1/4 nutrient, burnt rice	35	43	33	112
1/2 nutrient, rice	38	37	31	106
1/4 nutrient, rice	45	49	45	139
1:1 (sand:vermiculite)	57	61	53	171
1:1:1 (sand:soil:vermiculite)	30	22	30	82
Jiffy 7 pellet	25	17	27	69

Table 15. Seed transmission of sweet potato viruses.

Virus	*I. nil*		*I. setosa*
	I 57[x]	I 59	I 40
SPMMV	0/6[y]	0/4	
SPLV	0/5	0/4	
SPYDV	0/205	0/4	
SPV II	0/3		
FMV	0/120		0/5
SPLCV	0/9		0/5
Unknown virus 1 (sweet potato mosaic)	0/2	0/3	
Unknown virus 2 (1219-10)	0/5		

[x]Number refers to virus indicator plant collection accession. [y]Number of seedlings grown.

Improvement of Sweet Potato Scab Resistance Screening in Greenhouse

Summary

The SP percent disease area rating system (described in the 1987 Annual Review) has been adopted for greenhouse screening for scab resistance. This rating system is complex and time-consuming. Using a 0-8 scale, disease severity was compared with the SP percent disease area (on stem and petiole) rating. The resistance levels previously evaluated were reflected. The method was found more convenient.

Introduction

The SP percent disease area rating system has been adopted for greenhouse scab resistance screening at AVRDC. Since this rating system was found complex and time-consuming, a more convenient method (disease severity) was sought and compared.

Materials and Methods

Forty-two sweet potato breeding lines and accessions, including 16 highly resistant and 7 highly susceptible lines identified in 1987, 7 AYT and 9 PYT AVRDC breeding lines, and 4 imported lines from IITA, Tonga and Indonesia were tested. Eight-centimeter long cuttings from each variety were individually rooted in 5 cm-diameter plastic pots. Five pots of each eight varieties were placed in a plastic tray. Pots containing cuttings of the highly susceptible (HS) line (I-6), the moderately susceptible (MS) line (CN 1108-13) and the highly resistant (HR) line (V2-30) as checks were randomly arranged in each flat. After a month, the uniformly growing cuttings were inoculated with a suspension of 1.5×10^6 conidia of *E. batatas* isolate Y.S. 25 per ml, using an atomizer with 2.0 kg/cm^2 pressure. The inoculated plants were immediately transferred to a plastic covered moist chamber (R.H. > 98%) in an artificially lighted room at temperatures ranging from 25 to 42°C. Seven-day-old cultures of *E. batatas* for inoculum production were grown on carrot agar in both light and dark conditions for 12 hr at 24°C. Spores from colonies were washed with sterile distilled water, and adjusted to the concentration described above using a hemacytometer. The two disease rating methods used were: 1) 0 to 8 scale where scab disease levels that were similar to I-6 (HS), CN1108-13 (MS), and V2-30 (HR) were rated as 8, 6 and 2, respectively; and 2) the presently adopted SP % disease scale, where 1 = ≤10%; 2 = 11 to 20%; 3 = 21 to 30%; 4 = 31 to 40%; 5 = 41 to 50%; 6 = >50% diseased area of stem and petiole above the third expanded leaf. Disease ratings for both methods were taken on the eighth day after inoculation.

Results and Discussion

The disease indices obtained in two rating methods are shown in Table 16. Both rating methods generally appeared comparable, as reflected in the high correlation coefficient (r= 0.9599) between the two. The lines previously rated as resistant were found in both methods generally resistant in this year's greenhouse screening. Eleven of the 16 HR lines were found more resistant as V2-30 than the HR check. In method B, seven HR lines were found more resistant than the HR check. The resistance of previous HR lines was only slightly lower than the HR check. Two (CN 1831-42, CN 1489-43) of the newly screened lines were identified in both methods to have a resistance similar or better than V2-30. CN1831-14 was identified in method A to have the same resistance as V2-30 and was rated only slightly lower than HR in method B. Two lines from AYT (CN 1618-461 and CN 1517-139) and one line from PYT (CN 1831-55) were identified highly susceptible (HS), I-948 from IITA, and I-1186 from Indonesia were rated highly susceptible to scab among 15 HS cultivars identified last year.

Conclusion

Since ratings in both methods are comparable, the 0-8 scale using check cultivars might be adopted as a more convenient method.

However, most lines previously rated highly susceptible were identified in both methods (in this year's screening) as moderately susceptible. This may be due to last year's rating being more severe or another isolate used in the screening may have produced a higher disease severity than the isolate YS 25.

Scab Confirmation Screening Under Seminatural Field Conditions

Summary

The stability of disease resistance needs to be confirmed once identified in a line. Thirteen clones previously rated highly resistant were again identified as highly resistant. One introduced cultivar from Tonga I-1189 and reportedly resistant to scab elsewhere was also rated highly resistant. The cultivar I-55 was found more susceptible than the previously used HS check cultivars and should be used in further resistance screening.

Table 16. Scab disease severity evaluated in the greenhouse by two screening methods.

Cultivar	Previously HR: Disease Index Method A (0-8)	Previously HR: Disease Index Method B (SP)	Remark	Cultivar	Previously HR: Disease Index Method A (0-8)	Previously HR: Disease Index Method B (SP)	Remark
A. Lines previously rated as resistant				B. Lines previously rated susceptible and new lines			
I-1173	2.7 –[z]	1.8 –	HR 1987	I-971	6.3	5.0	HS 1987
I-944	1.8 +	1.5 –	HR 1987	I-1069	6.9	4.9	HS 1987
I-1206	2.2 –	1.4 –	HR 1987	I-103	6.2	4.8	HS 1987
I-1213	1.5 +	1.3 –	HR 1987	I-122	5.0	3.9	HS 1987
I-483	2.3 –	1.3 –	HR 1987	CN 1370-7	3.8	3.6	HS 1987
CN 1232-9	1.8 +	1.2 –	HR 1987	I-57	4.5	3.5	HS 1987
I-943	2.3 –	1.2 –	HR 1987	CN 1508-93	4.7	3.4	HS 1987
I-934	2.0	1.2 –	HR 1987	CN 1517-139	6.8	5.0	AYT
I-1219	1.6 +	1.1	HR 1987	CN 1618-461	6.8	4.9	AYT
I-849	1.0 +	1.0 +	HR 1987	CN 1525-11	4.8	2.3	AYT
71-7	1.0 +	1.0 +	HR 1987	CN 1661-15	3.3	2.2	AYT
I-844	1.4 +	1.0 +	HR 1987	CN 1656-89	2.3	2.1	AYT
71-1	1.3 +	1.0 +	HR 1987	CN 1510-25	2.8	2.1	AYT
I-949	1.2 +	1.0 +	HR 1987	CN 1489-43	1.8	1.0	AYT
I-673	1.4 +	1.0 +	HR 1987	CN 1831-55	4.9	3.0	PYT
71-4	1.3 +	1.0 +	HR 1987	CN 1831-33	4.5	2.8	PYT
I-6	8.0	4.8	HS CHECK	CN 1826-6	4.5	2.8	PYT
CN 1108-13	6.0	3.9	MS CHECK	CN 1827-5	2.8	1.9	PYT
V2-30	2.0	1.1	HR CHECK	CN 1828-37	2.9	1.8	PYT
				CN 1831-66	3.0	1.6	PYT
				CN 1828-46	2.7	1.6	PYT
				CN 1831-14	2.0	1.4	PYT
				CN 1831-42	1.6	1.1	PYT
				I-1186	5.9	4.4	INDONESIA
				I-948	5.0	3.6	IITA
				I-1191	2.8	1.6	TONGA
				I-1189	1.4	1.0	TONGA

[z] + Rating higher than the HR check. – : Rating lower than but not significantly different from the HR check.

Introduction

Disease resistance, once identified in a line usually needs confirmation screening to ascertain that resistance is stable. Lines found resistant to scab in last year's field screening were screened again under seminatural field conditions. This included I-55 whose suitability as a susceptible check source was determined.

Materials and Methods

Thirteen highly resistant lines from last year's screening as well as three introduced varieties with reported resistance from Tonga, IITA and Indonesia were tested. The susceptible and resistant check cultivars were I-6 and V2-30, respectively. Three highly susceptible lines, namely TN57, TN66 and I-55 were also included. Cultivar I-55 is distinguished by its palm-shaped leaves, deep purple stem and short internodes.

The experiment, in two replicates, was conducted on 18 May 1988. Plot size was 3.0 × 1.5 m. Plots were planted with nine 8-cm long cuttings of each test cultivar. One noninoculated resistant check (V2-30) was planted at one end and two susceptible checks (I-55) on the other end, one of which had been artificially inoculated with a spore suspension of *Elsinoe batatas* isolate Y.S. 25, which served as source of the disease. A resistant and a noninoculated susceptible cultivar were planted every sixth and seventh plot, respectively. Irrigation was done with overhead sprinkler twice daily for 15 min at 0830 and 1600 hr, Monday through Friday. Disease severity was evaluated on 18 July, using a 0-5 scale (where 1 = HR and 4 = HS). Lines that were similar in disease severity to I-6 (HS) were rated as 4 and those similar to V2-30 (HR) were rated as 1.

Results and Discussion

High disease incidence was observed in the susceptible check cultivars TN 57,TN 66, I-6 and I-55. In I-55, scab infection resulted in leaf curling and scab-like necrotic spots on the stems with a tendency to coalesce, often resulting in drying of the growing tip. On V2-30, the HR check, traces of the disease could be observed. All clones previously rated highly resistant were again identified as highly resistant. However, four lines, namely, I-844, I-949, I-1213 and I-1219 — previously rated resistant, showed no visible trace of disease and thus were rated 0. Among introduced cultivars, I-1189 from Tonga was rated highly resistant, I-1186 from Indonesia as moderately susceptible, and I-948 from IITA, highly susceptible (Table 17).

Table 17. Highly resistant cultivars to sweet potato scab, summer 1988.

Line	Disease[z] index	Reported level of resistance	Line	Disease[z] index	Reported level of resistance
71-1	1.0[y]	HR AVRDC	I-1186	3.0	Indonesia
71-4	0.5	"	I-948	4.0	IITA
71-7	1.5	"	I-1189	0.5	HR Tonga
I-673	2.0	"	TN 57	4.0	HS AVRDC
I-844	0.0	"	TN 66	4.0	"
I-849	1.0	"	I-55	5.0	"
I-934	0.0	"			
I-943	1.0	"	I-6		
I-944	1.0	"	(HS ck)	4.0	
I-949	0.0	"			
I-1173	3.5	"	V2-30		
I-1206	0.5	"	(HR ck)	1.0	
I-1213	0.0	"			
I-1219	0.0	"			

[z]0-5 scale, 1 = resistance level similar to V2-30, 4 = resistance level similar to I-6. [y]Mean of two replications.

Preliminary Screening for Scab Resistance in Field and Greenhouse

Summary

Previous preliminary screenings were conducted only under field conditions using seminatural infection. This year's preliminary screening was done following two steps: (1) seminatural field screening, immediately followed by (2) confirmation screening of all lines in the greenhouse using artificial inoculation. Using cuttings of 136 lines screened in the field, 55 lines were rated HR and 43 as HS when these were screened by artificial inoculation in the greenhouse. Only 16 lines were confirmed resistant.

Introduction

Previous preliminary screenings for scab resistance were conducted in the field at Hualien and AVRDC under seminatural conditions. Confirmation screenings were done in AVRDC. This year's preliminary screening was conducted at AVRDC fields. Confirmation screening was done in the greenhouse under high inoculum pressure and high moisture to promote disease development.

Materials and Methods

Field screening was conducted on 136 lines in AVRDC from July to October. Greenhouse screening was from October to November. The lines included 28 PYT entries, 24 AYT entries, 77 BC_1 progenies (sweet potato × 5x hybrid), and 4 imported cultivars from Tonga, IITA and Indonesia. The inoculum preparation, field design, disease evaluation method and screening procedure was similar

to that described last year, except that the inoculum source was an *E. batatas* isolate from AVRDC (YS 25), and not from Hualien. The concentration of the conidial suspension for inoculation of the susceptible I-6 was 1.02×10^6 conidia per ml. Disease intensity was evaluated on 12 October, using the 0-5 scale.

Greenhouse resistance screening was done on disease-free cuttings taken from each field plot (3 cuttings per plot) after termination of field evaluation. The cuttings were planted in 5-cm diameter plastic pots kept in flats. After 15 days, all cuttings were inoculated with a 1.02×10^6/ml suspension of conidia and placed in a moist chamber. Disease rating was done seven days after inoculation by the susceptibility rating system.

Results and Discussion

In field screening, severe scab epidemic occurred in HS checks which was sufficient for disease rating, ranging from 0-5. Fifty-five lines were rated HR and 43 as HS; the others had intermediate resistance levels. Among 55 lines screened by artificial inoculation in the greenhouse, 15 were confirmed resistant; 12 had resistance levels equal to or higher than that of the HR check; and three lines had resistance levels slightly lower than the HR check (Table 18). Similarly, only 18 of the 43 HS lines (from the field screenings) were confirmed HS in the greenhouse screening. There was a low correlation coefficient ($r = 0.3458$) between field and greenhouse scab ratings.

Confirmation Screening for Scab Resistance in the Field

Summary

Evaluated under two rating methods, a total of 26 cultivars (11 breeding lines and 15 accessions) were confirmed to be resistant as the HR check.

Introduction

A number of scab resistant lines were identified in a preliminary seminatural infection screening. These were subjected to a confirmation screening in the field using two different rating methods.

Materials and Methods

A total of 26 cultivars previously rated highly resistant to scab were screened in the field from 7 July to 4 November 1988. The lines included 11 breeding lines and 15 accessions. Plots for lines tested were 1.5×3 m and each contained nine cuttings of the cultivar for screening. At one end of each plot, one scab-infected cutting of the highly susceptible cultivar I-55 was planted, followed by one healthy, noninfected cutting of I-55. At the other end of the plot, one cutting of the highly resistant check cultivar V2-30 was planted. Plots of three check cultivars I-55, V2-30 and I-6 were also randomly planted in the same experimental field. The inoculation method used, inoculum concentration and application of overhead sprinkler irrigation were the same as described before. Disease intensity was evaluated on 14 October using (A) a 0-8 scale where scab levels in the test lines similar to I-55 (highly susceptible check) were rated as 8; those similar to I-6 (MS check), as 6; and those similar to V2-30 (highly resistant check) as 2; and (B) the SRS measuring percent diseased area on stem, leaves and shoot tip above the third expanded leaf below the plant tip.

Results and Discussion

Most cultivars found resistant to scab last year showed a lower level of disease than the highly susceptible check cultivar in this year's screening (Table 19). In method A, 17 lines gave a higher or equal rating than the highly resistant check V2-30. Seven lines were rated lower than the highly resistant check, but considerably higher than the MS check. In method B (SRS), the percent disease

Table 18. Sweet potato accessions and breeding lines identified as highly resistant and highly susceptible in both field and greenhouse screenings.

Line	Disease index	
	field[z]	greenhouse[y]
Highly resistant lines		
CN 1756-46	0.5	16.7
CN 1756-128	0.5	5.8
CN 1757-145	0.5	12.9
CN 1847-19	0.5	13.8
CN 1848-53	1.0	18.4
CN 1848-62	1.0	15.4
CN 1857-6	0.5	10.0
CN 1867-11	1.0	6.3
CN 1869-16	1.0	18.4
CN 1874-7	1.0	12.5
CN 1876-3	0.5	10.0
WT 129	0.5	15.8
CN 1405-14	0.5	14.2
I-1189 (Tonga)	0.5	8.8
I-1191 (Tonga)	1.0	11.3
Highly susceptible		
CN 1758-44	4.5	46.3
CN 1759-40	4.0	64.2
CN 1759-245	5.0	48.8
CN 1848-77	5.0	30.0
CN 1510-25	4.5	39.6
CN 1747-88	4.5	55.4
CN 1778-2	5.0	42.5
CN 1790-42	5.0	40.4
CN 1795-268	5.0	52.1
CN 1857-4	4.5	54.6
CN 1864-48	5.0	46.0
CN 1864-59	5.0	37.9
CN 1868-12	4.5	35.9
CN 1869-1	4.5	34.6
CN 1869-10	4.5	41.3
CN 1869-17	5.0	43.3
CN 1870-8	5.0	42.9
CN 1108-13	4.5	33.8
V2-30 (HR check)	1.0	16.6
I-6 (HS check)	4.0	45.4
CN 1008-13 (HS check)	4.5	33.3

[z]Disease severity rating, using a 0-5 scale, where 1 = HR and 4 = HS. [y]SRS system rating, using % disease area on stem and leaf shoot tip (SLST).

area of these ranged from 0.6 to 21.9% in these lines which were not significantly lower from these of V2-30 the highly resistant check cultivar, but significantly lower than the HS and MS checks. Although the lines previously found highly resistant had lower disease severity than the MS check in both rating methods the ratings did not exactly correspond. Only eight lines (I 673, I 844, I 849, I 1206, I 1213, 71-1, 71-3 and 71-7) were rated more resistant than the HR checks in both methods. In method A, 17 lines were rated higher or similar to the HR check compared to 10 in method B. This is reflected in the insignificant correlation coefficient ($r=0.6274$) of the regression analysis with scab rating by 0-8 scale as the independent variable and the percent diseases area rating method as dependent variable. For future reliable and reproductive screenings, additional check cultivars of intermediate resistance levels, such as MR as well as additional HR checks more resistant than V2-30, and HS checks more susceptible than I-55 need to be considered. Furthermore, confirmation screening using artificial inoculation of each line and high humidity should be used.

Table 19. Cultivars identified highly resistant in the field.

Line	Remarks	Disease severity	
		Rating A 0 - 8	Rating B (% disease area SLST)
CN 1827-5	HR, 1986 PYT	1.5 +[z]	17.1 –
CN 1828-6	HR, 1986 PYT	1.5 +	10.3 –
CN 1828-37	HR, 1986 PYT	2.3 –	13.3 –
CN 1828-46	HR, 1986 PYT	2.8 –	11.9 –
CN 1831-14	HR, 1986 PYT	2.3 –	15.0 –
CN 1831-42	HR, 1986 PYT	2.3 –	2.8 +
CN 1831-55	HR, 1986 PYT	2.3 –	15.5 –
CN 1831-66	HR, 1986 PYT	3.0 – **[y]	21.9 –
CN 1832-11	HR, 1986 PYT	2.0	4.4 +
CN 1232-9	HR, 1987	1.8 +	14.6 –
CN 1618-461	HR, 1987	1.5 +	19.0 –
I-483	HR, 1987	1.3 +	11.9 –
I-673	HR, 1987	1.3 +	5.4 +
I-844	HR, 1987	1.0 +	8.4 +
! 849	HR, 1987	1.3 +	1.1 +
I-934	HR, 1987	1.8 +	20.9 –
I-943	HR, 1987	1.0 +	18.3 –
I-944	HR, 1987	1.0 +	12.8 –
I-949	HR, 1987	1.3 +	20.4 –
I-1173	HR, 1987	3.0 – **	21.3 –
I-1175	HR, 1987	2.9 –	10.8 –
I-1206	HR, 1987	1.3 +	6.3 +
I-1213	HR, 1987	1.0 +	4.6 +
71-1	HR, 1987	1.3 +	3.5 +
71-4	HR, 1987	1.3 +	0.6 +
71-7	HR, 1987	1.3 +	0.6 +
I-55	HS Check	8.0	51.5
V2-30	HR Check	2.0	8.3
I-6	MS Check	6.0	46.3

[z] +: Rating more resistant than the HR check. –: Rating less resistant than, but not significantly different from the HR check. [y] **: Significantly different from the HR check.

Scab Development Under *In Vitro* Conditions

Summary

The potential of tissue culture as a tool for sweet potato scab resistance screening was investigated using two highly susceptible and two highly resistant lines. Under test tube conditions the two reaction types could be clearly differentiated. Significant higher infection percentage was found on two susceptible lines than on two resistant lines. On susceptible lines, callus symptoms were observed but were absent in the two resistant lines. Callus formation was most pronounced at 28°C. From these observations, callus formation may be useful as a parameter for resistance screening in the test tube. However, further testing is needed before this method can be adapted.

Introduction

Sweet potato scab (*Elsinoe batatas*) is known to be severe in tropical environments with rainfall and high humidity. However in Taiwan, incidence of the fungus in most areas is very low. *In vitro* conditions provide high humidity, thus favorable to scab disease development. The potential of tissue culture as a tool for scab resistance screening was investigated.

Materials and Methods

Two susceptible (I-981 and AIS35-2) and two resistant clones (71-1 and 71-4) were grown in modified MS medium in test tubes. One-month old plantlets with four expanded leaves were dusted

with the pathogen using a sterile brush dipped in suspensions of *Elsinoe batatas* (isolate YS 25) at concentrations of 5×10^4, 5×10^5 and 5×10^6 conidia/ml. The inoculation procedure was executed under sterile conditions. After inoculation, the test tubes were incubated at 22°C, 28°C and 32°C under 12-hour dark and 12-hour light conditions. A randomized complete block design with three replicates, and nine plantlets per treatment was used. Disease was rated on 30 May by the percent diseased area rating method. Callus symptoms were rated on 10 June 1988.

Results and Discussion

The disease severity on the different treatments is shown in Figure 2. The percent of infected area was significantly higher in two susceptible lines than in resistant lines.

In susceptible lines I-981 and AIS35-2, percentage of infection increased with rise in temperature. The optimal temperature for fungal infection was 28°C, regardless of the conidial concentration. Regardless of fungal concentration, infection was lowest at 32°C.

Very low disease was found in resistant lines 71-1 and 71-4, regardless of incubation temperature or conidial concentration. However, line 71-4 showed a slightly higher infection percentage than 71-1. Ninety-six percent of the plantlets of I-981 and 37% of AIS35-2 showed callus symptoms as a result of infection with *E. batatas*. There was no callus detected on two resistant cultivars. Callus formation may be a useful tool to distinguish susceptible from resistant cultivars. Further studies are needed to determine if this factor is reliably associated with susceptibility before it can be used in resistance screening.

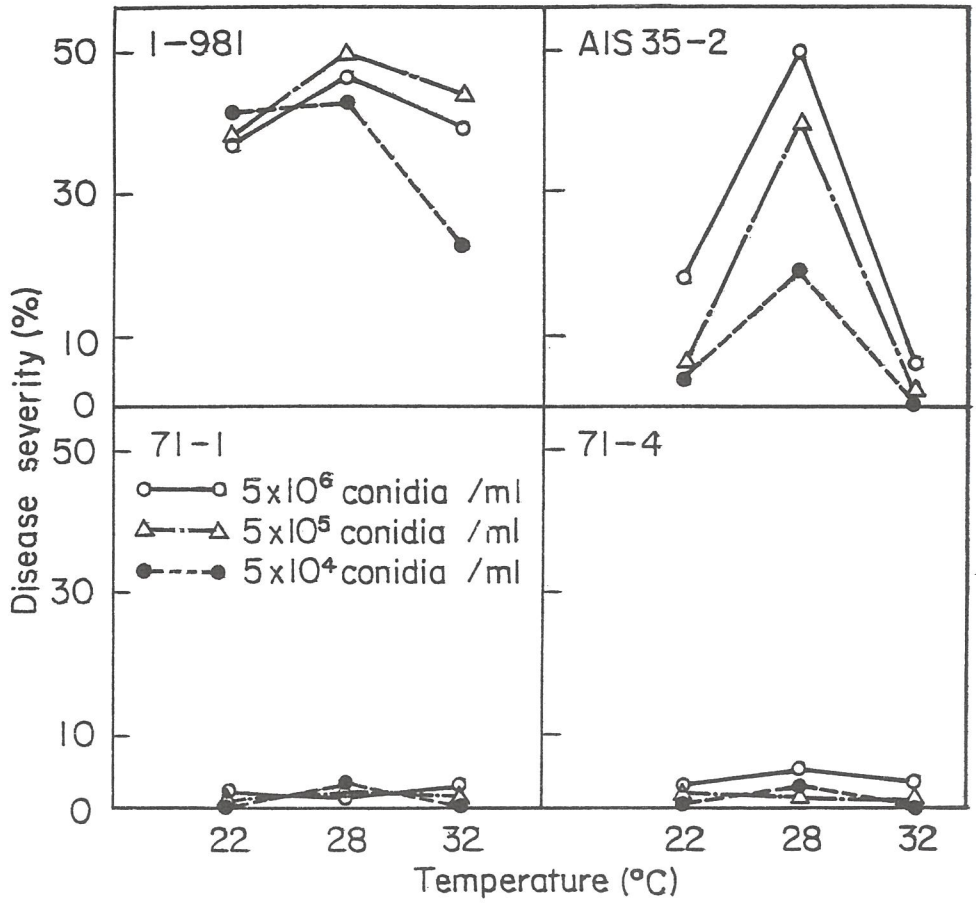

Fig. 2. Severity of scab over three temperatures on four sweet potato clones.

Sweet Potato Physiology

Growth Analysis in Different Seasons

Summary

Ten improved sweet potato clones were planted in four distinct seasons to examine the effect of environmental conditions on yield based on total dry matter production and partition of assimilate to the storage root. The latter seemed to play an important role in sweet potato production. The inclined diversion of dry matter to the storage root was related to sink strength. This trend was subject to change under high temperature and soil flooding.

Introduction

Unit area yield of sweet potato fluctuates with environmental conditions. However, little effort has been made to ascertain the limiting steps in storage root formation due to environmental factors. This study examined the assimilation, partition and growth of AVRDC's improved sweet potato clones in quantitative terms under different growing seasons, and assessed the effect of different environmental conditions on yield potential of sweet potato.

Materials and Methods

Ten clones of sweet potato, namely, Kinmen, Tainung New 31, Tainung 66, I1192 (low beta-amylase), CN 1028-15, CN 1108-13, CN 1121-312, CN 1232-9, CN 1367-2 and CN 1517-139, were planted on 21 July 1987, 19 October 1987, 1 March 1988 and 19 May 1988. A randomized complete block design with four replicates was employed in each planting. Plot size was 3 m × 7 m, each with three rows at a spacing of 1 m × 25 cm. Four plants from the middle row of each plot were randomly sampled once a month, starting from the first month after planting. Five samplings were made; the last one was done at 150 days after planting. Sample plants were measured for leaf area, dry weight of different plant parts and storage root yields. Leaves, storage roots and petioles were also evaluated for sugar and starch content and alpha-amylase. Crop growth rate (CGR), leaf area ratio (LAR) and net assimilation rate (NAR) of the total plant, and relative growth rate (RGR) of storage root were calculated. Yield, yield components and other parameters were also investigated.

Results and Discussion

Averaged across four plantings, CN 1028-15 had the highest storage root yield mainly due to its high dry matter content and harvest index (Table 1a). CN 1108-13, CN 1232-9 and CN 1517-139 were intermediate yielders. Among them, CN 1517-139 had also high total dry matter content and harvest index. The difference of maximum and minimum values in harvest index was greater than in total dry matter content. The lowest value was almost six times the highest in the harvest index while for total dry matter it was more than two times. The results suggest that enhanced dry matter content and harvest index determined the yield potential of sweet potato. However, enhanced harvest index seemed more critical than an increased dry matter among 10 clones examined.

From an average across 10 clones, planting in October had the highest storage root yield, total dry matter, storage root number and harvest index (Table 1b). This could be attributed to decreasing temperature throughout growth and the absence of heavy rainfall. On the contrary, planting in May, which coincided with increasing temperature and heavy rainfall in the third month after planting, had the least storage root yield, total dry matter content and harvest index.

High dry matter content in CN 1028-15 and CN 1517-139 and in the planting in October could be attributed to high CGR (Table 2a). Low CGR in the planting in May was caused by heavy rainfall (Table 2b), impairing storage root development.

Table 1a. Means of total dry matter, yield and yield components from four plantings of 10 sweet potato clones.

Clone	Storage root yield (g/plant)	Storage root no. (/plant)	Total dry wt. (g/plant)	Harvest index (%)
Kinmen	315 cd[z]	5.5 ab	160 c-e	43 c
TN 31	202 d	2.4 e	138 de	28 d
TN 66	314 cd	3.7 d	169 cd	39 c
I 1192	199 d	3.8 d	135 de	29 d
CN 1028-15	689 a	5.2 a-c	251 a	64 a
CN 1108-13	531 b	5.9 a	198 bc	58 ab
CN 1121-312	282 d	4.5 b-d	128 de	40 c
CN 1232-9	456 b	5.8 a	196 bc	50 bc
CN 1367-2	71 e	1.3 e	118 e	12 e
CN 1517-139	414 bc	4.2 cd	218 ab	56 ab

[z]Mean separation within columns by DMRT at 5% probability level.

Table 1b. Means of total dry matter, yield and yield components from four plantings of 10 sweet potato clones.

	Storage root yield (g/plant)	Storage root no. (/plant)	Total dry wt. (g/plant)	Harvest index (%)
July '87	324 b[z]	3.4 b	149 b	42 b
Oct. '87	580 a	8.0 a	214 a	71 a
March '88	340 b	2.3 c	198 a	32 c
May '88	146 c	3.1 b	123 c	22 d

[z]Mean separation within columns by DMRT at 5% probability level.

Table 2a. Mean crop growth rates ($g/m^2/day$) from four plantings of 10 sweet potato clones.

Clone	Growth intervals (days after planting)			
	30-60	60-90	90-120	120-150
Kinmen	8.7 a[z]	5.3 a-d	5.8 ab	-1.0 ns
TN 31	8.6 a	4.7 b-d	3.9 ab	-1.1
TN 66	7.9 a	8.8 a	2.1 b	0.6
I 1192	5.0 b	5.7 a-d	5.6 ab	0.6
CN 1028-15	9.6 a	7.7 a-c	8.7 a	5.1
CN 1108-13	8.3 a	8.1 ab	7.7 a	-0.1
CN 1121-312	5.4 b	4.0 cd	5.7 ab	0.3
CN 1232-9	8.7 a	5.6 a-d	5.8 ab	3.3
CN 1367-2	5.5 b	2.6 d	6.2 ab	0.6
CN 1517-139	8.1 a	8.4 ab	8.6 a	1.4

[z]Mean separation within columns by DMRT at 5% probability level.

Table 2b. Mean crop growth rates ($g/m^2/day$) from four plantings of 10 sweet potato clones.

Clone	Growth intervals (days after planting)			
	30-60	60-90	90-120	120-150
July '87	10.0 a[z]	5.0 c	-0.6 c	2.2 a
October '87	4.6 b	7.2 b	12.3 a	3.7 a
March '88	5.1 b	11.5 a	7.4 b	2.0 a
May '88	10.7 a	0.6 d	5.0 b	-3.9 b

[z]Mean separation within columns by DMRT at 5% probability level.

The damaged storage root likely affected the amount of assimilate translocated as storage root development advanced, thus inhibiting photosynthetic activities.

Moreover, high CGR of CN 1028-15 and CN 1517-139 could be ascribed to high NAR (Table 3a). Seasonal comparison of NAR revealed that planting in October maintained relatively higher NAR than others (Table 3b), due to low temperatures, which prevented high assimilate cost of respiration.

LAR expresses leaf area per unit dry weight of the plant. High yielding CN 1028-15 and CN 1517-139 had low LAR throughout the growing period, whereas low yielding CN1367-2 had high LAR (Table 4a). These results clearly indicated that high yielding clones were capable of diverting assimilates from the leaf. Low LAR in the May planting (Table 4b) was due to low leaf production instead of dry matter diversion from the leaf. On the average, planting in May had the least leaf area. The decrease in sink load in the developing storage root retarded leaf growth.

Table 3a. Mean net assimilation rates ($mg/dm^2/day$) from four plantings of 10 sweet potato clones.

Clone	Growth intervals (days after planting)			
	30-60	60-90	90-120	120-150
Kinmen	67.6 a-c[z]	24.9 b-d	27.3 ns	-16.6 ns
TN 31	53.7 d	17.3 de	15.5	-2.4
TN 66	68.1 a-c	43.0 a	14.9	6.0
I 1192	68.3 a-c	38.8 ab	34.3	11.2
CN 1028-15	68.6 ab	27.6 b-d	39.2	28.2
CN 1108-13	77.1 a	36.1 ab	39.1	2.3
CN 1121-312	57.4 cd	20.3 c-e	26.9	-7.9
CN 1232-9	64.2 b-d	24.3 b-d	25.8	31.5
CN 1367-2	39.9 e	9.1 e	21.8	-0.7
CN 1517-139	61.4 b-d	33.5 a-c	34.2	15.8

[z]Mean separation within columns by DMRT at 5% probability level.

Table 3b. Mean net assimilation rates ($mg/dm^2/day$) from four plantings of 10 sweet potato clones.

Planting month	Growth intervals (days after planting)			
	30-60	60-90	90-120	120-150
July '87	56.4 b[z]	20.0 b	-3.0 c	21.7 a
Oct. '87	56.8 b	43.8 a	68.4 a	19.3 a
March '88	75.5 a	43.6 a	25.8 b	9.6 a
May '88	61.7 b	2.6 c	20.4 b	-23.7 b

[z]Mean separation within columns by DMRT at 5% probability level.

Table 4a. Leaf area ratios (cm^2/g) from four plantings of 10 sweet potato clones.

Clone	Growth intervals (days after planting)				
	30	60	90	120	150
Kinmen	99 cd[z]	76 de	55 c	29 d-f	21 c
TN 31	128 b	96 b	59 c	34 cd	25 bc
TN 66	91 de	68 f	46 d	32 c-e	22 c
I 1192	86 e	84 c	59 c	37 bc	30 b
CN 1028-15	123 b	79 cd	53 c	24 f	13 d
CN 1108-13	87 e	69 ef	46 d	26 f	18 cd
CN 1121-312	107 c	98 b	70 b	39 b	25 bc
CN 1232-9	106 c	83 c	46 d	24 f	19 cd
CN 1367-2	146 a	149 a	112 a	60 a	51 a
CN 1517-139	95 de	82 cd	56 c	27 ef	21 c

[z]Mean separation within columns by DMRT at 5% probability level.

Table 4b. Leaf area ratios (cm^2/g) from four plantings of 10 sweet potato clones.

Clone	Growth intervals (days after planting)				
	30	60	90	120	150
July '87	112 a[z]	72 c	40 c	28 c	18 c
Oct. '87	116 a	97 b	64 b	27 c	24 b
March '88	107 b	120 a	78 a	33 b	32 a
May '88	92 c	64 d	60 b	46 a	25 b

[z]Mean separation within columns by DMRT at 5% probability level.

On the capability to divert dry matter from the leaf, both CN 1028-15 and CN 1517-139 maintained relatively high storage root RGR throughout the growing period (Table 5a). In the same manner, planting in October maintained relatively high storage root RGR (Table 5b). Since storage root RGR is a partial expression of sink strength in the storage root, it is probable that high yielding clones had high sink strength and low temperature in later stages of plant growth that favored sink strength. This could account for high harvest index in high yielding clones or decreasing temperature conditions of planting in October (Table 1).

The low sink strength in the storage root was associated with alpha-amylase activities. Negative correlations were found between storage root alpha-amylase activities and storage root yield of planting in May. Negative correlations were found between sugar/starch ratios of petioles from the mature leaves and starch content in the roots of those planted in July. On the other hand, positive correlations between these factors were found in those planted in May. These results suggested that sink strength in storage root affected the yield of different clones examined in different planting seasons.

Table 5a. Mean relative growth rates (mg/g/day) of storage root from four plantings for 10 sweet potato clones.

Clone	Growth intervals (days after planting)			
	30-60	60-90	90-120	120-150
Kinmen	91 ab[z]	37 ns	19 b	11 ns
TN 31	58 cd	42	28 b	0
TN 66	82 a-c	39	13 c	4
I 1192	55 d	41	33 b	18
CN 1028-15	88 ab	44	27 b	15
CN 1108-13	93 a	36	17 b	6
CN 1121-312	103 a	37	20 b	10
CN 1232-9	77 a-d	62	15 b	8
CN 1367-2	–	42	94 a	23
CN 1517-139	65 b-d	51	33 b	7

[z]Mean separation within columns by DMRT at 5% probability level.

Table 5b. Mean relative growth rates (mg/g/day) of 10 sweet potato clones in four plantings.

Planting month	Growth intervals (days after planting)			
	30-60	60-90	90-120	120-150
July '87	67 c[z]	47 b	1 b	14 a
Oct. '87	93 b	46 b	36 a	10 ab
March '88	111 a	67 a	37 a	-3 b
May '88	78 bc	13 c	7 b	16 a

[z]Mean separation within columns by DMRT at 5% probability level.

Temperature Effect on Rooted Leaf Cuttings

Summary

The effects of temperature on storage root yield and growth of rooted leaf cuttings were investigated. The early growth of rooted leaf cuttings exposed to high temperature resulted in poor root formation

and yield of I 424 and CN 1108-13. The late growth of rooted leaf cuttings exposed to high temperature resulted in poor bulking of storage root of I 423, CN 1028-15 and CN 1517-139. Varietal differences in the thermoperiodic requirement for root formation in sweet potato were observed.

Introduction

High temperature is detrimental to sweet potato root yield, possibly through the inhibition of photosynthesis or translocation of assimilates. This study investigated the effect of ambient temperature in three seasons on storage root formation and some growth characteristics of five sweet potato clones.

Materials and Methods

Leaf cuttings of I 423 (Tainan 17), I 424 (Tainan 18), CN 1028-15, CN 1108-13, and CN 1517-139 were planted in PVC pots (ID 10 cm) and grown in three seasons (6 January to 26 May 1987, 19 May to 30 September 1987, and 24 September 1987 to 11 February 1988) in the greenhouse. Monthly mean air temperature ranged from 19.5-28.3°C (January planting), 29.4-30.9°C (May planting), and 21.5-28.3°C (September planting). Monthly mean soil temperature ranged from 23.5 to 32.7°C (January planting), 32.2 to 35.7°C (May planting), and 25.0 to 33.7°C (September planting), respectively. Leaf cuttings were sampled at 0, 4, 8, 12, 16, and 20 weeks after planting. The different plant parts were investigated for dry weights. Leaf area, storage root yield and total sugar and starch contents in the leaf, petiole, storage root were also determined.

Results and Discussion

Among five entries, those planted in September had the highest storage root yield, followed by those planted in January; those in May had the least (Fig. 1). CN 1028-15 had the highest storage root yield in January and September, while I423 had the highest in May (Table 6).

Size of leaf area played an important role in dry matter accumulation and storage root production. However, leaf cuttings with initial large leaf did not ensure large leaf growth in the later stages, nor did high storage root yield. The initial leaf area was comparable among entries in January, while large variations existed in May and September plantings. The initial leaf areas from May and September were larger than those planted in January. High temperature in May and September plantings promoted leaf expansion of I 423, CN 1028-15 and CN 1517-139, but accelerated senescence of I 424 and CN 1108-13.

I 423, CN 1028-15 and CN 1517-139 accumulated more dry matter content in the petiole in May than those planted in January and September. Early senescence of I 424 and CN 1108-13 in May reduced sugar content in the leaf and sugar and starch contents in the petiole base, and decreased petiole dry weight. On the other hand, leaf sugar content in later stages was positively correlated with storage root yield; high sugar content in the leaf would have provided a continuous supply of carbohydrate for the developing storage root. Carbohydrate accumulated at the petiole base of CN 1028-15 in May. These results indicated that high temperature prevented translocation of dry matter

Table 6. Storage root formation of leaf-cuttings of five sweet potato clones grown in three seasons.[z]

Clone	Yield (g/cutting)			Storage root no. /cutting			Storage root size (g/root)		
	Jan.	May	Sept.	Jan.	May	Sept.	Jan.	May	Sept.
I 423	[y]b 5 c[x]	a 13 a	a 13 b	1.8 a	2.0 a	2.0 a	b 2.9 c	a 6.5 a	a 6.6 b
I 424	a 9 b	b 2 c	b 4 c	1.5 ab	0.8 b	1.4 b	a 5.7 ab	b 2.6 b	b 2.9 c
CN 1028	b 12 a	c 9 b	a 16 a	1.7 ab	1.6 a	1.8 a	ab 7.2 a	b 5.6 a	a 9.0 a
CN 1108	a 7 b	b 1 c	a 5 c	1.2 b	0.8 b	1.8 a	a 5.9 a	b 1.5 b	b 3.2 c
CN 1517	c 5 c	b 9 b	a 14 b	1.4 ab	1.5 a	1.6 ab	b 3.8 bc	ab 6.2 a	a 8.4 a

[z]Measured at 12 weeks after planting. [y]Mean separation within row by DMRT at 5% probability level. [x]Mean separation within columns by DMRT at 5% probability level.

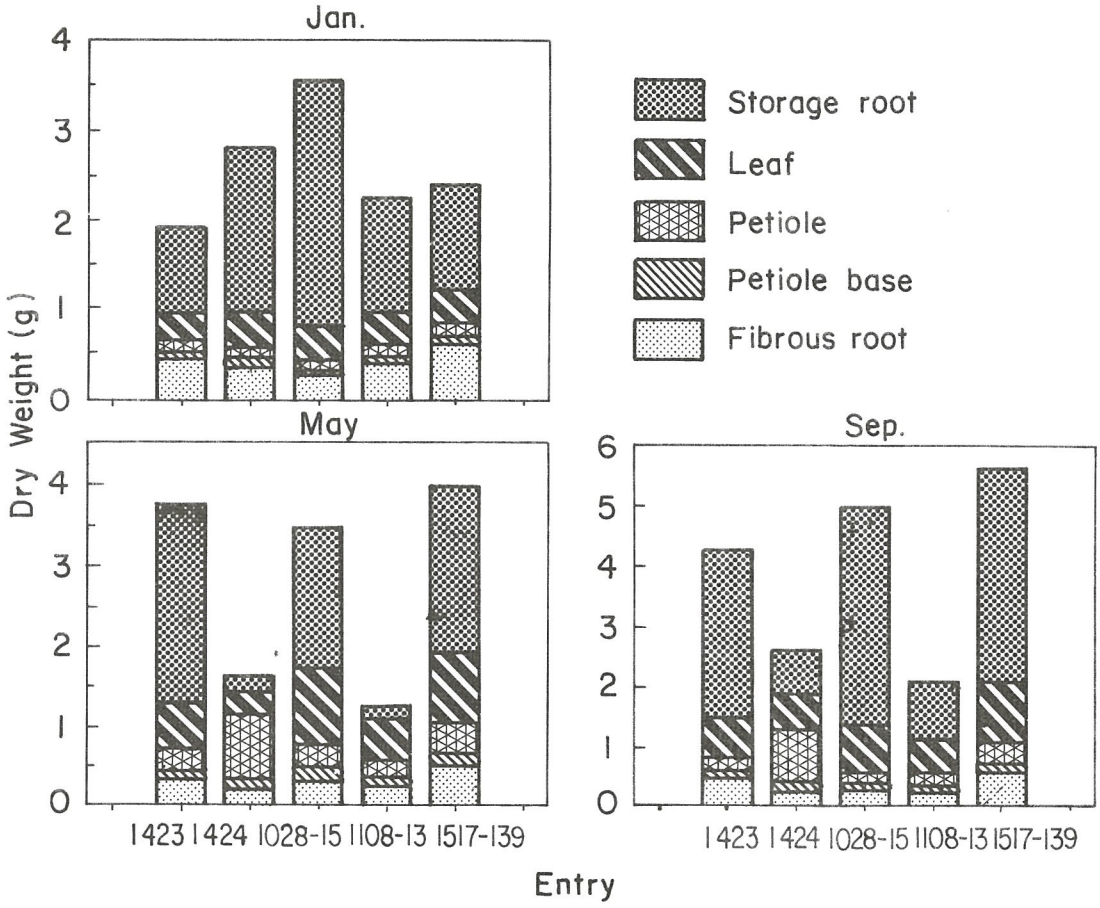

Fig. 1. Storage root yield and dry matter partitioning in leaf cuttings of five sweet potato clones grown for 12 weeks.

to the storage root. In general, I 423 and CN 1517-139 tended to produce more fibrous root than other entries especially in September; this may further improve their general growth.

Rooted leaf cuttings of sweet potato planted in May and September were exposed to comparable temperatures at early stage, which were higher than those in January; however, rooted leaf cuttings in May were exposed to about 8°C higher than those in September at later stage. On the other hand, rooted leaf cuttings in January and May had comparable temperatures at later stage, which were higher than plantings in September. Rooted leaf cuttings in May were exposed to about 8°C higher than plantings in January at early stage. Thus high temperature at an early stage seemed detrimental to the initial development of storage root of I 424 and CN 1108-13, while high temperature at a later stage reduced bulking of storage root of CN 1028-15, CN 1108-13 and CN 1517-139. Temperature increase from early to later stages seemed favorable for storage root yield of I 424, CN 1028-15 and CN 1108-13.

Planting seasons also influenced the quality of storage roots. High temperature in May tended to increase sugar content and decrease the starch content (Table 7). Among five entries, starch content in storage roots of I 424 and CN 1108-13 decreased due to high temperature.

Table 7. Total soluble sugar and starch contents (% of dry weight) in storage root of leaf cuttings of five sweet potato clones grown in three seasons.[z]

Clone	Soluble sugar			Starch		
	Jan.	May	Sept.	Jan.	May	Sept.
I 423	[y]ab 16 a[x]	a 16 a	b 14	a 45 c	b 32 bc	ab 35
I 424	b 12 b	a 16 a	b 11	a 61 a	c 19 d	b 33
CN 1028	b 13 b	a 16 a	ab 14	a 60 ab	b 40 ab	b 40
CN 1108	13 b	17 a	16	a 56 b	c 26 cd	b 46
CN 1517	b 8 c	a 10 b	a 10	a 59 ab	b 42 a	b 40

[z]Measured at 12 weeks after planting. [y]Mean separation within row by DMRT at 5% probability level. [x]Mean separation within columns by DMRT at 5% probability level.

Effects of Growth Regulators

Summary

Brassinolide and epi-brassinolide effectively promoted growth of plantlets under *in vitro* conditions, whereas BAS106 was effective in retarding growth. They may be utilized in manipulating plantlet growth under *in vitro* conditions. The role of these growth regulators in the storage root formation or the sink strength however, is not clear.

Introduction

Sink strength plays an important role in storage root formation of sweet potato. It is also possible that plant hormones are involved in sink strength. In relation to sink strength of storage root, storage root formation under *in vitro* conditions is usually difficult. Furthermore, regeneration cycle of *in vitro* plantlets for storage/distribution purpose is easily and readily manipulated - too fast for storage and too slow for distribution. This study examined the effect of growth regulators on growth and storage root formation of plantlets under *in vitro* conditions, and leaf cuttings under greenhouse conditions.

Materials and Methods

One cm-long nodal sections of AIS35-2 at one node/section were cultured in test tubes (3 cm × 12 cm) containing 1.8 g perlite saturated with 20 ml of 2/3 strength MS medium per test tube. Before culturing, liquid MS medium was incorporated with various growth regulators: choline chloride (30, 120 and 480 ppm), brassinolide (2×10^{-2}, 8×10^{-2} and 32×10^{-2} ppm), KT-30 (1, 4 and 16 ppm), BAS-106 (5, 20 and 80 ppm), epi-brassinolide (2×10^{-2}, 8×10^{-2} and 32×10^{-2} ppm), CCC (50, 200 and 800 ppm), kinetin (2, 8 and 32 ppm), and 2,4-dinitrophenol (0.4, 1.6 and 6.4 ppm). Nodal sections were grown for 100 days in the tissue culture room with 15-h photoperiod.

In another experiment, leaf cuttings of CN 1489-43 were prepared and grown in plastic pots (ID 10 cm) containing vermiculite and sand mixture under greenhouse conditions. Soil was drenched with the above growth regulators of the same concentrations at 20 ml/pot at two or seven weeks after planting. Each treatment had three replicates. Leaf cuttings were grown for 15 weeks.

Results and Discussion

Under *in vitro* conditions, both brassinolide (2×10^{-2}, 8×10^{-2} and 32×10^{-2} ppm) and epi-brassinolide (8×10^{-2} and 37×10^{-2}) effectively promoted formation of the leaf, adventitious root formation and shoots of plantlets (Table 8). On the contrary, KT-30 at 16 ppm, BAS106 at 5 ppm, kinetin at 8 and 32 ppm retarded growth of plantlets; among them BAS106 seemed to be very effective in retarding growth. In contrast to previous findings, none of the growth regulators in perlite induced storage root formation under *in vitro* conditions. This could be due to the variety used and/or absence of auxins in the medium.

In an experiment with leaf cuttings under greenhouse conditions, none of the treatments significantly outperformed the control in terms of leaf area, storage root formation and dry matter production. The minimal effect of these growth regulators for leaf cuttings may be due to soil drench, degradation under soil conditions, timing of application or concentrations. The difference in responses between *in vitro* and *in vivo* conditions may be due to constant exposure of growth regulators under *in vitro* conditions.

Table 8. Effect of growth regulators on AIS 35-2 plantlets under *in vitro* conditions.

Chemical	Concentration (ppm)	Leaf no.	Adventitious root no.	Shoot dry wt. (g/plantlet)
Choline chloride	30	3.0 a-f	3.1 c-e	0.07 b-d
	120	3.0 d-f	4.2 bc	0.11 a
	480	2.4 d-f	3.2 c-e	0.10 ab
Brassinolide	2×10^{-2}	4.0 cd	3.2 c-e	0.05 d-f
	8×10^{-2}	4.1 cd	7.1 a	0.09 a-c
	32×10^{-2}	5.1 bc	7.3 a	0.05 d-f
KT-30	1	1.4 g-j	0.3 g	0.03 fg
	4	1.0 g-j	0.8 e-g	0.02 fg
	16	0.2 ij	0.6 fg	0.03 e-g
BAS 106	5	0 j	0.2 g	0.02 fg
	20	0 j	0 g	0 g
	80	0 j	0 g	0 g
Epi-brassinolide	2×10^{-2}	2.4 e-g	2.2 c-g	0.03 e-g
	8×10^{-2}	5.6 b	5.7 ab	0.09 a-c
	32×10^{-2}	7.8 a	6.4 a	0.09 a-c
CCC	50	3.0 d-f	2.8 c-f	0.06 c-e
	200	1.7 f-i	2.9 c-f	0.05 d-f
	800	1.1 g-j	2.4 c-g	0.05 d-f
Kinetin	2	2.0 e-h	4.2 bc	0.03 e-g
	8	0.5 h-j	4.2 bc	0.03 e-g
	32	0 j	1.5 d-g	0.04 d-f
2,4-dinitrophenol	0.4	4.0 cd	2.9 c-f	0.09 a-c
	1.6	3.4 c-e	3.9 b-d	0.10 ab
	5.4	1.0 g-j	2.2 c-g	0.02 fg
Control		2.3 e-g	2.3 c-g	0.03 fg

Tomato Breeding

Crosses and Breeding Populations

In 1988, a total of 248 crosses were made to further improve the most advanced tropical breeding lines for various traits such as fruit set, fruit size, firmness and additional resistance to diseases, especially black leaf mold (*Cercospora fuligena*). This disease was previously reported by AVRDC's Southeast Asian cooperators and became serious at AVRDC and in farmers' fields in the past two years. In addition, eight double crosses and 20 backcross families for tropical tomato and seven crosses for potato virus Y (PVY) resistance were developed.

New biparental combinations were made to develop hybrid cultivars with varying objectives in mind. On processing tomato, AVRDC continued to look for hybrids with high yield, good concentrated set and firm fruits for once-over mechanical harvesting, heat tolerance, resistance to major diseases such as bacterial wilt (BW), tomato mosaic virus (ToMV) and nematode (NEM), and acceptable processing quality. The fresh market type hybrid combinations aimed at combining disease (BW, ToMV and NEM) resistance with heat tolerance and desirable horticultural traits such as improved fruit size, firmness, crack resistance and good fresh taste. The cherry-type hybrid combinations attempted to combine disease resistance (as above), heat tolerance, crack resistance and desirable cherry tomato characters such as a large number of uniformly small, sweet,round and firm fruits per cluster and a thick pericarp with relatively tough skin.

The program also advanced and/or selected during 1988 desirable progenies from 91 breeding populations originating from different sources: backcrosses, single-seed descent families, double crosses, triple crosses and F_4-F_6 lines from single crosses.

Performance of New Germplasm

Summary

Four evaluation trials of newly introduced genetic materials were carried out in 1988. None of the introduced processing cultivars outyielded the best AVRDC processing hybrids. PT 4026 and PT 4172 showed the most concentrated maturity, outyielding the check variety TK-70 at first harvest by about eight to nine times even though their final yields were statistically similar. Two determinate fresh market introductions, E 334 and Celebrity, gave the best marketable yields over 100 t/ha, had slight to no fruit cracking and good to excellent vine cover. However, fruits of these cultivars were generally soft. Among indeterminate fresh market introductions, Bermuda, GC 775 and Jackpot were the best, all yielding over 100 t/ha and outyielding the check cultivar, KY 301 by about three to four times. In general, the best introduced cultivars had large fruits weighing over 200 g apiece. One entry, GC 775 had particularly firm fruits. The best entries also showed good foliage cover, affording better protection from sun scorch damage to the fruits.

With the exception of differences in lycopene (controls external color) and β-carotene contents, the beta-derivatives of some cultivars did not differ appreciably in performance from their normal counterparts indicating that the gene Beta has no eminent undesirable effect on performance.

Introduction

The AVRDC tomato breeding program receives new genetic materials from various sources every year. The germplasm is evaluated for general performance, either for inclusion in AVRDC's advanced test materials or as parental stocks in the breeding program if they carry special characteristics.

AVRDC received 40 new cultivars from foreign seed companies and research institutions for inclusion in the AVRDC Demonstration Trials carried out in collaboration with the International Tomato and Pepper Symposium. This collection comprised of 8 processing cultivars, 12 fresh market determinate cultivars and 20 fresh market indeterminate cultivars.

The Center also received new hybrids which combined the gene *Beta* (high beta-carotene) and/or *alcobaca* (long shelf-life) in fresh market cultivars from the United States Department of Agriculture/Puerto Rico.

Materials and Methods

All entries for the demonstration trials were sown on 10 November 1987 and transplanted five weeks later on 17 December.

The new processing cultivars were evaluated with the five best processing hybrids from AVRDC against check cultivars, Tainan No 3 and TK-70. In the absence of a local, determinate fresh market check variety, the determinate fresh market entries, along with two AVRDC hybrids, were comparatively evaluated. On the other hand, the indeterminate fresh market cultivars were evaluated against KY 301, a popular dark green-fruited hybrid.

All the above trials were planted in a randomized complete block design with two replications each. A unit plot of the processing tomato trial consisted of two rows, each 5.4-m long with 1.5-m spacing between rows and .45 m spacing between plants within each row. A similar plot dimension was used for the determinate fresh market trial. However, plants in this trial were staked. On the other hand, an individual plot of the indeterminate fresh market trial consisted of two rows, each 5.4-m long inside a 1.5-m bed. Plants within the row were spaced .45 m apart. Plants in this trial were staked; their lateral shoots were also pruned.

For the observational trial, the USDA/Puerto Rico high β-carotene materials were planted in a randomized complete block design with two replications. A unit plot consisted of a 4.8-m long row with spacing of 1.5 m between rows and 0.5 m between plants within the row. The experimental plots were mulched with silver/black plastic.

Results and Discussions

Processing Cultivars. None of the introduced processing cultivars outyielded the best AVRDC processing hybrids (Table 1).The best new entry was Red Agate #140, with a total marketable yield of 99 t/ha, statistically comparable to the highest yield of 109 t/ha obtained in PT 4060.

In terms of soluble solids content, Red Agate #144 was the best with a brix value of 6.45. However, it was the poorest yielder, with only 19 t/ha. Solids content of the best performing hybrids were comparable to that of TK-70.

Entries with the best concentrated yields were PT 4026 and PT 4172, giving first harvest yields of 79 and 74 t/ha, respectively. In contrast, the check cultivar TK-70 yielded only 9 t/ha at first harvest although its final yield was not statistically different from those of the above hybrids.

Determinate Fresh Market Cultivars. Two introduced entries, E 334 and Celebrity, showed the best performance among the determinate fresh market cultivars (Table 2). The two AVRDC hybrids, FMTT 124 and FMTT 32, performed comparably well. These four entries gave marketable yields well over 100 t/ha and fruit weights ranging from 97 to 207 g per fruit.

In addition, fruits of the above entries showed only very slight radial cracking (E 334 and FMTT 124), and good to excellent vine cover (except FMTT 124). However, their fruits were soft to moderately soft, except FMTT 32 which had moderately firm fruits.

Table 1. Yield and other horticultural characters of processing hybrids in the demonstration yield trial, AVRDC, 1987.

Entry	DM	Marketable yield		Fruit size	Fruit set	Firmness[z]	Vine cover[y]	Vine comp.[x]	pH	Brix	Acidity	Hunter color
		Final	First	(g)	(%)							
		(t/ha)										
PT 4060	101	109	55 bc	96 b-d	66 a-c	F	G	G	4.11 fg	4.65 c-e	.31 b	2.57 b-d
PT 4172	100	111	74 a	79 de	63 a-c	MF	F	F	4.21 ef	4.70 cd	.32 bc	2.62 a-c
PT 4026	101	113	79 a	88 cd	64 a-c	MS	F	F	4.15 fg	4.75 cd	.34 b	2.67 ab
PT 4121	101	104	48 b-d	95 b-d	67 a-c	F	G	F	4.17 fg	4.40 de	.34 b	2.51 cd
TN-3 (ck)	100	96	46 c-e	68 ef	76 a	MS	F	F	4.20 e-g	4.15 e	.34 b	2.65 ab
TK 70 (ck)	107	92	9 g	117 a	62 bc	S	E	E	4.19 e-g	5.00 bc	.45 a	2.69 ab

[z]VF = very firm; F = firm; MF = moderately firm; MS = moderaterly soft; S = soft. [y]F = fair cover; G = good; E = excellent. [x]F = fairly compact; G = good; E = excellent.

Table 2. Yield and other horticultural characters of determinate fresh market cultivars in the demonstration yield trial; AVRDC, 1987.

Entry	DM	Marketable yield	Fruit set (%)	Cracking[z]	Fruit size (g)	Firm-cover[y]	Vine cover[x]	Vine com-pactness[w]
E 334	110 a-c	132	61	none	135 f	S	G	F
Celebrity	112 ab	122	59	VSLR	207 bc	MS	E	G
FMTT 124	104 g	113	59	none	97 g	MS	F	G
FMTT 32	108 b-f	115	44	VSLR	132 f	MF	G	F

[z]VSLR = very slight radial cracking. [y]VF = very firm; F = firm; MF = moderately firm; MS = moderately soft; S = soft. [x]F = fair cover; G = good; E = excellent. [w]F = fairly compact; G = good; E = excellent.

Indeterminate Fresh Market Cultivars. The best yielding indeterminate fresh market hybrids were Bermuda, GC 775 and Jackpot, all yielding over 100 t/ha and outyielding the check cultivar, KY 301 by about three-four times (Table 3). The best AVRDC entry was FMTT 6, a variety that is also adopted to the hydroponics culture system, yielding two times more than KY 301.

Bermuda showed moderate to severe radial fruit cracking, a weakness of this variety. In contrast, the other high-yielding entries had fruits with slight radial cracks.

On fruit firmness, the best entry was GC 775 which showed very firm fruits followed by FMTT 6 with firm fruits. Jackpot and the check variety, KY 301, both had moderately soft fruits.

In general, the best introduced cultivars had large fruits; all had fruits weighing above 200 g apiece. FMTT 6 and KY 301 had fruits significantly smaller than the introduced varieties. All entries listed in Table 4 had large to very large stem-end scar but with small to medium blossom-end scar.

With the exception of FMTT 6 and KY 301, the best entries showed good foliage cover, indicating better potential protection from sun scorch damage to the fruits.

USDA High Vitamin A/Long Shelf-life Germplasm. Among USDA's Beta and/or alcobaca genotypes, Kewalo-Beta yielded the highest although this was not statistically different from that of the normal Caraibe (Table 4). With the exception of differences in lycopene which controls external color and β-carotene contents, the beta derivatives of most cultivars did not seem to differ appreciably in performance from their normal parents, indicating that the high β-carotene trait (gene Beta) has no undesirable effects on other horticultural characters.

A graphic comparison of lycopene and β-carotene contents among the cultivars listed in Table 4 is shown in Figure 1. It is notable that some cultivars, e.g. Caraibe, have Vitamin A content comparable to the hybrid Beta-carrying cultivars. Conversely, some Beta-carrying cultivars, like Hybrid Floradade-Beta-Alc, have lycopene content comparable to the normal cultivars. The homozygous Beta-alcobaca stock was the lowest yielding entry; however, it produced five times more β-carotene than the best high Beta entry in Table 5. Moreover, its lycopene content was comparable to those of Kewalo and Floradade but lower than Caraibe's.

Table 3. Yield and other horticultural characters of the indeterminate fresh market cultivars in the demonstration yield trial, AVRDC, 1987.

Entry	DM	Marketable yield	Fruit set (%)	Fruit size (g)	Cracking[z]	Firmness[y]	Foliage cover[x]
Bermuda	101 b-d	125 a	76 a-c	234 ab	SR	MF	G
GC 775	113 a	129 a	91 a	217 a-f	SLR	VF	G
Jack pot	103 a-d	111 ab	64 b-e	223 a-c	MR	MS	G
FMTT 6	99 b-d	73 c-f	61 b-e	189 e-h	SLR	F	F
KY 301 (ck)	95 a	37 g-k	42 e	146 j-l	MC/R	MS	F

[z]SLR = slight radial crack; MR = moderate radial; MC/R = moderate concentric and radial; SR = severe radial. [y]VF = very firm; F = firm; MF = moderately firm; MS = moderately soft; S = soft. [x]F = fair cover; G = good; E = excellent.

Table 4. Yield and other horticultural characters of the Beta-Alcobaca stocks and hybrids; AVRDC, 1987.

Entry	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g)	pH	Brix°	Acidity	Hunter color	Firmness[z]	Fruit color[y]
Kewalo-Beta (B)	109 a	60 b-d	116 fg	4.53 ab	4.90 ab	3.1 e-g	1.6 b-e	MS	u+/o
Caraibe	105 a	56 b-d	138 b-g	4.34 cd	4.50 a-d	3.8 bc	1.9 a-e	S	u+/r
Floradade-B-Alc F1	95 ab	67 ab	148 a-f	4.29 cd	4.00 c-e	4.6 a	1.4 de	S	u+/o
Floradade	91 a-c	74 a	126 d-g	4.26 cd	3.45 e	3.8 bc	2.1 a-d	F	u+/r
Kewalo	75 a-c	63 a-c	123 e-g	4.55 a	4.75 a-c	2.8 g	1.6 b-e	S	u/r
Stock Beta-Alc	55 c	42 e	167 ab	4.35 b-d	5.70 a	4.0 a	1.4 de	MS	u+/o

[z]VF = very firm; F = firm; MF = moderately firm; MS = moderately soft; S = soft. [y]u+ = green shoulder; u = uniform; o = orange; r = red.

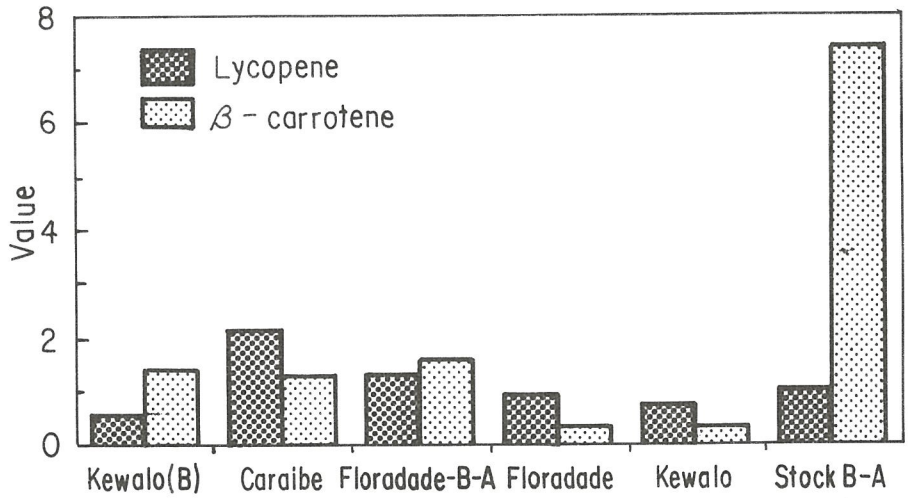

Fig. 1. Comparative lycopene and β-carotene contents of normal vs. Beta gene-carrying backcross derivatives and/or hybrids.

Bacterial Wilt Resistance of Breeding Lines

Summary

Two tomato breeding materials were screened for bacterial wilt (BW) resistance using a vigorous field screening procedure. Two advanced breeding lines already homozygous for rootknot nematode resistance showed high levels of BW resistance and were also selected for good performance under hot, humid conditions in a separate hot set trial.

Although one-parent stock in the processing hybrids is usually BW susceptible, the levels of BW resistance obtained in the ensuing hybrids were as good as in the highly resistant stocks, L285 and CL65-349, partly indicating non-additive action of the gene(s) for resistance.

The most resistant fresh market hybrids were from crosses among BW-resistant parent stocks. Two of these hybrids, FMTT 114 and FMTT 95, are also resistant to root-knot nematode and had fair marketable yields during the hot summer with fruit sizes at least twice as large as the most heat-tolerant tropical tomato could typically produce during this period.

The mortality rates due to BW infection among cherry tomato hybrids were generally higher than in other materials tested. Only one combination, CH 108, compared favorably with the highly resistant checks.

Introduction

New tomato breeding materials undergo extensive tests for resistance to bacterial wilt (BW) because of the importance of this disease in tropical tomato production.

During the year, a range of genetic materials was subjected to a rigorous field screening procedure developed jointly by AVRDC plant breeders and pathologists in 1986 (see 1986 Progress Report).

Materials and Methods

Details about materials tested for bacterial wilt resistance in the nursery are given below.

Type of materials	Total lines	Date sown	Date transplanted
SSD BC_1F_6 lines (I)	63	15 April 1988	5 May 1988
F_1 processing tomato (I)	66	6 May 1988	5 June 1988
F_1 fresh market tomato	36	6 May 1988	5 June 1988
F_1 cherry tomato	72	9 May 1988	6 June 1988

To create a uniform inoculum distribution in all tests, L 390, a highly susceptible cultivar, was seeded thickly in the BW nursery, four rows to a bed, with rows 20 cm apart. Seeding date of the susceptible cultivar was normally six-eight weeks before the test materials were transplanted to the nursery. At seven-leaf stage, the leaves of L 390 were cut with sickles to allow wilt infection. BW inoculum was immediately applied with a power sprayer. The field was plowed and prepared for planting the test materials when nearly 100% of the susceptible plants had died. To further ensure good inoculum potential in each bed, the new beds were prepared exactly at the same location as the original beds.

Each test line was transplanted to two outside 4-m long rows with a spacing of 40 cm between plants. For relative comparison, susceptible L 390 and resistant L 285 plants were planted in interspersed fashion in the center of each bed. All tests were replicated twice in a randomized complete block field design.

Survival rate (%) was transformed to arcsin multiplied by the square root of the percentage before statistical analysis. In addition, the relative resistance of each test line against the highly resistant check (L 285), designated as RRL, and against the best breeding line (CLN 365), designated as RRB, were calculated to determine their levels of resistance. Further analyses compared the RRL of each entry with its within-plot RRL (survival of test entry vs L 285 in the same bed) to test the homogeneity of inoculum distribution in the nursery.

Results and Discussion

The advanced breeding lines which showed high levels of resistance to bacterial wilt are listed in Table 5. Two of these lines were also selected for good general performance under hot, humid conditions in a separate trial (see Table 9). It may also be noted that these lines are already homozygous for the dominant gene for rootknot nematode resistance, *Mi*, thus affording them broader protection to soil-borne pathogens.

Figure 2 reveals a close relationship between the relative resistance of test lines vs the highly resistant L 285 situated in its own plot and the relative resistance vs L 285 plants planted within the same bed as the test lines, thus indicating good uniformity of inoculum distribution. In this test the coefficient of variation (CV) of 31.8% for survival rate was also acceptable.

Processing tomato hybrids. The most resistant processing hybrids are given in Table 6. Again, an excellent distribution of BW inoculum in the nursery was indicated by the regression line in Figure 3. The CV of survival rate in this experiment, 18.9%, was also very low compared to the high CVs normally obtained in previous BW tests using other inoculation/screening techniques.

Although one parent stock in the processing hybrids is usually BW susceptible, it may be noted that the levels of BW resistance in the ensuing hybrids are as good as those of the highly resistant stocks, L 285 and CL 65-349, partly indicating non-additive action of the gene(s) for resistance.

Table 5. Bacterial wilt reaction of the most advanced breeding line vs checks, AVRDC, 1988.

Entry	Survival rate (%)	RRL	RRB	Other resistance	
				ToMV[z]	Nematode[y]
L 285 (res check)	100 a	100	106	+/+	+/+
CLN 65-349D_5-2-0 (res check)	94 a-e	94	100	2a/2a	+/+
CLN 475BC_1F_2-265-4-19	97 a-c	97	103	2a/2a	Mi/Mi
CLN 475BC_1F_2-265-4-16	95 a-d	95	101	2a/2a	Mi/Mi
CLN 698BC_1F_2-358-4-13	95 a-d	95	101	2a/2a	Mi/Mi
L 390 (sus check)	4 pq	4	4	+/+	+/+
Mean of all entries	34				
CV %	31.8				

[z]2a/2a = homozygous resistant for gene Tm2a; +/+ = susceptible; 2a/+ = heterozygous resistant. [y]Mi/Mi = homozygous resistant for gene Mi; Mi/+ = heterozygous resistant; +/+ = susceptible.

Table 6. Promising bacterial wilt-resistant F_1 processing tomato hybrids vs checks, AVRDC, 1988.

Entry	Type of cross[z]	Survival rate (%)	RRL	RRB	ToMV resistance[y]
L 285 (res check)	–	100 a	100	100	+/+
CLN 65-349D_5-2-0 (res check)	–	100 a	100	100	2a/2a
PT 4142	HBWR/BWR	100 a	100	100	2a/2a
PT 4056	BWR/BWS	97 ab	97	97	2a/+
PT 4065	BWR/BWS	95 a-f	95	95	2a/+
PT 4172	BWR/BWS	95 a-e	92	92	2a/+
L 390 (sus check)	–	5 qr	5	5	+/+
Mean of all entries		71			
CV %		18.9			

[z]HBWR = high bacterial wilt resistance; BWR = bacterial wilt-resistant; BWS = susceptible. [y]2a/2a = homozygous resistant for gene Tm2a; +/+ = susceptible; 2a/+ = heterozygous resistant.

Fresh market hybrids. The most resistant fresh market hybrids were from crosses among resistant parent stocks (Table 7). Two of these hybrids, FMTT 114 and FMTT95, are also resistant to root-knot nematode and had fair marketable yields of 22 and 21 t/ha, respectively during hot summer, with fruit sizes at least twice as large as the most heat-tolerant tropical tomato could typically produce during this period. In other trials described above, distribution of BW inoculum in this test was good (Fig. 4).

Cherry tomato hybrids. The survival rates among cherry tomato hybrids were not comparable to the highly resistant checks with the exception of one combination. CH 108 (Table 8). When compared to the highly susceptible L 390, however, the resistance levels among these cherry hybrids are still appreciable. The relative inaccuracy of results from this nursery, as indicated by a high CV of 59%, is recognized.

Table 7. Bacterial wilt resistant F_1 fresh market tomato hybrids vs checks; AVRDC, 1988.

Entry	Type of cross[z]	Survival rate (%)	RRL	RRB	Marketable yield (t/ha)	Fruit size (g/ft)	Other resistances[y]	
							ToMV	Nematode
FMTT 104	HBWR/BWR	100 a	100	100	20	56	2a/2a	+ / +
FMTT 114	BWR/BWR	97 ab	97	97	22	52	2a/2a	Mi / +
FMTT 95	BWR/BWR	97 ab	97	97	21	65	2a/2a	Mi / +
L 285 (res check)	–	100 a	100	100	–	–	+ / +	+ / +
CLN 65-349 (res check)	–	100 a	100	100	–	–	2a/2a	+ / +
L 390 (sus check)	–	0 j	0	0	–	–	+ / +	+ / +
Mean of all entries		55						
CV %		22.8						

[z]HBWR = high bacterial wilt resistance; BWR = bacterial wilt resistant; BWS = bacterial wilt susceptible. [y]2a / 2a = homozygous resistant for gene Tm2a; + / + = susceptible; 2a/ + = heterozygous resistant Mi/Mi = homozygous resistant for gene Mi; Mi/ + = heterozygous resistant; + / + = susceptible.

Table 8. Bacterial wilt reaction of F_1 cherry tomato hybrids vs checks, AVRDC, 1988.

Entry	Type of cross[z]	Survival rate (%)	RRL	RRB	Marketable yield (t/ha)	Fruit size (gm)	ToMV[y]
CHT 108	HBWR/BWS	85 a-c	92	85	15.6	20	2a/ +
CHT 104	HBWR/BWS	74 b-d	80	74	17.0	23	2a/ +
CHT 105	HBWR/BWS	63 b-f	68	63	23.5	21	2a/ +
L 285 (res ck)	–	92 ab	100	92	–	–	+ / +
CLN 65-349 (res ck)	–	100 a	109	100	–	–	2a/2a
L 390 (sus ck)	–	5 j-l	5	5	–	–	+ / +
Mean of all entries		24					
CV%		59.3					

[z]HBWR = high bacterial wilt resistance; BWR = bacterial wilt resistant; BWS = bacterial wilt susceptible. [y]2a / 2a = homozygous resistant for gene Tm2a; + / + = susceptible; 2a/ + = heterozygous resistant.

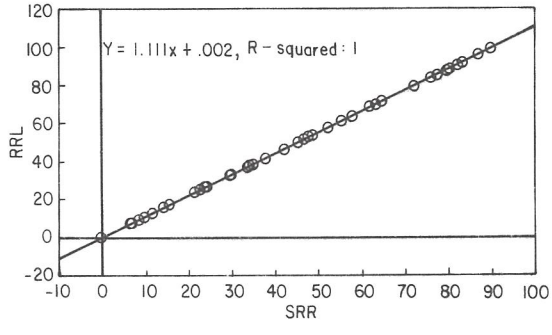

Fig. 2.
Regression of relative resistance vs the highly resistant check L 285 within the same bed (RRL) against relative resistance vs L 285 in an independent plot (SRR); advanced breeding lines.

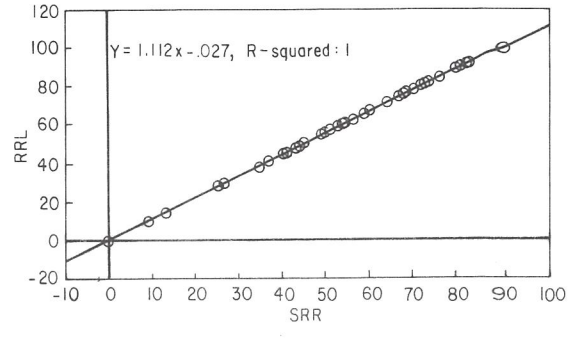

Fig. 3.
Regression of relative resistance vs the highly resistant check L 285 within the same bed (RRL) against relative resistance vs L 285 in an independent plot (SRR); processing hybrids.

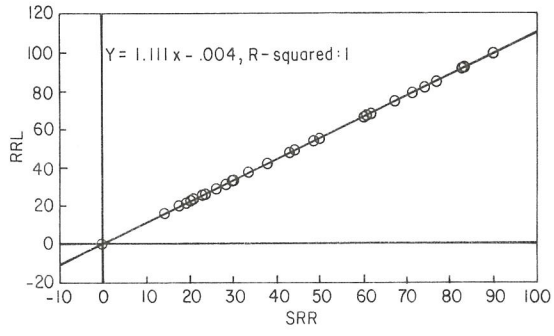

Fig. 4.
Regression of relative resistance vs the highly resistant check L 285 with the same bed (RRL) vs relative resistance vs L 285 in an independent plot (SRR); fresh market hybrids.

Evaluation of Tropical Breeding Lines

Summary

Several observational and preliminary trials were conducted to evaluate tropical tomato breeding lines with greater resistance to diseases and improved horticultural characters.

Three new selections were chosen from the Batch I observation trial for further test next summer. On the other hand, two lines outyielded the heat-tolerant check in the Batch II trial and were selected for further evaluation. The advantages of the new lines over the heat tolerant checks included improved fruit firmness and nematode resistance.

A number of promising cherry tomato hybrids carrying acceptable levels of heat tolerance were selected from the observation trial. The best ones ranged in yield from 22 to 26 t/ha, greatly outyielding the check hybrid, Girl Sweet, which yielded only 8 t/ha; they also had lesser or no fruit cracking tendencies. These hybrids also carry resistance to tomato mosaic virus, some levels of BW resistance and also some discernible resistance to bacterial leaf spot.

None of the nematode-resistant determinate lines in the preliminary yield trial outyielded the check line, CL 5675, although one line outyielded CL 5915-153, previously the most heat-tolerant line in the breeding program.

The best nematode-resistant indeterminate tropical lines did not outyield the heat-tolerant check, CL 5915-206-2-2-0-4, but were apparently better than King Kong, a fresh market hybrid whose seeds are commercially available to tropical farmers. The new selections are also firm-fruited, crack-resistant and carry excellent levels of BW resistance.

The best relatively large-fruited fresh market hybrids yielded from 29 to 32 t/ha during the hot wet season. FMTT 138, the most outstanding entry also showed better apparent resistance to bacterial leaf spot and good foliage cover.

Introduction

AVRDC continued the development of advanced tropical tomato breeding lines with greater resistance to diseases and improved horticultural characters. In the past three years, research was focused on the incorporation of nematode resistance into tropical lines. Selection for better fruit firmness and resistance to fruit cracking was also carried out among breeding populations.

Advanced selections from the above populations provided the test materials for the series of evaluation trials conducted during the hot summer in 1988. In addition, a few test hybrids with potentially larger fruits than have been obtained from heat-tolerant open-pollinated lines were also evaluated.

With the increasing interest in cherry tomato in the past few years, AVRDC has also opted to develop preliminary hybrids with potentially better heat tolerance than the popularly grown local cherry hybrids. A large number of these cross combinations will be available for evaluation in 1989.

Materials and Methods

General information on the evaluation trials conducted in hot summer among different tropical breeding materials is given below:

Type of trial	Type of material	No. of entries	Date sown	Date transplanted
Observation I	determinate lines	69	13 May 1988	14 June 1988
Observation II	determinate lines	34	24 May 1988	25 June 1988
Observation	indeterminate lines	15	25 May 1988	24 June 1988
Observation	indeterminate cherry hybrids	104	18 May 1988	16 June 1988
Preliminary	determinate lines	16	25 May 1988	24 June 1988
Preliminary	indeterminate lines	16	25 May 1988	24 June 1988
Preliminary	indeterminate hybrids	22	7 June 1988	7 June 1988

All observation trials were invariably not replicated and in most cases, generally involved a relatively large number of test materials. On the other hand, preliminary trials were evaluated using a randomized complete block design with two replications.

Experimental plots of determinate entries consisted of 4.8-m long single-row plots, each with plants spaced 0.4 m apart within the row. Rows were spaced 1.5 m apart. The indeterminate lines, on the other hand, consisted of two-row plots 4.8-m long each, with rows within the bed and plants within the row spaced at 0.6 m and 0.4 m apart, respectively.

Unit plots of determinate entries under preliminary test consisted of two rows, 4.8-m long each, with 1.5 m between rows and plants within the row spaced 0.4 apart. For indeterminate entries, plots consisted of two 4.8-m long rows spaced 0.6 m apart within one bed, with plants within the row spaced 0.4 m apart.

Both determinate and indeterminate trials were supported with stakes to minimize fruit rot. Among indeterminate entries, only two stems per plant were allowed to develop and their lateral shoots were pruned.

Results and Discussion

Observation Trials. In the Batch I trial of new determinate tropical lines, three new selections were chosen for further test next summer (Table 9). These lines had a yield range of 8-17 t/ha while the heat tolerant check, CL 5915-93, yielded only 7 t/ha during the hot, dry period. However, none outyielded the other check, CL 5675, a breeding line which combines heat tolerance with parthenocarpic fruit trait. Other advantages of the new selections are better fruit firmness (moderately firm to firm fruits) and nematode resistance.

Compared to only 3 t/ha for the heat-tolerant check CL 5675 in Batch II trial, two lines yielded 8-9 t/ha and were therefore selected for further evaluation (Table 10). Again, additional advantages of the new lines are better fruit firmness and nematode resistance relative to the checks.

Table 9. Yield and other horticultural characters of the best determinate tropical lines vs checks in the Batch I trial, AVRDC, summer 1989.

Entry	Days to maturity	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g/ft)	Cracking[z]	Firmness[y]	Other traits[x]	
							BLS	Flood damage
CLN 698BC$_1$F$_2$-358-2-11-8	82	17.4	32	29	SLSA	MF	7.5	7
CLN 475BC$_1$F$_2$-265-4-19	88	10.6	33	29	SL R/C	F	5.5	3
CLN 698BC$_1$F$_2$-358-4-13	88	8.1	30	34	SL SA	F	7.0	4
CL 5675BC$_1$F$_2$-1-2-2-12 (ck)	82	21.1	57	23	none	S	7.5	5
CL 5915-93D$_4$-1-0-12 (ck)	82	7.0	25	24	M SA R/C	S	8.0	3

[z]SLSA = slight superficial abrasion-like cracks; SLR/C = slight radial/concentric; M SA R/C = moderate superficial, radial/concentric cracks. [y]VF = very firm; F = firm; MF = moderately firm; MS = moderately soft; S = soft. [x]Rating scale of 1 = none to 10 = severe.

None of the indeterminate lines outperformed the heat-tolerant check, CL 5915-206-2-2-0-4, an older indeterminate tropical line which yielded 18 t/ha during the hot, wet period.

A number of promising cherry tomato hybrids carrying acceptable levels of heat tolerance were selected from the observation trial. The best ones are those compared in Table 11 against the standard hybrid check, Girl Sweet. These hybrids ranged in yield from 22 to 26 t/ha, greatly outyielding Girl Sweet which yielded only 8 t/ha; they also had lesser or no fruit cracking tendencies. Moreover, these hybrids carry resistance to tomato mosaic virus, some levels of resistance to bacterial wilt and, based upon observations during the trial, also some discernible resistance to bacterial leaf spot.

Preliminary Trials. None of the nematode-resistant determinate lines in the preliminary yield trial outyielded the check line, CL 5675 (Table 12). However, one line outyielded CL 5915-153, previously the most heat-tolerant line in the breeding program. CL 5915-153 yielded only 3 t/ha, indicating the severe stress that the test materials apparently encountered during this season. Apart from its nematode resistance, this line also carried a high level of BW resistance compared to the two checks.

The best nematode-resistant indeterminate tropical lines did not outyield the heat-tolerant check, CL 5915-206-2-2-0-4, but were apparently better than the commercial check cultivar, King Kong, a large-fruited fresh market hybrid whose seeds are commercially available to tropical farmers (Table 13). Other advantages of the new selections are their firm fruit and crack resistance. They also carry excellent levels of BW resistance.

Table 10. Yield and other horticultural characters of the best determinate tropical lines vs check in Batch II summer trial, AVRDC 1988.

Entry	Days to maturity	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g/ft)	Cracking[z]	Firmness[y]	Other traits[x]	
							BLS	Flood damage
CLN 657BC$_1$F$_2$-267-0-3-12-7	76	9.2	25	43	SL R/C	MF	8	M
CLN 657BC$_1$F$_2$-267-0-3-14	76	7.8	23	39	S C	MF	7	SL
CL 5675BC$_1$F$_2$-1-2-2-12 (ck)	76	2.9	50	13	none	S	10	S

[z]SL R/C = slight radial/concentric; S C = severe concentric cracks. [y]MF = moderately firm; S = soft. [x]Rating scale of 1 = none to 10 = severe or M = moderate; SL = slight and S = severe.

Table 11. Yield performance and other horticultural characters of the best cherry hybrids vs check in the observation trial, AVRDC, summer 1988.

Entry	Days to maturity	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g/ft)	Cracking[z]	Firmness[y]	Other traits[x]				
							Foliage cover	Wall thick	Tough skin	Taste	BLS
CHT 90	75	26.2	17	19	none	MF	G	M	T	SL sour	4
CHT 105	75	23.5	27	21	M R/C	F	G	T	T	SL sour	4
CHT 160	75	22.3	27	26	VSL R/C	F	G	T	VT	SL S/S	6
Girl Sweet (ck)	75	8.0	19	20	S R/C	F	F	T	VT	SL S/S	9

[z]M C/R = moderate radial/concentric; VSL C/R = very slight radial/conc; S R/C = severe radial/conc. [y]MF = moderately firm; F = firm. [x]G = good foliage cover; F = fair cover M = moderately thick wall; T = thick wall T = tough skin; VT = very tough SL sour = slightly sour; SL S/S = slightly sour (some fruits) and sweet (others)

Table 12. Yield performance and other horticultural characters of the best determinate tropical lines vs checks in the preliminary yield trial, AVRDC, summer 1988.

Entry	Days to maturity	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g/ft)	Cracking[z]	Firmness[y]	Other traits[x]	
							BLS	Flood damage
CLN 466BC$_1$F$_2$-45-34-9-9	76	8.5 b	31 ab	34 bc	none	MS	6.5	5.5 b
CL 5675BC$_1$F$_2$-1-2-2-12 (ck)	76	11.1 a	41 a	18 c	none	S	7.5	7.0 ab
CL 5915-153D$_4$-3-3-0 (ck)	76	3.1 d-f	31 ab	23 c	none	MS	8.0	8.0 ab

[z]MS = moderately soft; S = soft. [y]Rating scale of 1 = none to 10 = severe.

The best relatively large-fruited fresh market hybrids were compared with the check hybrid, FMTT 22 (Table 14). The new hybrids yielded at least twice as much as the check, ranging in marketable yield from 29 to 32 t/ha, with comparable fruit size, fruit firmness and fruit cracking tendency, and slightly higher levels of BW resistance than the check. The highest yielding hybrid, FMTT 138, also showed better resistance to bacterial leaf spot and good foliage cover.

Table 13. Yield performance and other horticultural characters of the best indeterminate tropical lines vs checks in the preliminary yield trial, AVRDC, summer 1988.

Entry	Days to maturity	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g/ft)	Cracking[z]	Firmness[y]	Other traits[x]	
							BLS	Flood damage
CLN 657BC$_1$F$_2$-274-0-15-4	71 bc	10.6 a	20 a-d	44 a-c	none	F	7.5	3.0 b-d
CLN 657BC$_1$F$_2$-274-0-15-0	70 c	10.3 ab	33 ab	54 ab	none	F	7.5	1.0 e
CL 5915-206D$_4$-2-2-0-4 (ck)	71 bc	8.1 a-c	11 b-d	41 bc	VSL R	MF	8.0	1.0 e
King Kong (ck)	81 a	1.4 d	1 d	38 bc	S R/C	S		

[z]VSL R = very slight radial; S R/C = severe radial/concentric. [y]S = soft; MF = firm; F = firm. [x]Rating scale of 1 = none to 10 = severe.

Table 14. Yield performance and other horticultural characters of the best fresh market hybrids vs check cultivar in the preliminary yield trial, AVRDC, summer 1988.

Entry	Days to maturity	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g/ft)	Cracking[z]	Firmness[y]	Other traits[x]	
							Foliage cover	BLS
FMTT 138	78 bc	32.0 a	19 a-d	57 a-c	VSL SA	MF	G	2
FMTT 105	74 c	29.1 a	18 cd	59 a-c	VSL SA	MF	F	6
FMTT 94	74 c	29.7 a	30 ab	52 b-c	VSL SA	MF	F	6
FMTT 22 (ck)	79 bc	14.4 c-g	12 c-g	68 a	VSL R	MF	F	7

[z]VSL SA = very slight superficial cracks; VSL R = very slight radial cracks. [y]MF = moderately firm. [x]G = good cover; F = fair cover Rating scale of 1 = none to 10 = severe.

Evaluation of New Processing Tomato Hybrids

Summary

Three observation trials, one preliminary and two batches of advanced yield trials were conducted in 1987-88 to evaluate new processing tomato hybrids with heat tolerance, resistance to pests and diseases, high yield and acceptable processing quality.

The best new hybrids in the 1987 and 1988 observation trials showed better concentrated maturity, final marketable yield and fruit firmness compared with the check cultivars. With the exception of a few hybrids, most had shortcomings, however, in fruit size and solids content. The best selections of these new hybrids are currently undergoing further evaluation.

Three hybrids showed comparable heat tolerance to the heat-tolerant check, TN-3, in the 1987 late summer preliminary trial. Among new high yielding hybrids, PT 4121 appears to be the most promising because of its firm and large fruits and good vine cover. The entries selected from the preliminary trial were evaluated further in the 1987 and 1988 advanced trials.

PT 4121 and PT 4172, both outstanding entries in the 1987 late summer preliminary trials, and PT 4026, were the best entries in the 1987 Batch I advanced trial, giving the following advantages over the checks: higher final yield, better concentration of maturity, improved firmness (except when compared to TN-2), fair to good vine cover, good vine compactness and generally acceptable processing qualities. PT 4121 produced the largest fruits among outstanding hybrids.

In the Batch II advanced trial towards the cooler period, none of the best hybrids outperformed TN-2 in concentration of maturity although their final marketable yields were significantly higher than the latter's. Other advantages of TN-2 over the new hybrids were better fruit firmness, larger fruit size, better color and higher soluble solids.

Introduction

AVRDC continued to search for processing tomato genotypes with heat tolerance (for late planting in summer and spring), resistance to BW, tomato mosaic virus and nematode, high concentrated yield of firm fruits (for mechanical harvesting) and acceptable processing quality. In 1988, a number of hybrids were advanced to various trial stages.

Materials and Methods

Information on entries, planting dates and types of trials conducted at different times in 1988 is given below:

Type of trial	Number of entries	Sown	Transplanted
Observational	40	23 July 1987	25 August 1987
Observational	40	15 September 1987	15 October 1987
Observational	16	1 December 1987	10 January 1988
Preliminary	24	23 July 1987	25 August 1987
Advanced (I)	16	15 Sepetember 1987	12 October 1987
Advanced (II)	14	1 October 1987	27 October 1987

All observation trials were single-row plots, unreplicated plantings designed principally to make general selection for entries which deserved further evaluation. Each plot was planted to a single-row 4-m long bed, spaced 1.5 m apart from adjoining beds, with within-row spacing of 40 cm. Oftentimes, observation trials involved a large set of untested entries.

The preliminary trial was replicated twice in a randomized complete block design. A unit plot was 6 m^2 and consisted of a single row in a 4-m long bed, spaced 1.5 m from adjoining beds and with plants within the row 40 cm apart.

The advanced trials were planted in a more elaborate design — randomized complete block with three replications; each plot consisted of four beds, 4-m long each and 1.5 m apart, with plants within each single-row bed spaced 40 cm apart.

Results and Discussion

Observation Trials. The best performing processing hybrids in the 1987-88 observation trials are given in Tables 15, 16 and 17. By and large, the new hybrids showed better concentration of maturity, final yield and fruit firmness. However, they generally fell short in fruit size (especially vs TK-18), and soluble solids (only a few had comparable soluble solids readings against either checks).

Overall, the best entries in the individual observation trials were as follows: 1987 late summer trial - PT 4300 because of its relatively good first and final marketable yield, its very firm fruits, good vine cover, and brix content and color comparable to those of the checks; 1987 fall season trial - both PT 4287 and PT 4225 because of their better yields, firmness, vine cover, and compactness, and comparable soluble solids against the checks; 1988 spring season trials - PT 4186 because of its excellent concentration of maturity, improved firmness, and soluble solids not drastically below those of the checks. The best selections from these new hybrids are currently undergoing further evaluation.

Table 15. Yield performance and other horticultural characters of the best processing hybrid cultivars in the observation trial, AVRDC, late summer 1987.

Entry	Marketable yield (t/ha)		Fruit size (g)	Firmness[z]	Vine cover[y]	Compact vine[x]	pH	Brix°	Acidity	Hunter color
	Final	First								
PT 4215	60	42	80	F	E	G	4.21	3.20	.25	2.25
PT 4238	57	49	80	F	F	F	4.29	3.20	.26	2.06
PT 4300	56	46	73	VF	G	F	4.23	3.80	.30	2.43
PT 4237	54	50	63	VF	F	F	4.33	3.30	.22	2.14
TN-3 (ck)	43	39	67	MS	F	F	4.26	4.00	.25	2.52
TK 18 (ck)	14	4	85	MS	G	F	4.37	3.90	.28	2.56

[z]F = firm; VF = very firm; MS = moderately soft. [y]F = fair cover; G = good; E = excellent. [x]F = fairly compact; G = good.

Table 16. Yield performance and other horticultural characters of the best processing hybrid cultivars in the observation trial, AVRDC, fall 1987.

Entry	Marketable yield (t/ha) Final	First	Fruit size (g)	Firmness[z]	Vine cover[y]	Compact vine[x]	pH	Brix°	Acidity	Hunter color
PT 4287	132	78	83	MF	E	F	4.28	3.90	.32	2.39
PT 4225	118	79	70	MF	G	G	4.32	3.50	.31	2.46
TN-3 (ck)	103	64	62	MS	F	F	4.38	3.80	.25	2.50
TK 18 (ck)	95	52	117	MS	G	F	4.38	4.00	.28	2.62

[z]F = firm; MF = moderately firm; MS = moderately soft. [y]F = fair cover; G = good. [x]F = fairly compact; G = good.

Table 17. Yield performance and other horticultural characters of the best processing hybrid cultivars in the observation trial, AVRDC, spring 1988.

Entry	Marketable yield (t/ha) Final	First	Fruit size (g)	Firmness[z]	Vine cover[y]	Compact vine[x]	pH	Brix°	Acidity	Hunter color
PT 4274	132	87	72	MF	E	G	4.20	3.50	.35	2.22
PT 4271	126	64	92	F	G	G	4.37	3.20	.34	2.26
PT 4275	121	71	78	MF	G	F	4.35	3.30	.32	2.28
PT 4186	112	112	80	MF	F	G	4.39	3.90	.25	2.31
TN-3 (ck)	94	81	73	MS	F	F	4.40	4.70	.35	2.63
TK 18 (ck)	81	71	142	MS	G	F	4.38	4.40	.32	2.42

[z]F = firm; MF = moderately firm; MS = moderately soft. [y]F = fair cover; G = good; E = excellent. [x]F = fairly compact; G = good.

Preliminary Trial. Three hybrids showed comparable heat-tolerance to the heat tolerant check, TN-3, in the 1987 late summer preliminary trial (Table 18). All four entries dramatically outyielded the heat-sensitive checks, TN-2 and TK-18. Among high yielding hybrids. PT 4121 appears to be the most promising because of its firm and large fruits, and good vine cover. Soluble solids of the entries listed in Table 18 did not vary appreciably.

The entries selected from the preliminary trial were evaluated further in the advanced trials carried out in 1987 and 1988 (see advanced trials below).

Advanced Trials. PT 4121 and PT 4172, both outstanding entries in the 1987 late summer preliminary trials (see Table 18), along with PT 4026, were the best entries in the Batch I advanced trial conducted in 1987 fall season (Table 19). These hybrids had the following advantages over the checks: higher final yield, better concentration of maturity (high first harvest yields), improved firmness (except when compared to TN-2), fair to good vine cover, good vine compactness and generally acceptable processing qualities. However, all were inferior to TK-18 in fruit size. Among outstanding hybrids PT 4121 produced the largest fruits.

Table 18. Yield and other horticultural characters of the best processing hybrid cultivars in the preliminary yield trial, AVRDC, late summer 1987.

Entry	Marketable yield (t/ha) Final	First	Fruit size (g)	Firmness[z]	Vine cover[y]	Compact vine[x]	pH	Brix°	Acidity	Hunter color
PT 4172	47 ab	44 a	75 c-e	MF	F	F	4.26 bc	4.00	.29	2.52
PT 4121	42 ab	34 a-c	88 bc	F	G	F	4.30 a-c	3.80	.32	2.42
PT 4071	41 a-c	37 a-c	58 f	MS	F	G	4.25 c	3.85	.30	2.46
TN-3 (ck)	41 a-c	37 a-c	63 ef	MS	F	F	4.32 a-c	3.90	.25	2.48
TN 2 (ck)	22 de	11 ef	103 a	F	F	F	4.41 a-c	4.25	.25	2.42
TK 18 (ck)	18 de	3 f	72 d-f	MS	G	F	4.48 a	4.30	.32	2.64

[z]F = firm; MF = moderately firm; MS = moderately soft. [y]F = fair cover; G = good; E = excellent. [x]F = fairly compact; G = good.

In the Batch II advanced trial planted towards the cooler period, none of the best hybrids outperformed TN-2 in concentration of maturity although their final marketable yields were significantly higher than the latter's (Table 20). Other advantages of TN-2 over the new hybrids were better fruit firmness, larger fruit size, better color and higher soluble solids. One of the best yielders, PT 4071, was also outstanding in the previous late summer preliminary trial.

Table 19. Yield performance and other horticultural characters of the best processing hybrid cultivars in Batch I advanced yield trial, AVRDC, fall 1987.

Entry	Marketable yield (t/ha)		Fruit size (g)	Firmness[z]	Vine cover[y]	Compact vine[x]	pH	Brix°	Acidity	Hunter color
	Final	First								
PT 4026	115 a	79 a	72 gh	MF	G	G	4.28	3.90 c-e	0.35 ab	2.62 a-c
PT 4121	114 a	75 a	86 de	MF	G	G	4.30	3.97 b-e	0.29 cd	2.45 ef
PT 4172	104 a-c	78 a	76 f-h	MF	F	G	4.30	4.10 b-d	0.28 cd	2.53 c-e
TN-2 (ck)	99 bc	55 c	88 de	F	G	G	4.39	4.03 b-e	0.28 cd	2.66 ab
TN-3 (ck)	105 a-c	65 b	68 h	MS	F	F	4.37	3.77 de	0.28 cd	2.46 d-f
TK 18 (ck)	81 d	26 g	131 a	MS	G	F	4.37	3.97 b-e	0.33 a-c	2.71 a

[z]F = firm; MF = moderately firm; MS = moderately soft. [y]F = fair cover; G = good; E = excellent. [x]F = fairly compact; G = good.

Table 20. Yield performance and other horticultural characters of the best processing hybrid cultivars in Batch II advanced yield trial, AVRDC, 1987.

Entry	Marketable yield (t/ha)		Fruit size (g)	Firmness[z]	Vine cover[y]	Compact vine[x]	pH	Brix°	Acidity	Hunter color
	Final	First								
PT 4149	112 a	41 c-e	71 d-f	MS	G	G	4.25	4.33 bc	0.36 ab	2.35 bc
PT 4065	105 ab	33 ef	64 f	MF	E	F	4.18	4.23 cd	0.37 ab	2.22 d
PT 4071	104 ab	51 bc	69 d-f	MS	E	G	4.25	4.17 cd	0.34 bc	2.39 b
TN-2 (ck)	85 c	84 a	96 b	F	G	F	4.38	5.00 a	0.33 bc	2.63 a
TN-3 (ck)	111 a	49 bc	65 ef	MS	G	F	4.33	3.97 cd	0.34 bc	2.37 bc
TK 18 (ck)	86 c	27 f	150 a	MS	G	F	4.39	4.20 cd	0.30 c	2.58 a

[z]F = firm; MF = moderately firm; MS = moderately soft. [y]F = fair cover; G = good; E = excellent. [x]F = fairly compact; G = good.

International Distribution and Testing

In 1988, AVRDC distributed a total of 2,405 seed packets to 168 cooperators in 65 countries. AVRDC's cooperators continued to test new genetic materials developed by the tomato improvement program. New official releases were reported in 1988. Promising results were obtained by cooperators in other trials.

Official Releases

Dr. Jill E. Wilson of the Institute for Research, Extension and Training in Agriculture (IRETA) of the University of South Pacific in cooperation with the Department of Agriculture, Forests and Fisheries, Western Samoa, reported the official release of three tomato varieties selected from AVRDC breeding materials. These are Alafua Early (CL 2729-0-2-1-12-0), Alafua Winner (CL 5915-93D4-1-0) and Alafua Large (CL 5915-206D4-2-2-0). The above lines were selected for their high levels of BW resistance combined with a range of maturities, resistance to fruit cracking and acceptable eating quality. All were considered appropriate for home gardens, subsistence and market farming.

To date, the total number of AVRDC tomato germplasm released worldwide is 62 lines in 24 countries.

Feedbacks

Feedbacks were received from a number of cooperators on various trials they conducted in 1987 and 1988. Some of these trials are summarized below. The most promising results were filed by cooperators from Costa Rica, Fiji, Indonesia, Saudi Arabia, Senegal and Sri Lanka.

Costa Rica. Mr. E. Cooper of CINDE, San Jose, Costa Rica, reported the excellent performance of AVRDC processing tomato hybrids in trials at Guanacaste, considered a hot, dry area, and at Alajuela, a moderately cool growing location. The best hybrids were PT 4165 and PT 4172 which combine very high yields with fairly good processing qualities, especially good solids content (Table 21) in the Guanacaste trial. The performance of the hybrids at Alajuela was not nearly as good as in Guanacaste.

Table 21. Performance of AVRDC processing tomato hybrids at Porvenir, Guanacaste, Costa Rica, 1987.

Entry	Marketable yield (t/ha)	Brix°	pH	Firmness[z]	Interior flesh color[z]
PT 4165	129.0	5.0	4.25	2	2
PT 4172	88.3	5.0	4.25	2	1
Tainan No 3	98.7	4.5	4.15	2	2

[z]1 = high; 2 = good; 3 = medium; 4 = low.

In a BW screening conducted by the Integrated Pest Management Project of CATIE, Turrialba, six out of seven accessions/breeding lines from AVRDC showed BW resistance. However, only two lines, CL 5915-206-2-2 and CL 5915-206-2-5 were considered to have good commercial fruit traits and yields of 1,748 and 1,141 g of fruits per plant, respectively.

Fiji. Mr. M. Iqbal of the Sigatoka Research Station reported the preliminary selection of four processing tomato hybrids from AVRDC in a 1987 bacterial wilt/heat tolerance test of 29 entries that AVRDC supplied earlier. These selected hybrids were PT 862, PT 913, PT 3025 (or Tainan No. 3) and PT 870. Mr Iqbal also reported that variety Alton, a selection from AVRDC's CL 143-0-4B-1-0-0-0, celebrated its 10th anniversary after release and that to date, the research station has sold a total of 500 kg of its seeds to growers. Another variety, Sada Bahar, derived from CL 8d-0-7-1-0-0-0, celebrated its 5th anniversary.

Indonesia. Mr. P. T. Li of the ROC Agricultural Technical Mission reported the excellent performance of AVRDC breeding lines in the 1987 hot season trial at Blendung, Kulonprogo, Indonesia. A field day attended by many local farmers highlighted the demonstration trial which was highly publicized in the local newspapers. The best tropical lines were CL 5915-206-2-2-0 and CL 5915-153-3-3-0, with marketable yields of 66 and 53 t/ha, respectively. In contrast, commercial cultivar Peto 86 yielded only 20 t/ha in the same trial. AVRDC materials were also noted to have moderate to good firmness; fruit sizes were also acceptable.

Saudi Arabia. Mr. J. Y. Lin of the Ministry of Agriculture and Water, Qassim Agricultural Research Center, reported that all 12 AVRDC lines and hybrids introduced into the Kingdom outyielded the check cultivar, Pearson Improved A-1. The best AVRDC materials are compared to the check, Pearson Improved A-1, in Table 22. The best yielders, CLN 363 DC1F2-344-0-0 and FMTT 32 are considered suitable for cultivation in the Qassim area.

Table 22. Performance of AVRDC genetic materials in Qassim, Saudi Arabia, 1988.

Entry	Marketable yield (t/ha)	Fruit size (g/ft)	Cracking	Firmness[z]
CLN363-344-0-0	80 a	72	none	MF
FMTT 32	79 ab	51	none	S
FMTT 23	65 a-c	82	very slight	MF
CL 5915-223-2-1-0	55 cd	30	none	MF
PT 4176	51 cd	44	none	F
Pearson Improved (check)	23 f	114	slight	S

[z]S = soft; MF = moderately firm; F = firm.

Senegal. Dr. G. van den Plas of Senegal's Institute for Agricultural Research reported the selection for advanced trials of four AVRDC breeding lines from preliminary observations in a hot, humid season trial in June 1987. These are CL 5915-93-1-0-L-2-0 and CL 5915-206-2-2-0-4, both selected for good yield and medium fruit size, and CLN 229-4-1-4-1-1 and CLN 236-26-3-3-15, both high yielding and nematode-resistant. The latter also reportedly produced acceptable medium fruit size.

Sri Lanka. The Department of Agriculture at Peradeniya reported the selection of five AVRDC breeding lines for further testing based on results obtained from a trial at Maha Illuppallama. The selected lines had a marketable yield of 20 to 31 t/ha, excellent resistance to BW, good to excellent fruit setting ability and good fruit crack resistance. In contrast, the local check variety, T-146, itself a product of AVRDC genetic resources, yielded about 20 t/ha. Commercial varieties Luxor, All Star and Duke, introduced by US seed companies, yielded about 6-7 t/ha.

Vietnam. One preliminary trial was conducted on 10 AVRDC lines vs one local check (Hocmon) by the Hiep Thanh Cooperative in Hocmon District, Ho Chi Minh City in the 1988 spring season (sown 27 March, transplanted 20 April and harvested June to July, 1988). Two lines, CL 5915-93 and CL 5915-223, yielded only as high as the local check (13 t/ha) but had better horticultural traits such as absence of fruit cracking. Their fruits were smaller, however, compared to that of the check (30-34 g/ft for the AVRDC lines vs 52 g per fruit for the local check).

Tomato Entomology

Selection of Fruitworm-resistant Breeding Progeny

Summary

Nineteen families of BC_3F_4 population, derived from a cross between high yielding tomato breeding line and a fruitworm – resistant *Lycopersicon hirsutum* f *glabratum* parent, were screened for resistance to tomato fruitworm. Damage ranged from 14 to 53% in fruits. Eleven plants with good horticultural characteristics and fruitworm resistance were selected for evaluation of yield potential.

Introduction

Tomato fruitworm (TFW), *Heliothis armigera* Huebner (Lepidoptera: Noctuidae), infests tomato and several other economically important crops in southeast Asia. The adults lay eggs on the foliage and the larvae feed on the leaves, then move to the fruit and bore inside. In 1980, laboratory findings at AVRDC confirmed the TFW resistance in two *Lycopersicon esculentum* f *glabratum* accessions which showed resistance to other lepidopterous insect pests. The accession was crossed with high yielding breeding lines carrying desirable horticultural characteristics. During subsequent seasons, lines carrying TFW resistance were selected. In 1987-88 season BC_3F_4 populations for TFW resistance were screened, and plants carrying a higher level of resistance and desirable horticultural characteristics were selected.

Materials and Methods

From the screening of BC_3F_3 in 1986-87 season, 19 plants were selected. Seeds from the fruit were extracted and 50 plants of each selection (family) were tested for TFW resistance.

Tomato seeds were planted in small plastic pots and one-month old seedlings were transplanted in the field in single rows on the top of 1.5-m wide beds at a distance of 1 m between two adjacent plants in each row. A susceptible line was transplanted in every fifth row and one plant of resistant parent on both ends of each row.

When flowering started, a large number of laboratory-reared TFW pupae were uniformly released throughout the field.

Occasionally each of the 50 plants of each family was observed and TFW damaged and total number of fruits on each plant were recorded. Data in all observations were combined and the percentage of fruits damaged was computed.

Results and Discussion

Percentage of fruit damage among 19 families ranged from 14 to 53%. Fruit damage was 49% in the susceptible check. The resistant parent did not bear fruits until most of the test materials were harvested. Eleven plants were selected, based on the least percentage of fruits damaged (less than 10%) and size of fruits (medium to large). The progeny of these plants, along with other breeding

lines, will be included in a preliminary yield trial. They will also be evaluated for yield and TFW damage in 1988-89.

Screening of Insect Growth Regulators and *Bacillus thuringiensis* for Tomato Fruitworm Control

Summary

Three insect growth regulators, Chlorfluazuron, BAS 166801 and WL 115110 and one *Bacillus thuringiensis* formulation, SAN 415 gave excellent control of tomato fruitworm. All these formulations are toxic to the pest but are nontoxic to beneficial parasites and predators. They are thus suitable for an integrated control of TFW.

Introduction

Tomato fruitworm (TFW), *Heliothis armigera* Huebner (Lepidoptera: Noctuidae), is a polyphagous pest that infests tomatoes in Taiwan and other parts of Southeast Asia. The adults lay eggs on foliage and after initial feeding on the leaves, the larvae bore into the fruits, thus making them unfit for human consumption and processing. At present, farmers use insecticides to control this pest. Apart from the cost disadvantage, frequent use of insecticide leads to the development of resistance in the pest, destroys natural enemies which regulate pest population, and increases health hazards to farmers and consumers, and environmental pollution.

Recently, insect growth regulators (IGRs), chemicals which are specifically effective against caterpillar insects, have been developed. These chemicals are less toxic to parasites, hence, have potential use in integrated pest management. The efficacy of five IGRs along with two *Bacillus thuringiensis* formulations, also not toxic to parasites, and one standard conventional insecticide to control tomato fruitworm was evaluated.

Material and Methods

A parcel of land was rototilled and, after basal fertilizer application, 1.5 m beds were prepared and further divided into 4.5 m × 3.3 m plots. One-month old tomato seedlings were transplanted on a single row on each bed at a distance of 40 cm apart. Post-planting cultural practices such as top-dressed fertilizer application, irrigation, weed and disease control were adopted to ensure high yield.

Each insecticide was applied to four replicated plots arranged in a randomized complete block design. A 10-liter air pressure sprayer charged to 2.7 kg/cm^2 (40 PSI) was used. Spraying was done at a volume of 0.75 liter/plot for the first four and 1.5 liter/plot for the remaining applications. Each sprayer was individually calibrated with a stopwatch to ensure that the specified spray volume was delivered to each plot.

The number of fruitworm-damaged and healthy ripe fruits was recorded at each sampling (fruit picking) interval. Total and marketable yields were also recorded. All insect count and yield data were analyzed by ANOVA followed by DMRT to compare efficacy of each chemical.

Results and Discussion

The effectiveness of various IGRs and *B. thuringiensis* in controlling TFW is summarized in Table 1. Three IGRs; chlorfluazuron, WL 115110 and BAS 166801 gave excellent control of TFW. Chlorfluazuron was as effective as the standard conventional insecticide, deltamethrin. SAN 415, a strain of *B. thuringiensis*, gave good control to TFW. This is significant because most *B. thuringiensis* strains available are not very effective against *Heliothis* and *Spodoptera* species. Tomato fruit yield increased with the application of insecticide. Yield response due to deltamethrin and chlorfluazuron was the best. It was found that either chlorfluazuron or *B. thuringiensis* formulation SAN 415 can effectively control TFW. Both chemicals are specific to most caterpillar pests and are safe to most species of parasites, thus, suited to an integrated pest management program.

Table 1. Evaluation of IGRs and *B. thuringiensis* for the control of tomato fruitworm on tomato.[f]

Insecticides	Rate kgAI/ha	Damaged fruits (%)							Yield t/ha
		87/12/1	12/9	12/16	12/23	12/30	88/1/6	1/13	
Teflubenzuron 15EC	0.0375	40.8 b	40.9 a	32.7 b	26.5 b	28.2 bc	30.2 b	18.5 b	17.3 d
WL 115110 5EC	0.050	12.4 e	16.6 b	15.9 c	14.1 c	12.5 d	8.7 e	6.1 e	41.5 cd
Chlorfluazuron 5EC	0.050	5.3 g	8.3 b	10.6 c	6.6 d	6.3 e	3.3 f	2.3 f	54.2 ab
PH70-23 25SC	0.075	19.5 de	20.0 b	17.9 c	15.4 c	20.3 cd	15.3 d	13.9 c	30.1 d
PH70-23 25SC	0.150	26.8 cd	21.1 b	20.1 c	17.3 c	17.4 d	13.4 de	10.3 d	31.4 d
BAS 166801 50EC	0.050	13.6 e	11.7 b	14.0 c	17.0 c	13.0 d	7.2 e	4.6 e	47.3 bc
SAN 415[g]	0.500	9.5 f	9.9 b	17.2 c	15.3 c	11.4 d	7.2 e	6.9 de	43.8 c
ABG 6162 [g]	0.500	29.0 c	39.0 a	34.7 b	29.4 b	29.7 b	23.7 c	18.2 b	23.4 d
Deltamethrin 2.8EC	0.050	2.0 h	11.2 b	4.3 d	2.5 e	3.1 f	1.7 g	1.5 g	59.4 a
Control		49.9 a	38.9 a	52.5 a	41.2 a	40.7 a	39.5 a	37.7 a	11.1 e

[a]Cultivar: TN-3. [b]Transplanting date: 87/10/1. [c]Insecticides applied: 87/10/29, 11/5, 11/13, 11/19, 11/26, 12/3, 12/10, 12/17, 12/24, 12/31, 88/1/7. [d]Observation data for damaged fruit: 87/12/1, 12/9, 12/16, 12/23, 12/30, 88/1/6, 1/13. [e]Data shown are means of four replicates. Mean separation by DMRT (P = 5%). [f]Plot size: 15 m^2. [g]*B. thuringiensis* formulations.

Tomato Pathology

Resistance to CMV and Leaf Curl Virus

Summary

A total of 113 lines were screened for CMV resistance and five lines for leaf curl virus resistance. The lines, which are wild types, consisted mainly of those with reported resistance to these two viruses. None of the lines was found resistant.

By using c-DNA hybridization, the relationship of Taiwan tomato leaf curl virus with the tomato yellow leaf curl virus (TYLCV) prevalent in the Near East was investigated. The Taiwan probes reacted weakly to the TYLCV probes, indicating a certain percentage of nucleic acid homology and close relationship between these two viruses.

Introduction

Five tomato viruses, namely TMV, PVY, CMV, tomato leafcurl virus and tomato spotted wilt virus are important in the tropics. The last three considerably reduce yield. Resistance to TMV has already been incorporated into the AVRDC breeding lines. Resistance to PVY has been found in two *L. hirsutum* accessions and is being studied. However, resistance to CMV has not been found, despite screening of a large number of wild type germplasm. Similarly, all reportedly TYLCV-resistant lines were found susceptible to the virus. Biotechnology is being explored elsewhere to solve the CMV problem and the virus causing leaf curl. Only limited screening for resistance is presently conducted at AVRDC. Furthermore, investigation on the relation of tomato leaf curl virus in Taiwan to tomato yellow leaf curl virus (TYLCV) which has severely damaged tomato in the Near East is underway.

Materials and Methods

CMV. For the AVRDC accessions, 40 to 50 plants per entry were screened through mechanical inoculation, first with the isolate CMV-Peet, followed by CMV-yellow.

One hundred and four accessions, comprising of *L. esculentum*, *L. esculentum cerasiforme*, *L. pimpinellifolium*, *L. peruvianum*, *L. glandulosum*, *L. peruvianum* var. *humifusum*, *L. hirsutum*, were screened. These accessions were L149-159, L161-187, L191-196, L198-201, L690, L734-738, L882, L884-900, L1034-1035, L1037-1038, L1132, L1597, L1720-1721, L1745-1750, L1753, L1747-1750, L1753, L1755, L1947-1948, L3062, L3230, L3234, L3387, L3684, L3717-3718, L4379 and L4392-4393.

Nine *Solanum pennellii* lines with reported resistance to CMV were received from Dr. Rick (University of California), namely: LA 2772 SAL 7530-5 OP, LA 2772 SAL 7530-4, LA 2781 SAL 7539-7, LA 2776 SAL 7534-5, LA 2776 SAL 7534-4, LA 2777 SAL 7535-4, LA 2385 SAL 4136, LA 1990 PI 255549 and LA 2387 SAL 4834.

Leaf curl virus of tomato. The following lines were screened: two lines, VL 282 (*L. pimpinellifolium* LA 1478 83L 5280) and VL 257 (*L. hirsutum* LA 386 83L 5355) with reported

resistance to TLCV; *Solanum lycopersicoides* lines (Campbell Institute for Research and Technology); and, three *Solanum lycopersicoides* lines (LA 1964, LA 1974, LA 2408). Ten to 20 plants per entry were screened using the double grafting method described previously for resistance screening.

Comparison between Taiwan tomato leaf curl virus and tomato yellow leaf curl virus (TYLCV)

Dot hybridization on nitrocellulose membranes using c-DNA of the TYLCV was used to determine the relationship between these two viruses. Leaves and stems of *L. esculentum* and *N. benthamiana* infected with Taiwan tomato leaf curl virus were squashed onto a nitrocellulose membrane. The squashes were challenged with labelled TYLCV c-DNA probes*.

Results

CMV. All AVRDC accessions and *Solanum pennellii* lines were found susceptible.

Tomato leafcurl virus. Dr. Rick's lines with reported resistance to TLCV and three *Solanum lycopersicoides* lines (Campbell Institute) were found susceptible.

With the TYLCV c-DNA probes, all Taiwan tomato leaf curl squashes reacted, although weaker than the homologous challenges, indicating a certain degree of homology and close relationship between the two viruses. Monoclonal antibodies which are presently prepared at AVRDC may provide further evidence of the relationship between these viruses.

*The tests were conducted by H. Czosnek, Bet Dagan.

Tomato Physiology

Growth Analysis of Tomato Applied with Growth Regulator

Summary

CPA application at anthesis or two weeks after anthesis increased fruit yield of heat tolerant CL 5915-206 and FMTT 3. The pronounced effects were observed on clusters of high order position. CPA application increased harvest index. There was a balanced effect on the number of fruits and fruit size due to different timings of CPA application, CPA application at anthesis resulted in larger but lesser fruits without seeds, whereas CPA application at two weeks after anthesis increased the number of fruits but they were smaller with some seeds.

Introduction

High temperature reduces fruit-set as well as prevents assimilate distribution to the tomato fruit. Furthermore, it usually decreases fruit size of heat-tolerant tomatoes. Possibly, high temperature disturbs the balance of endogenous hormones between vegetative and generative parts of tomato plants, thereby causing the reduced diversion of assimilates to the plant's generative parts. Earlier it was demonstrated that the application of para-chlorophenoxy acetic acid (CPA) increased tomato fruit-set and yield under high temperature conditions. The present study aimed to examine the effect of CPA on dry matter distribution of tomatoes in relation to fruit size under high temperature conditions.

Materials and Methods

Seeds of (*Lycopersicon esculentum* Mill.) varieties, FMTT 3 (indeterminate type and heat-tolerant with medium large fruits) and CL 5915-206D_4-2-2-0 (indeterminate type and heat-tolerant with medium fruits), were sown on 20 April 1988. Seedlings were transplanted to the field on 16 May 1988. Plants were pruned into two stems. CPA at 100 ppm in 0.01% Tween 20 solution was applied to the first to eighth clusters individually when each cluster reached first anthesis or two weeks after anthesis. The control cluster was treated with 0.01% Tween 20 only. Six treatments (three growth regulator applications × two varieties) in a randomized complete block design with four replicates were employed. Each replicate (plot) was 1.5 m × 12.0 m double-row-bed with an intra- and inter-row spacing of 40 and 60 cm, respectively. Four plants in each replicate were randomly sampled at the time of transplanting, and at 3, 6, 9, 11 and 13 weeks after transplanting. Sample plants were measured for height, leaf area, and fresh and dry weights of different plant parts. Days to first anthesis and first harvest of each cluster were also recorded. Plot sections were subjected to yield and yield component investigation. Harvested fruits were randomly selected to determine fruit color rating, acidity and soluble solids. Petioles and peduncles were also investigated for sugar and starch contents. Means of maximum and minimum temperatures from field planting to final harvest were 31.2°C and 24.0°C, respectively.

Results and Discussion

At 13 weeks after field planting, the number of fruits and yield of each cluster decreased as clusters increased, with or without CPA applications. The top most (6th, 7th and 8th) clusters without CPA

application had negligible fruit-set and fruit yield (Figs. 1 and 2). CPA application at first anthesis or two weeks after anthesis increased fruit-set and fresh weight of each cluster. Clusters of high order in both varieties were greatly affected. There was no significant difference between CPA application at anthesis and two weeks after anthesis in the number of fruits and fresh weight in both entries. High temperatures prevented normal pollen and ovule development and enhanced style elongation, resulting in the absence of fertilization for seed formation which would enable hormonal production for fruit development. Therefore, CPA application at anthesis or two weeks after anthesis would make no difference in influencing flower abscission because of high temperature conditions. CPA application at anthesis tended to promote fruit-set of early flowers of the cluster, whereas CPA application at two weeks after anthesis induced late flowers in the same cluster.

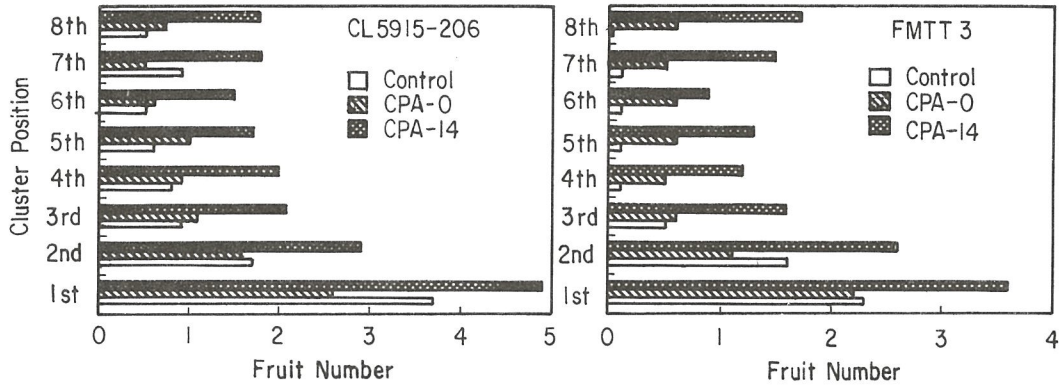

Fig. 1. Effect of CPA application at anthesis (CPA-0) or two weeks after anthesis (CPA-14) on fruit number on individual clusters of CL 5915-206 and FMTT 3.

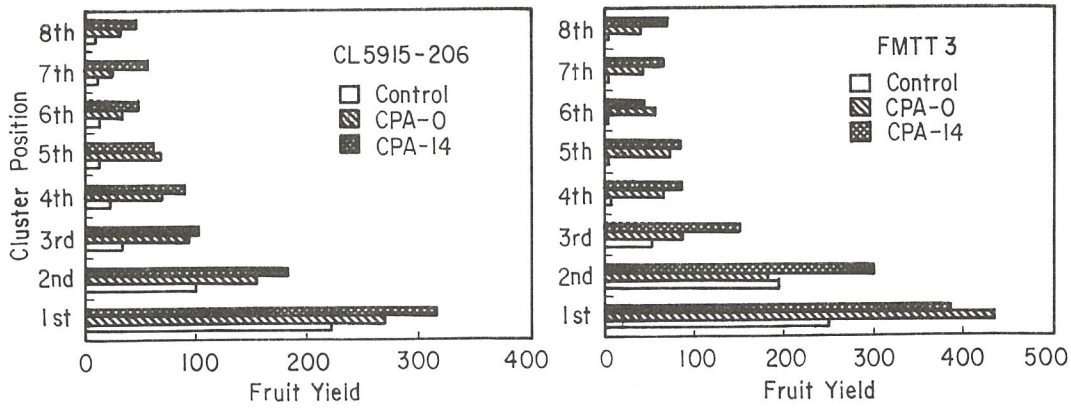

Fig. 2. Effect of CPA application at anthesis (CPA-0) or two weeks after anthesis (CPA-14) on fruit yield on individual clusters of CL 5915-206 and FMTT 3.

CPA application at anthesis or two weeks after anthesis increased total fresh weight (Fig. 3). The trend was also evident in total dry weight but the extent of increment was lesser than in fresh weight (Fig. 4). Apparently, CPA slightly increased the photosynthetic potential of tomato. CPA also increased the harvest index (either fresh weight or dry weight). However, harvest indices on dry weight basis (Fig. 5) were generally lower than on fresh weight basis. Fruits induced by CPA could create the sink load for assimilates, thus increasing the diversion of dry matter to the fruit. Fruits induced by CPA would also preserve more water because of low surface/volume ratio in the fruit, hence increasing the total fresh weight.

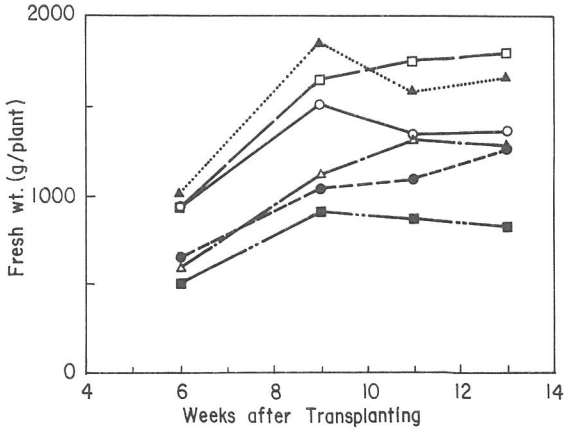

Fig. 3. Total fresh matter of CL 5915-206 and FMTT 3 with their clusters treated with CPA at anthesis (CPA-0) or two weeks after anthesis (CPA-14).

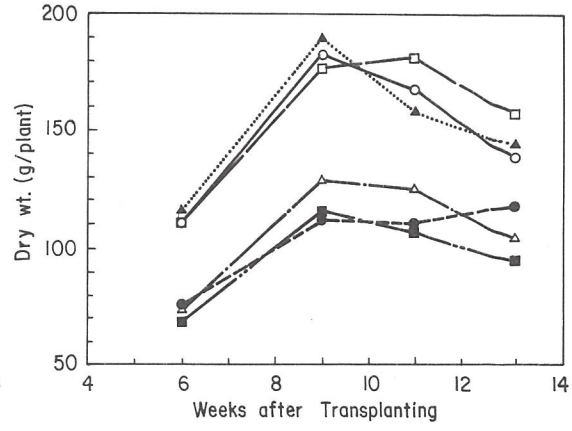

Fig. 4. Total dry matter of CL 5915-206 and FMTT 3 with their clusters treated with CPA at anthesis (CPA-0) or two weeks after anthesis (CPA-14).

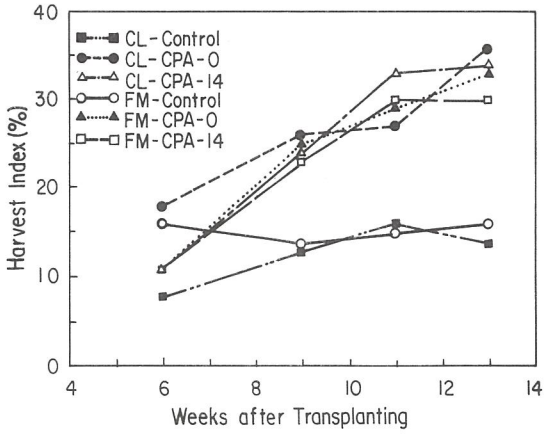

Fig. 5.
Harvest index on dry matter basis of CL 5915-206 and FMTT3 with their clusters treated with CPA at anthesis (CPA-0) or two weeks after anthesis (CPA-14).

CPA application reduced the total number of flowers; CPA application at anthesis reduced more flowers than when it was applied at two weeks after anthesis. On the contrary, CPA increased the number of fruits, especially when it was applied two weeks after anthesis (Table 1). Obviously, tomato plants without CPA application under high temperature conditions produced more flowers to compensate for those which did not set fruits. Plants treated with CPA were able to set fruits. The difference in the number of fruits and fruit size between CPA application at anthesis and two weeks after anthesis could be due to early induced fruits. Similarly, the rapid ovary enlargement caused by CPA application at anthesis could have prevented fertilization, resulting in reduced seed formation. Since the ovary growth at the early stage is attributed to cell division, it is possible that CPA application at anthesis could have affected cell division and carpel development which is associated with fruit size.

Sugar and starch contents in the pedicel increased at three to six weeks after transplanting (WAT) before declining at 11 WAT in both entries. Similarly, CPA application either at anthesis or two weeks after anthesis seemed not to change the carbohydrate concentrations in the pedicel or peduncle. It is possible that CPA influenced the rate of translocation instead of metabolism of carbohydrate during fruit-set and development. On the contrary, CPA application at anthesis decreased the total solids content but increased the color rating of harvested fruits (Table 2). Large fruits induced by CPA application at anthesis could have increased moisture accumulation and promoted ripening of fruit.

Table 1. Effect of CPA applied at anthesis (CPA-0) or two weeks after anthesis (CPA-14) on yield and yield components of CL 5915-206 and FMTT 3.

Variety	Treatment	Flower no. (/plant)	Fruit yield (g/plant)	Fruit no. (/plant)	Market. fruit no. (/plant)	Fruit wt. (g/fruit)	Carpel no. (/fruit)	Parthenocarpy (%)
CL 5915	Control	122 a	418 c[y]	9.4 b	3.9 b	44 b	3.9 b	59 a
	CPA-0	63 c	739 b	8.8 b	6.7 a	83 a	4.4 a	100 c
	CPA-14	97 b	904 a	18.7 a	7.9 a	48 b	4.1 b	80 b
FMTT	Control	88 a	516 c	4.7 c	4.1 c	109 b	4.3 b	16 a
	CPA-0	45 b	977 b	6.7 b	5.9 b	146 a	4.9 a	99 c
	CPA-14	80 a	1187 a	14.2 a	10.1 a	84 c	4.2 b	63 b

[z]Flower number was investigated at 13 weeks after transplanting. [y]Mean separation within columns at 5% level by DMRT.

Table 2. Effect of CPA applied at anthesis (CPA-0) or two weeks after anthesis (CPA-14) on fruit quality of CL 5915-206 and FMTT 3, harvested on 14 July 1988.

Entry	Treatment	pH	Titratable acid (%)	Total soluble solids (%)	Color rating
CL 5915	control	4.26	0.43 a[z]	5.31 a	1.06 b
	CPA-0	4.22	0.37 b	4.81 b	1.60 a
	CPA-14	4.16	0.44 a	5.27 a	1.30 ab
FMTT 3	control	4.24	0.46 ns	5.20 a	1.34 b
	CPA-0	4.17	0.43	4.87 b	1.68 a
	CPA-14	4.22	0.45	5.07 ab	1.43 ab

[z]Mean separation within columns by DMRT at 5% level.

Production Systems Program

Chemistry

Screening for Starch Digestibility of Sweet Potato

Summary

The traditional practice of incorporating sweet potato-based feed for hog raising generally required cooking to improve the feeding efficiency. A screening method based on CO_2 gas production by yeast fermentation of sugars obtained from pancreatic digestion of sweet potato starches was developed. This method proved useful to detect those easily digestible varieties from those of the resistant lines. AVRDC improved lines, CN 1108-13 and CN 1448-59 were found to be easily digestible by this method. Analysis of sweet potato samples harvested from different seasons revealed that roots produced during wet seasons are generally lower in starch digestibility. A significant interaction between genotypical and seasonal effects was also observed for this property.

Introduction

In Asia, the tuberous roots of sweet potato, *Ipomoea batatas* (L.) *Lam.*, are traditionally used as supplemental staple food, feed and raw material in industry. Although sweet potato is a tropical crop, about 80% of the world's production is confined in China. The popularity of sweet potato cultivation in China was often associated with food crises. The crop was introduced in different parts of China as a 'survival crop'. Sweet potato, however, has never become a popular staple food in China. When the crises were over, sweet potato was used for feed. The multiple uses of sweet potato in China provided a steady demand, thus providing additional incentives for farmers to gain higher yield.

Using sweet potato for animal feed entails additional labor and fuel. It lends itself well in subsistence farming systems but is not as suitable for large scale commercial production. AVRDC's previous work suggested that the low protein digestibility of sweet potato diet is mainly due to its starch property. The result of experiments on flatulence also indirectly confirmed that sweet potato starch is not easily digestibile. Rat feeding trials further revealed that there are genotypical differences in starch digestibility among sweet potato lines. Thus, it could be possible to breed and select for varieties with higher digestibility (without precooking). Animal feeding experiments, however, are very expensive to conduct. A rapid screening technique is essential for an efficient breeding program. A modified laboratory method based on CO_2 gas production by fermentation of sugars obtained from pancreatic digestion of starch was developed. The procedures of this method and results obtained in 1988 are summarized in this report.

Materials and Method

Sweet potato samples were harvested from yield trials and prepared into flour at the Chemistry laboratory.

Sweet potato starches were extracted and purified using distilled water as medium. Routine analytical procedures were used for sugar, starch and other constituents. Pancreatin was purchased from Sigma Company and its activity was monitored periodically. Pressed baking yeast was locally purchased.

Results and Discussion

Development of *vitro* method. Many factors may affect the digestibility of starch. Previous experiments of *in vitro* digestion confirmed that the low digestibility of sweet potato starch is mainly due to the resistance to enzyme digestion. The digestibility of raw starches isolated from two sweet potato varieties, as measured by their conversion to sugars by pancreatic enzyme is shown in Figure 1.

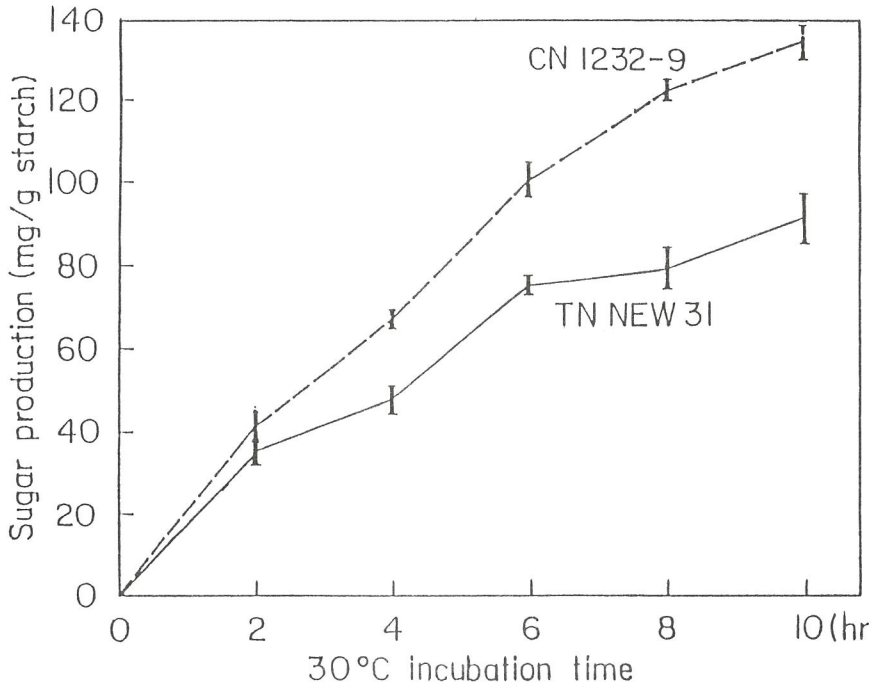

Fig. 1. *Vitro* digestion of purified sweet potato starches by pancreatin.

Since sugars are further fermented to alcohol and carbon dioxide, and CO_2 is easier to measure than sugars, a modified laboratory procedure based on CO_2 gas production by fermentation of sugars obtained from pancreatic digestion of starches was developed to replace sugar analysis. The reaction is carried out in a fermentation tube under 30°C for two hours. The volume of CO_2 gas observed in the fermentation tube is used as a parameter for digestibility. The procedure used is shown in Figure 2. A blank test without pancreatic enzyme for each sample was used to estimate the sugar content in the original sample. The volume of CO_2 gas produced from flours of two sweet potato cultivars under this system by time is shown in Figure 3. The digestion susceptible line (CN 1232-9) produced much more CO_2 gas than the resistant check (TN New 31). A fermentation period of two hours was sufficient to demonstrate a distinct difference between these two lines. This result indicated that gas formation by yeast can be used as a simple screening technique for starch digestibility.

The sugar released from flour of different varieties by *in vitro* enzymatic digestion for 10 hours was compared to CO_2 production of the above mentioned fermentation method (Table 1). Reaction mixtures, flour and enzyme were placed in a dialysis tube to minimize the amount of enzymes required for *in vitro* digestion. Sugar which is permeable to the dialysis membrane is determined and considered to be biologically available. Significant differences on amounts of sugar released and CO_2 gas production were observed among genotypes tested. Although there were only limited numbers of samples included in this experiment, it was observed that the highly digestible line generally has higher CO_2 gas production. Correlation analysis showed a highly significant correlation coefficient (0.72) between the amount of sugar released and volume of CO_2 gas produced. This result suggested that

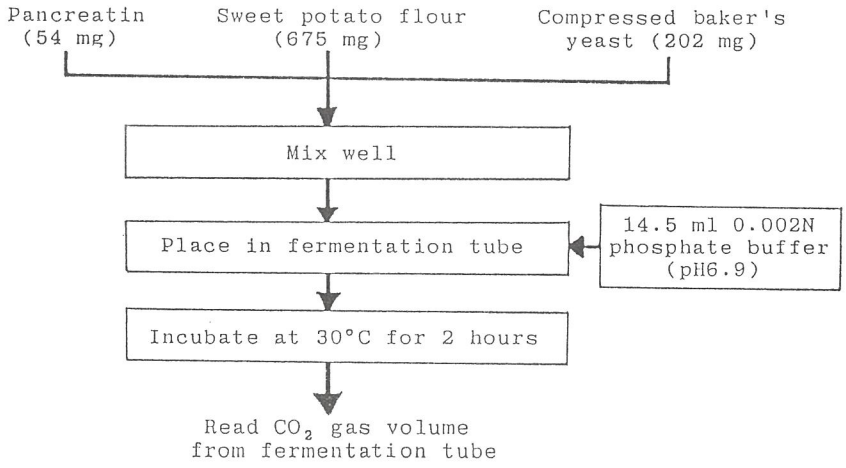

Fig. 2. Procedures of starch digestibility by fermentation method.

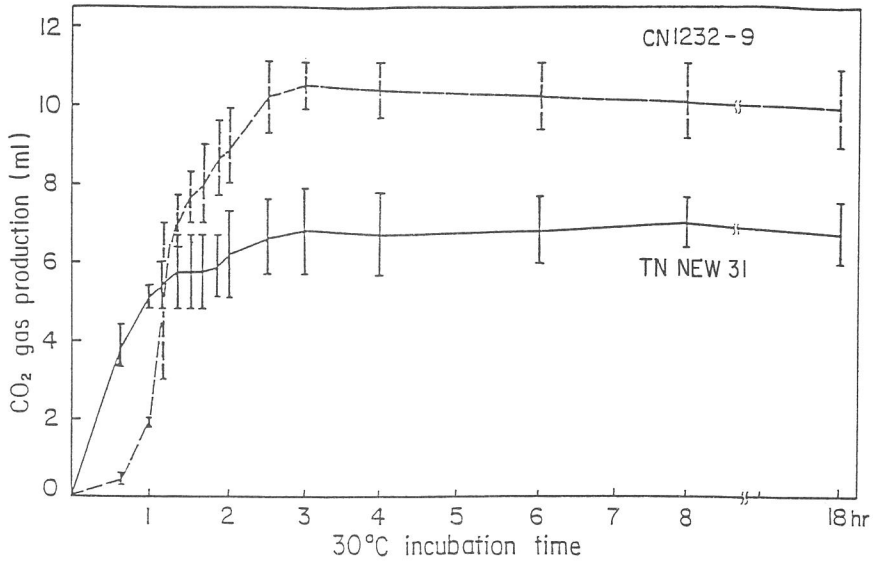

Fig. 3. *In vitro* digestion of sweet potato flours by fermentation method.

Table 1. Relative starch digestibility of sweet potato by two *in vitro* methods.

Sweet potato line	Sugar released[z] (mg/g starch)	CO_2 gas[y] produced (ml)
CN 1232-9	194.8	8.7
CN 1108-13	219.5	11.4
CN 1448-59	160.5	10.3
CN 1489-89	145.9	4.2
CN 1489-43	165.5	4.7
CN 1028-15	160.7	3.6
CN 1038-16	102.1	3.8
TN 57	123.6	5.6
TN 67	151.6	4.8
TN 31	70.9	3.4

[z]14.5 ml reaction mixture consists of sweet potato flour 675 mg, pancreatin 54 mg (385 units alpha-amylase activity) phosphate buffer (0.002 N pH 6.9) placed in a dialysis tube submerged in 10 ml of phosphate buffer. Incubated under 30°C for 10 hours. [y]Values observed based on the procedure in Fig. 2.

the fermentation method developed can be used as a preliminary screening technique for digestibility of sweet potato starch. The methods are relatively simple and the only facility needed is an oven. More samples can be analyzed within a relatively short period at a minimum cost. A check sample, such as corn meal, is recommended to be included in every batch as a standard. Lines found to be easily digestible by this method can be further confirmed by animal feeding experiments.

Seasonal variation in digestibility of sweet potato starch. Farmers and consumers observed that sweet potato roots harvested in the wet season generally have poor cooking quality, and are less digestible. Studies were conducted to estimate the digestibility of sweet potato flour sample harvested in spring and fall using the fermentation method described in the preceding section. A distinct seasonal effect on digestibility was observed in all varieties tested (Table 2). Sweet potatoes harvested during the wet season were found more resistant to pancreatic enzyme digestion. The percent reduction in susceptibility due to seasonal effect varied from 18.7% to 75.3% with an average value of 48%. This result implies that feeding quality of sweet potatoes needs to be evaluated according to planting season. The relationship between poor starch digestibility and cooking quality of sweet potatoes harvested in the wet season still needs further investigation.

Table 2. Seasonal variation in starch digestibility of sweet potato.

Variety	Digestibility (ml CO_2/g/DW)	
	Fall	Spring
CN 1232-9	8.7 ± 0.1[z]	3.2 ± 0.1
CN 1489-89	4.2 ± 0.2	2.9 ± 0.2
CN 1489-43	4.7 ± 0.2	3.8 ± 0.1
CN 1028-15	3.6 ± 0.4	1.6 ± 0.2
CN 1108-13	11.4 ± 0.2	6.6 ± 0.2
CN 1448-59	10.3 ± 0.8	2.5 ± 0.3
Corn (check)	9.8 ± 0.2	–

[z]Mean ± SD.

Two AVRDC improved lines, CN 1108-13 and CN 1448-59, were found highly susceptible to pancreatic digestion. CN 1108-13, which has wide adaptability in terms of yield, is most promising. In the wet season, this cultivar is more digestible than other varieties tested in the dry season. The feeding properties of these two promising lines will be evaluated through a rat feeding experiment next year.

The starch digestibility of four sweet potato varieties, CN 1108-13, CN 1232-9, CN 1510-25 and TN 66, harvested from trials of different seasons was evaluated. The growing environment parameters, such as temperature and precipitation, differed according to planting seasons. The accumulated precipitation during 60 days before harvest varied from 72.5 to 878.0 mm among 13 trials. However, not all four varieties were planted in every trial. The samples were 11, 7, 10 and 9 for CN 1108-13, CN 1232-9, CN 1510-25 and TN 66, respectively. Regression analysis on accumulated rainfall and starch digestibility did not show a distinct relationship in all varieties tested. However, digestibility tended to be higher in two of the varieties in assoication with less accumulated precipitation.

The starch digestibility of sweet potatoes harvested under accumulated rainfall at different growth stages is summarized in Table 3. The data revealed that the critical time to rainfall damage may differ genotypically. These data also suggested that other factors may affect the digestibility of starches.

The nature of low digestibility of sweet potatoes is not clear. Analyses of starch isolated from different sweet potato cultivars suggested that it may be associated with phosphorous and amylase contents. More work on the properties of starch granules, as well as starch molecular structure, will be needed to better understand the phenomenon and to develop better screening techniques for evaluation.

Table 3. Relationship between accumulated rainfall and sweet potato starch digestibility.

Accumulated precipitation (mm)	Digestibility (CO_2 gas ml)			
	CN 1108-13	CN 1232-9	CN 1510-25	TN 66
60 days before harvest				
<100	11.4(1)[z]	7.5(2) a	–	5.6(2) a
200-400	7.9(5) b	1.9(3) b	2.5(5) a	5.8(5) a
>800	5.2(5) b	2.9(2) b	3.0(4) a	5.0(2) a
30 days before harvest				
<100	11.4(1) a	7.5(2) a	–	5.6(2) a
100-250	6.4(6) b	2.5(3) b	3.0(4) a	6.9(3) a
>250	6.8(4) ab	2.0(2) b	2.6(6) a	4.7(4) a
Between 30-60 days before harvest				
<100	9.8(4) a	5.2(3) a	2.2(3) b	5.6(6) a
100-250	8.6(3) a	2.1(2) a	3.0(3) a	4.2(2) a
>250	4.8(4) b	2.9(2) a	3.1(4) a	8.3(1) a

[z]Value in parenthesis indicates the number of samples for average.

Conclusions

The utilization of sweet potato other than as a survival crop can be maximized if it would be considered more than just for human consumption. One alternative use is for feed. Uncooked sweet potatoes with easily digestible starches are most ideal for feed use. A simple method to estimate CO_2 gas production based on fermentation sugars from enzymatic digestion was found to be acceptable for screening purposes. AVRDC improved lines CN 1108-13 and CN 1448-59 were identified to possess good starch quality for feed use through this fermentation method. Wet season sweet potatoes were found more resistant to pancreatic digestion. This property, however, varied among varieties. The critical time when rainfall affected the starch property varied according to varieties tested. The nature of starch property related to its digestibility was not clear and needs further investigation.

Application of Methionine for Mungbean Sprout Production

Summary

The application of DL-methionine for mungbean sprout production was studied. Methionine treatment was found effective in improving the quality and obtaining shorter root and bigger hypocotyl diameter of mungbean sprouts. Unlike physical pressure, methionine treatment also promotes the growth of mungbean sprouts which may shorten the growing period. Genotypical difference in responses to methionine treatment was observed. Thus, information on sprouting properties of mungbean varieties can be useful for processors. It is more practical to add methionine only in the soaking water. Since mungbean sprouts respond to methionine differently than to physical pressure, it is speculated that methionine may play biological functions other than serving as an ethylene precursor during the sprouting process.

Introduction

Mungbean sprouts are a traditional oriental vegetable and have recently become more popular in the Western world. As sprouting requires neither sunlight nor soil and is not limited by season, sprouts are reliable sources of vitamin C in the Chinese diet. Although sprout production involves a simple germination process, proper conditions are very important to obtain good quality sprouts.

A smooth seed coat with proper seed weight which gives a yield between 8-10 kg/kg seed is a major characteristic of mungbean seeds for sprout use. Rootless or short-rooted mungbean sprouts of 3-4 mm diameter which are white and crispy are generally preferred by consumers. It has been reported that ethylene shortens root length and increases the diameter of hypocotyl, thus improving the quality of mungbean sprouts. The application of physical pressure or ethylene-release chemicals, such as ethephon, 2,4-D and benzyladenine (BA) was found effective for this purpose. Some sprout processors have been using 2,4-D in commercial production. The residues of these chemicals in the sprouts have become a concern to consumers. A safe and easy use of a chemical which promotes ethylene production during sprouting is needed.

Methionine, an essential amino acid, is known to be the precursor of ethylene. This amino acid is generally low in legume seed, thus limiting the nutritional quality of legume protein. Mungbean has been reported to have a very low methionine content. Black gram, another legume seed commonly used for sprout production, contains 40% higher methionine than mungbean. Part of the methionine in black gram is in the form of r-glutamyl-methionine, which could be easily converted for metabolic functions. The supply of additional methionine could effectively promote ethylene release, thus improving the quality of mungbean sprouts.

Chemically synthesized feed grade methionine is available in the market. The cost of feed grade DL-methionine is only about US$4.25 per kg. It is economical to use this chemical for sprout production if found effective. Experimental results on the effects of methionine application for mungbean sprout production conducted in 1988 are summarized in this report.

Materials and Methods

Mungbean seeds of three varieties, VC 3890A, VC 1628 (TN Sel NO. 2) and V 2010, were used without sorting.

The sprouting process was carried out by a home-designed sprouting machine. After air-bubbling for 3-4 hr, the machine automatically supplies water every 4 hr to wash the sprouts. No temperature control device was installed on the system, thus temperature regulation depended entirely on the ambient temperature in the room. Pre-soaking was carried out for 6 hr under room temperature before placing the seeds in the sprouting machine. Weight ratio before and after soaking was used to express water absorption rates. A physical pressure treatment of 5.17 g/cm^2 was applied. The thickness of seed testae was measured under the microscope and the mean values of 10 samples were recorded. The seeds used for each treatment weighed 40 g and the mean values of 30 sprouts were used to express the hypocotyl length, diameter and root length.

The concentration of methionine in all treatments was 1000 ppm. The chemical used was provided by TAKEDA Ltd., Japan.

Results and Discussion

The effect of applying DL-methionine in soaking water was first studied. The traditional method of providing physical pressure was included in the experimental design. Since the temperature was not well controlled, the comparison was made based only on the data obtained from the same batch. Table 4 shows that bean sprouts produced under additional physical pressure were generally shorter but larger than that of the control, which is due to the release of more endogenous ethylene. Since the growth of the sprouts, as expressed by hypocotyl length was partially retarded by ethylene, the yield of 4-day-old etiolated bean sprouts was not significantly different from the check. The application of 1000 ppm DL-methionine in soaking water promoted the growth of sprouts in three varieties tested with and without physical pressure. However, the trend of methionine effect on hypocotyl diameter was not as pronounced as the effect of physical pressure. Statistical analysis indicated that only variety VC 1628 responded to methionine application on the plump of hypocotyl. This genotypical difference may be due to the amount of methionine absorbed during the soaking period. This explanation was indirectly supported by the higher water absorption rate and thinner seed coat of this particular variety (Table 5).

Table 4. Effect of methionine in soaking water on 4-day old etiolated mungbean sprouts.[z]

Variety	Treatments[y]					
	WO/P	W/P	WO/P	WO/PM	W/P	W/PM
	Hypocotyl length (cm)					
V 2010	6.1	5.9	4.7	5.5	5.0	5.9
VC 3890A	8.1	6.3[x]	6.7	7.1	6.0	6.5[x]
VC 1628	8.1	6.4	5.9	6.4	8.1	6.5[x]
	Hypocotyl diameter (mm)					
V 2010	3.2	3.3	3.4	3.2	3.4	3.3
VC 3890A	2.8	3.2	2.9	2.9	3.2	3.1[x]
VC 1628	3.0	3.3	2.9[x]	3.1	3.0	3.2
	Sprout yield (g/40 g seed)					
V 2010	329.2	320.8	292.4	303.2	298.4	317.6
VC 3890A	338.0	320.0	301.6	312.8	276.0	313.6
VC 1628	342.8	330.0	296.4	298.0	340.8	320.8

[z]Methionine concentration: 1000 ppm. [y]WO/P: Without physical pressure; W/P: With physical pressure; WO/PM: Without physical pressure and with methionine; W/PM: With physical pressure and methionine. [x]Significant by T test.

Table 5. Seed properties of three mungbean varieties.

Variety	1000 seed wt. (gr)	Water absorption rate (g water/g seed)	Thickness of seed testa (mm)
V 2010	54	1.2	95.7 ± 13.1
VC 3890A	60	1.2	94.4 ± 16.2
VC 1628	62.7	1.3	82.3 ± 16.4

It has been reported that the proper time for application of ethylene release agents for sprout production is 36 hr after germination. However, a longer lag period may be needed for methionine than ethephon for the release of ethylene. An experiment wherein methionine was added in both soaking and sprinkling water during the entire growth period was conducted to study the overall effects of methionine on sprout properties. The results observed are summarized in Table 6. The general trend of mungbean seed response to methionine treatment was similar to the results observed in past experiments, whereby methionine was only added in the soaking water. The degree of response of some varieties was enhanced in this experiment. For instance, a 39% increase in hypocotyl length of VC 1628 was observed. Methionine treatment significantly improved the sprout quality of VC 1628 and VC 3890A, in hypocotyl length, diameter and root length. However, it significantly failed to improve V 2010. This suggests that even methionine application in the sprinkling water was unable to make V 2010 respond to methionine treatment. The effects of methionine treatments on hypocotyl diameter was not as pronounced as that of physical pressure, which could be due to the compensatory effect between plumpness and growth of the sprout. The best quality sprouts were produced when both methionine and physical pressure were applied. Mungbean sprouts produced under this condition had the shortest roots and highest hypocotyl diameter. However, 4-day old sprouts were found shorter than that of methionine treatment without physical pressure. Since the application of methionine in sprinkling water needs additional work or device, the application of methionine only in soaking water is recommended for commercial production.

Conclusions

In addition to shortening the roots and increasing the hypocotyl diameter, methionine treatment was found effective to promote the growth of mungbean sprouts. This low cost and very safe-to-use essential amino acid has the potential to replace physical pressure or ethylene release agents for commercial production of quality mungbean sprouts. Varietal differences in responding to methionine treatment were observed. Information on sprouting properties of mungbean varieties could be useful for processors. The addition of methionine only in the soaking water is recommended for methionine sensitive varieties such as VC 1628. Since mungbean sprouts responded to methionine treatment

differently than physical pressure, it is assumed that methionine may play other biological functions apart from serving as an ethylene precursor during sprouting stage.

Table 6. Effect of methionine[z] on 4-day old etiolated mungbean sprouts.

Variety	Treatments				
	Control	W/P[y]	W/M[x]	W/PM[w]	Mean
			Hypocotyl length (cm)		
V 2010	3.8 ef	3.4 f	4.0 e	3.8 ef	3.7
VC 3890A	5.1 c	4.0 e	6.1 b	4.6 d	5.0
VC 1628	4.8 cd	4.0 e	6.7 a	4.5 d	5.0
Mean	4.6	2.8	5.6	4.3	
			Hypocotyl diameter (mm)		
V 2010	3.3 ed	3.5 abc	3.5 abc	3.6 a	3.5
VC 3890A	2.8 h	3.2 efg	3.1 fg	3.4 cd	3.1
VC 1628	3.0 g	3.5 bcd	3.2 ef	3.6 ab	3.3
Mean	3.1	3.4	3.3	3.6	
			Root length (cm)		
V 2010	1.9 b	1.4 c	1.7 bc	1.0 d	1.5
VC 3890A	2.4 a	1.8 b	1.4 c	0.7 de	1.5
VC 1628	2.4 a	1.7 bc	1.4 c	0.6 e	1.5
Mean	2.2	1.6	1.5	0.8	
			Sprout yield (g/40 g seed)		
V 2010	258.5	240.7	258.1	242.0	
VC 3890A	253.6	256.2	292.9	262.3	
VC 1628	249.6	255.6	287.8	251.7	

[z]Methionine concentration in soaking and sprinkling water: 1000 ppm. [y]With physical pressure; [x]with methionine; [w]With physical pressure and methionine.

Application of Near Infrared Reflectance Spectroscopy on Composition Analysis of Vegetable Soybean

Summary

Near Infrared Reflectance Spectroscopy (NIRS) was used to estimate the major constituents of vegetable soybean. This technique was found useful in determining moisture, protein and oil contents but not accurate enough for starch and sugar content. A modification of determination procedures indicated that NIRS could be used as a primary screening technique to select samples. The selected samples, however, need to be analyzed by conventional method for confirmation.

Introduction

Near Infrared Reflectance Spectroscopy (NIRS) has been successfully used as a routine method for compositional analysis of soybean, mungbean and sweet potato at the Chemistry laboratory. The method proved to be a reliable, low-cost and rapid analytical tool for screening purposes. This technique was thus applied for the analysis of large amounts of other commodities within a relatively short time.

Recently, vegetable soybean generated more interest from consumers due to its nutritional content as well as its export potential. This study aimed to evaluate the reliability of NIRS in predicting the composition of vegetable soybean seeds to replace or supplement the presently adopted analytical laboratory procedures.

Materials and Methods

Vegetable soybean seeds were dried under 45°C for 72 hr. The dehydrated seeds were ground with a rotor-speed mill into powder with a 200 mesh screen. The methods used for chemical analysis are the routine procedures used in the Chemistry laboratory.

Results and Discussion

Following the common procedures of NIRS filter selection method, one set of vegetable soybean samples each was prepared for calibration and prediction tests. Calibration test indicated that no acceptable filter combination was found for any constituent when filters were less than four. The results of the best selected filter combinations for various constituents are presented in Table 7. The correlation coefficients (R) observed for calibration varied from 0.9169 of sugar to 0.9681 of oil. The R values for moisture, protein and oil were found lower than values of grain soybean (0.97-0.99). The low correlation coefficient of sugar and starch may be due to the complex constituent of soluble sugar in vegetable soybean seeds. The accuracy of the NIRS method can be expressed by the standard error of prediction (SEP). Except for moisture, the SEP observed is higher than that of other commodities. The extremely high SEP of sugar suggested that NIRS is not applicable to sugar analysis of vegetable soybean. Since sugar is an important constituent for the quality evaluation of vegetable soybean, a modification of the analytical method either on wet chemistry or NIRS procedure is needed.

Table 7. Characteristics of selected calibration curves for vegetable soybean.

Component	Best of filters	R of cal. curve	Content range of calibration	Sample size		SEP of cal. test		No. of sample for cal. test	
				By sample	By record	By sample	By record	By sample	By record
Moisture	15, 16, 18, 19	0.9337	7.25-5.33	54	70	0.3293	0.3258	32	54
Protein	6, 11, 14, 15, 16	0.9433	44.31-33.11	62	98	1.9537	1.9452	29	50
Oil	4, 5, 12, 18, 20	0.9681	21.77-13.53	64	106	0.7784	0.7762	34	61
Sugar	4, 11, 12, 14, 17	0.9169	7.78-2.88	91	155	8.4485	8.4253	34	44
Starch	2, 5, 9, 11, 15, 18	0.8775	12.89-4.58	73	116	1.9617	1.9468	32	47
Carbohydrate	6, 9, 15, 18, 19	0.8841	19.47-9.12	76	100	1.3943	1.4197	33	43

The calibration test for total available carbohydrates, starch and sugar was tried. With different filters selected, an R value of 0.8841 carbohydrate in prediction test was observed. The SEP for total available carbohydrates observed was 1.3943. It is still too high for an accurate prediction but much lower than that of sugar. This condition was considered acceptable as a primary screening method.

The sugar content can then be estimated by the difference between the total available carbohydrates and starch content determined by the NIRS. The correlation coefficient between the sugar content of 35 samples predicted by this method and that analyzed by conventional method was found to be 0.9372 with a SEP of 0.4128. The higher R value and lower SEP indicated that this modified method is better than the direct prediction of sugar content by the NIRS. Since the starch and sugar contents determined by a modified NIRS method are still not very accurate, NIRS can only serve as a primary screening technique to select lines of interest. The selected samples, however, still need to be analyzed through the conventional method.

Crop Management

Effects of Climatic Factors on Sweet Potato Yield

Summary

A field experiment was conducted to evaluate the importance of temperature, solar radiation and precipitation on root yield and yield components of sweet potato, and to identify the optimum planting dates for Tainung 66, CN 1108-13 and CN 1345-8 sweet potato varieties. Planting was year-round, except in June and July, beginning on 15 January and at 10-day intervals thereafter. Results showed that temperature had significant effect on root size, number of roots/plant and survival rate. Solar radiation had a positive relationship with root size only. Precipitation showed a significant effect on root size and number of roots/plant. Multiple nonlinear regression analysis indicated that 81% of the total variation in yield was explained by variation in three climatic factors. In general, the optimum planting for the crop was between 16 and 26 March. This period subjected the plants to cool weather (in March and early April) during root formation, and to warm weather (in late April and May) during root enlargement. This climatic condition enhanced root formation and stimulated root enlargement.

Introduction

The storage-root yield of sweet potato can be significantly affected by seasonal variation in climate. Vigorous vine growth during the hot-wet season frequently gives low yields. On the other hand, growing of the crop in the cool season usually results in high yield. The best planting season in Trinidad was during September to March, when the early growing period was wet followed by dry and sunny weather before harvest. In Papua New Guinea, high root yield was obtained from plantings in May to July. In Queensland, the highest root yield occurred in May and lowest in March.

The study aimed to evaluate the importance of three climatic factors: air temperature, solar radiation and precipitation on root yield and yield components of sweet potato. It also attempted to identify optimum planting dates for the different sweet potato varieties when grown under tropical conditions in Taiwan.

Materials and Methods

A field experiment was conducted at 120°17'E longitude and 23°7'N latitude. The treatments were arranged in a randomized complete block design and replicated three times. The main plots included Tainung 66, a small and semierect plant with large leaf; CN 1108-13, a medium and prostrate plant with small leaf; and CN 1345-8, a medium, semierect plant type with medium leaf. Subplot treatments were year-round plantings (Table 1), except in June and July, beginning on 15 January 1987 and at 10-day intervals thereafter. Individual plots were 3 × 3 m and consisted of three ridges spaced 1 m apart. Each ridge was planted to one row of 0.3-m long sweet potato tip cuttings, spaced at 0.3 m within rows. Fertilizer was broadcast at the rate of 45 kg N/ha, 26 kg P/ha and the soil was plowed before the ridges were formed. An additional sidedressing of 45 kg N and 75 kg K/ha was applied 30 days after planting (DAP). Furrow irrigation was administered twice, at planting and at 21 DAP, when the soil was dry. The crop was harvested 130 DAP.

Air temperature, solar radiation and precipitation during the experiment are presented in Figure 1. The effects of these climatic factors and their influence on relationships with root yield and its components, during different periods of plant growth were evaluated using simple linear, nonlinear, and multiple nonlinear regression analyses. The following weather measurements were recorded:

a) Mean daily temperature (1 to 60 DAP)*
This covered the root formation of the crop.

b) Mean daily temperature (1 to 5 DAP)* i.e. average of daily maximum and minimum temperatures.

c) Total solar radiation (61 to 120 DAP)
This covered the root enlargement period of the crop.

d) Total precipitation (1 to 60 DAP). This covered the root enlargement period of the crop.

Results and Discussion

Effect of planting date on yield. The effects of planting date on marketable yield, yield components and plant survival are presented in Table 1. Yield was significantly affected by date of

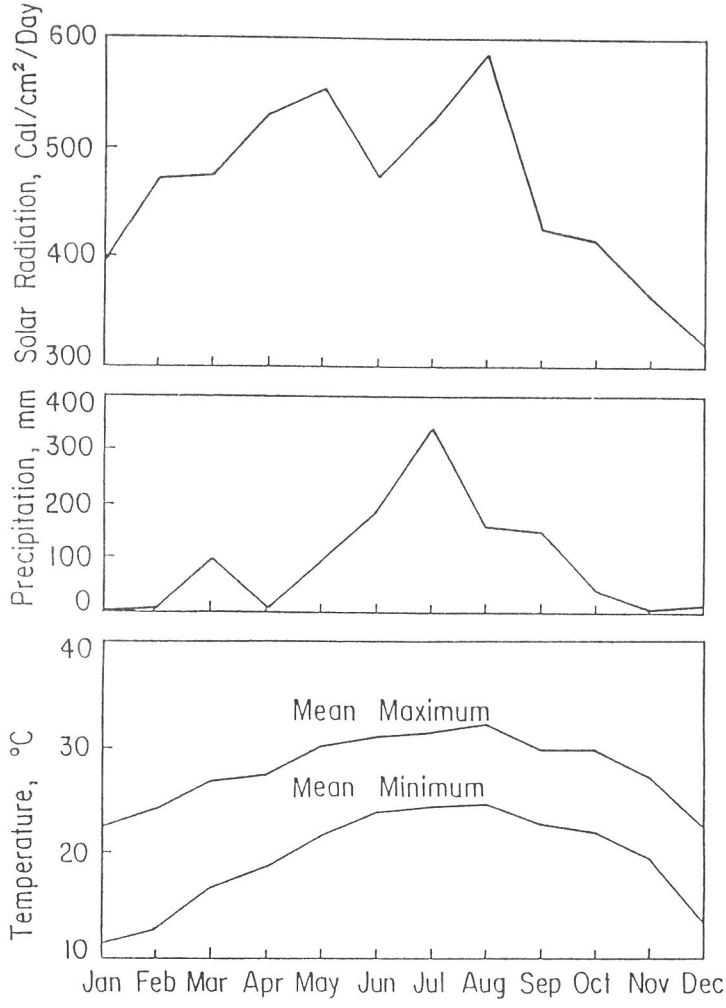

Fig. 1.
Mean daily air temperature, precipitation and solar radiation during the experiment in 1987.

planting. Planting sweet potato in October and November resulted in high number of roots/plant, no reduction in plant survival rate, but lower yield due to small roots. When the crop was planted in January and early February, the number of roots/plant was high and root size was medium, but survival rate was very low which also resulted in low yield. The survival rate was not affected when the crop was planted in April, May, August and September, but roots were very small and few per plant, resulting in low yield. In terms of yield, the best planting dates were in the later part of February and during March. Plants grown during these periods had higher number of large roots and high survival rate.

Table 1. Yield attributes and survival rate of sweet potato when planted at different times of the year.[z]

Planting date	Yield (t/ha)	Root size (g)	Root number (no./plant)	Survival rate (%)
15 January	8.7	190.1	3.0	64.4
25 January	9.2	231.6	3.8	42.2
4 February	14.4	231.7	4.1	58.9
14 February	32.2	252.2	4.2	91.1
24 February	26.7	300.6	3.7	81.1
6 March	29.9	329.4	3.6	78.9
16 March	31.7	279.9	3.8	93.3
26 March	31.2	331.0	3.1	96.7
5 April	13.5	240.4	1.8	97.8
15 April	13.4	191.4	2.2	94.4
25 April	6.7	162.9	1.0	94.4
5 May	2.4	169.6	0.4	96.7
15 May	1.3	74.2	0.2	92.2
25 May	1.7	89.4	0.4	97.8
7 August	2.6	93.7	0.8	93.3
17 August	5.2	139.7	1.2	88.9
27 August	4.4	171.5	0.8	73.3
6 September	5.2	149.7	1.1	87.8
16 September	10.4	135.6	2.7	84.4
26 September	10.4	139.6	2.3	94.4
6 October	14.7	123.8	3.6	98.9
16 October	15.5	144.3	4.2	81.1
26 October	16.5	118.0	4.3	98.9
5 November	12.0	103.0	4.0	88.9
15 November	10.7	89.8	3.7	96.7
25 November	7.1	75.9	3.0	94.4
L.S.D. (0.05)	4.4	57.5	0.7	12.1
L.S.D. (0.01)	5.8	75.6	1.0	15.9

[z]Means of three varieties.

Relationship between climatic factors and yield components. Correlation analysis showed that relationships between climatic factors and yield components and survival rate were either quadratic or linear (Table 2). Temperature had a significant relationship to root size, root number per plant and survival rate, whereas solar radiation had a significant relationship to root size only. Precipitation was correlated with root size and root number per plant.

Table 2. Significance of temperature, solar radiation and precipitation in relation to root size, root number and plant survival rate.

Climatic[z] factor	Root size				Root number				Survival rate[z]			
	Linear		Quadratic		Linear		Quadratic		Linear		Quadratic	
	r^2	F	R^2	F	r^2	F	R^2	F	r^2	F	R^2	F
Temperature	0.0	ns	0.4	**	0.7	**	0.9	**	0.4	**	–	–
Solar radiation	0.4	**	–	–	0.0	ns	0.0	ns	0.0	ns	0.1	ns
Precipitation	0.0	ns	0.6	**	0.2	*	0.5	**	0.1	ns	0.1	ns

[z]Temperature = Mean daily temperature (1 to 60 DAP), except for survival rate, which used mean daily temperature of the first 5 DAP. Solar radiation = Total solar radiation (61 to 120 DAP). Precipitation = Total precipitation (61 to 120 DAP)

Effect of mean daily air temperature (1 to 60 DAP) on root size. Root size was significantly reduced when air temperature was either too high or too low (Fig. 2). Low temperature reduced photosynthesis in the leaves resulting in less photosynthate translocated to the roots. High temperature favored leaf expansion and tip growth but resulted in less photosynthate translocated to the roots. These may be the reasons why sweet potato had small roots when air temperature was either too high or too low. The roots grew larger at a temperature of 22.9°C.

Relationship between root size and total precipitation (61 to 120 DAP). Figure 3 showed the significant quadratic relationship between these two factors. When precipitation was low, the root was small, implying that soil was dry during the later growth stage of the crop. Irrigation at 21 DAP was inadequate to sustain root growth, especially during the dry season. The same relationship was shown earlier by Gollifer. In Papua New Guinea, it was found that the root was largest when total precipitation was about 300 mm during the entire growing period, and decreased linearly with increasing precipitation. This may be due to rotting of large roots caused by high precipitation or an increase in the vegetative growth of the crop at the expense of root enlargement.

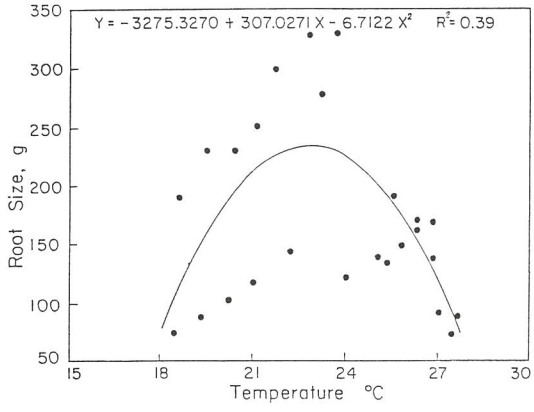

Fig. 2. The relationship between mean daily temperature (1-60 DAP) and root size.

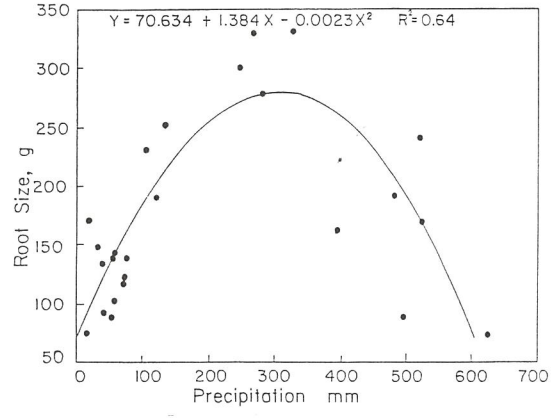

Fig. 3. The relationship between total precipitation (61-120 DAP) and root size.

Relationship between root size and total solar radiation (61 to 120 DAP). The relationship between these two factors was complicated, although high solar radiation increased root size (Fig. 4). Between 30 to 35 kCal/cm^2, root size varied from 70 to 330 g. Effects of temperature and precipitation may explain this response. When sweet potato was planted in March (treatment no. 6-8), roots enlarged between May and June (61 to 120 DAP) when precipitation was neither too high nor too low and the temperature was warm (Fig. 1). When planting was in late April and May (treatment no. 11-14), 61 to 120 DAP, when precipitation and temperature were high (Fig. 1), plants yielded small roots. At late planting (treatment no. 15-26), the period for root enlargement was characterized by low solar radiation, low precipitation and low temperature resulting in small roots. In general, the response of root size to solar radiation would have been a positive linear relationship had it not been complicated by temperature and precipitation.

Relationship between number of roots per plant and mean daily air temperature of the first 60 DAP. At temperature ranges from 18.5°C to 27.7°C, the number of roots per plant correlated quadratically well (R^2 = 0.93) with air temperature (Fig. 5). The highest number of roots per plant (4.0) was observed when the mean daily air temperature was 21.2°C. High temperature significantly reduced the number of roots per plant. Number of roots per plant was less than 1.0 when the temperature was higher than 26.7°C. This finding confirms those of Sakr's who obtained less storage roots per plant from plants previously exposed to high temperature. The number of roots per plant was about 3.2 under the lowest temperature of 18.5°C.

Relationship between plant survival rate and mean daily air temperature (1 to 5 DAP). A significant number of plants died when air temperature was low. Percentage of plant survival increased with an increase in air temperature. The survival rate was highest when temperature was greater than 21°C (Fig. 6).

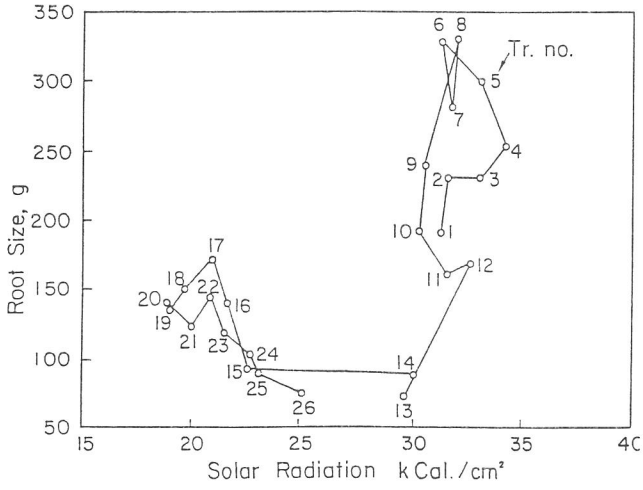

Fig. 4. The relationship between total solar radiation (61-120 DAP) and root size.

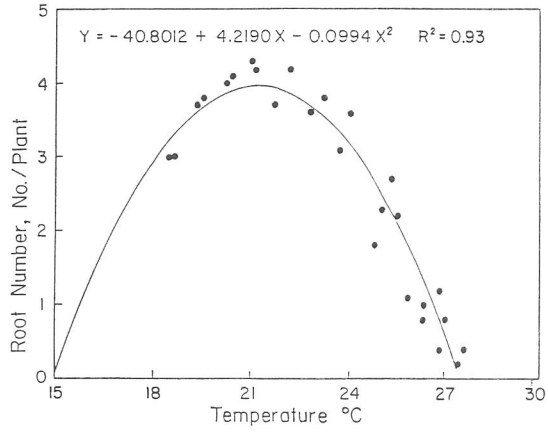

Fig. 5. The relationship between mean daily temperature (1-60 DAP) and root number.

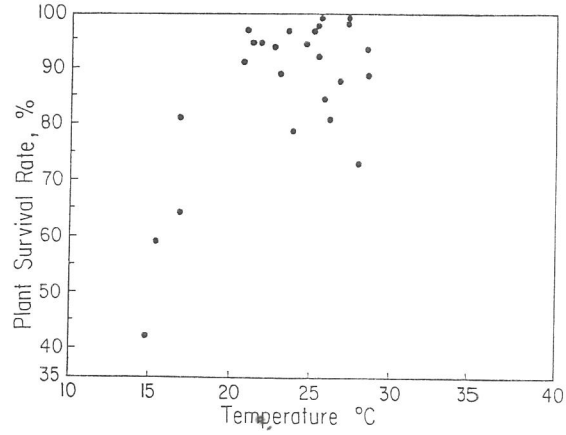

Fig. 6. The relationship between mean daily temperature (1-5 DAP) and plant survival.

Yield vs planting dates and climatic factors. Analysis of variance indicated a highly significant interaction between cultivar and planting dates. Table 3 shows the effect of planting dates on yield of three varieties. Tainung 66 gave the highest yield of 42.3 t/ha (planted 14 February), whereas CN 1108-13 and CN 1345-8 yielded 33.8 and 30.9 t/ha, respectively. The higher yield of Tainung 66 planted on 14 February was due to higher air temperature during the first five days after planting. In general, the best planting date would be between 16 and 26 March. Planting during this period subjected the sweet potato plants to cool weather which enhances root formation and warm weather which stimulates root enlargement.

To predict crop yield grown under different climatic conditions, an attempt was made to establish the relationship between yield and three climatic factors using multiple nonlinear regression analysis.

Results showed that yield response of sweet potato to temperature, solar radiation and precipitation can be adequately described at 1% significance level by the quadratic equation:

$$y = -382.8917 + 33.3339X_1 - 0.7330X_1^2 + 1.0177X_2 - (9.4998 \times 10^{-4})X_2^2 - 0.0130X_3 - (0.0413 \times 10^{-7})X_3^2$$

where:

X_1 = mean daily temperature (1 to 60 DAP), °C

X_2 = total solar radiation (61 to 120 DAP), kCal/cm^2

X_3 = total precipitation (61 to 120 DAP), mm

$R^2 = 0.81$

$F = 13.41^{**}$

Since the R^2 value was 0.81, it is indicated that 81% of the total variation in yield could be explained by variation among these three climatic factors. The R^2 value could be higher if interaction between the different climatic factors was introduced into the regression equation. The interaction was ignored because of the complexity of calculation. The regression equation also showed that temperature played a more important role than solar radiation and precipitation in reducing sweet potato yield.

Table 3. Effect of planting dates on marketable yield of three sweet potato varieties.

Planting date	Yield (t/ha)		
	Tainung 66	CN 1108-13	CN 1345-8
15 January	9.5	12.3	4.3
25 January	11.3	13.3	3.0
4 February	18.2	12.5	12.5
14 February	42.3	30.5	23.8
24 February	20.2	31.1	28.7
6 March	27.4	33.0	29.2
16 March	30.3	33.8	30.9
26 March	31.0	31.9	30.6
5 April	14.8	13.2	12.4
15 April	9.9	13.8	16.4
25 April	1.1	4.6	14.4
5 May	0.4	3.6	3.2
15 May	0.0	1.1	2.8
25 May	0.0	2.9	2.2
7 August	2.1	2.8	3.0
17 August	2.6	4.7	8.2
27 August	5.8	2.5	6.7
6 September	3.6	3.1	8.9
16 September	7.5	7.6	16.0
26 September	5.4	13.2	12.6
6 October	10.3	18.2	15.6
16 October	15.2	14.0	17.3
26 October	15.1	19.4	15.0
5 November	16.5	11.8	7.6
15 November	10.4	16.0	5.7
25 November	8.2	9.5	3.5
L.S.D. (0.05)	4.65	4.65	4.65
L.S.D. (0.01)	6.14	6.14	6.14

Spacing for Sweet Potato

Introduction

Many improved sweet potato varieties have been bred lately and released by various research institutes, including AVRDC. Due to growth differences, the standard planting space of 0.3 m intra-row and 1.0 m inter-row may not be suitable for these improved varieties. A program initiated late last year aimed to identify the optimum spacing for improved varieties grown in different seasons.

Materials and Methods

A field experiment was conducted in fall (30 October 1987-27 February 1988), spring (11 March-9 July 1988), and summer (15 June-13 October 1988). The experiment used a split-split-plot design, replicated three times. The main plots included TN 66, a small and semi-erect plant with large leaf, and CN 1108-13, a medium and prostrate plant type with small leaf. The subplot treatments were two inter-row spacings (0.75 and 1.0 m); the sub-subplot treatments, four intra-row spacings (20, 25, 30 and 35 cm). Individual plots were 3-m long and consisted of three ridges, spaced 0.75 or 1.0 m apart. Each ridge was planted to one row of 0.3-m long sweet potato tip cuttings. Fertilizer was broadcasted at the rate of 45 kg N, 60 kg P_2O_5 and 90 kg K_2O/ha, and the soil was plowed before the ridges were formed. An additional 45 kg N and 90 kg K_2O/ha were sidedressed at 30 DAP. Furrow irrigation was administered when necessary. The crop was harvested at 120 DAP.

Results and Discussion

Top weight, marketable root yield and yield components are presented in Table 4 . Plants grew bigger at wider spacing. The same trend was observed in both inter- and intra-row spacings. Under the inter-row spacing, yield (15.7 t/ha) obtained from 75 cm spacing was significantly higher than from 100 cm spacing (13.4 t/ha), but the number of roots per plant and root size between the two treatments did not differ. Difference in yield was due to difference in plant stand. Root size and yield were not affected by intra-row spacing. On the other hand, number of roots per plant significantly increased as intra-row spacing increased.

Although the average yield of the two varieties was not significantly affected by intra-row spacing, analysis of variance on yield and number of roots per plant indicated strong interaction between varieties and spacing (Table 5). Apparently, yield and number of roots per plant of TN 66 were not affected by the intra-row spacing, whereas those of CN 1108-13 changed positively with spacing. The optimum spacing for CN 1108-13 was 30 cm. High yield of this treatment was due to high number of roots per plant. Planting TN 66 at 20 cm apart tended to give the highest yield.

Table 4. Top weight, marketable yield and yield components of sweet potato grown in three seasons at different spacings.[z]

Spacing	Plant stand (no./ha)	Top wt. (g/plant)	Yield (t/ha)	Root no. (no./plant)	Root size (g)
Inter-row (cm)					
100	37976	410 a	13.4 b	3.3 a	111.4 a
75	50633	318 b	15.7 a	3.1 a	103.2 a
Intra-row (cm)					
20	58332	293 b	14.4 a	2.4 b	104.3 a
25	46666	330 b	14.7 a	2.9 b	110.7 a
30	38888	355 b	15.5 a	3.9 a	103.8 a
35	33333	479 a	13.5 a	3.6 a	110.4 a

[z]Means within a column followed by the same letter are not significantly different at 5% level by DMRT.

Table 5. Marketable root yield and root number of two varieties grown at different intra-row spacings.[z]

Intra-row (cm)	Yield (t/ha)		Root number (no./plant)	
	TN 66	CN 1108-13	TN 66	CN 1108-13
20	16.1 a	12.7 b	2.7 a	2.1 b
25	15.4 a	14.1 b	3.2 a	2.6 b
30	11.5 a	19.5 a	2.8 a	4.9 a
35	11.4 a	15.5 ab	3.1 a	4.1 a

[z]Means within a column followed by the same letter are not significantly different at 5% level by DMRT.

Conclusion

Wider inter-row spacing had a positive relationship with top growth per plant, and a negative relationship with root yield, but did not affect root size and number of roots per plant. Higher root yield from narrow spacing was due to higher number of plants.

Intra-row spacing had a positive relationship with top growth, but had no effect on root size. Yield of two varieties and number of roots per plant responded differently to intra-row spacing. Yield of TN 66 and number of roots per plant were not significantly affected by spacing, whereas those of CN 1108-13 were strongly influenced. Highest yield of TN 66 was obtained at a spacing of 20 cm, whereas that of CN 1108-13 was at 30 cm. High yield of TN 66 was due to higher number of plants, whereas that of CN 1108-13 was due to high number of roots per plant.

Solarization Against Soft Rot in Chinese Cabbage

Summary

Bacterial soft rot caused by *Erwinia carotovora* is one of the most destructive diseases in Chinese cabbage (*Brassica pekinensis*) in the hot and humid season. At present there is no reliable chemical control for the disease and not a single variety of the crop is resistant to it. When beds of Fong-Luh variety were covered and solarized by clear plastic sheets for 4 to 14 days, soft rot incidence was suppressed at an early stage.

Introduction

Soft rot is one of the most destructive soil-borne diseases in Chinese cabbage. Chemical control, use of disease-tolerant cultivars and other cultural practices had been carried out to control the disease. This study aimed to evaluate the effect of solarization on soft rot and on the growth and yield of Chinese cabbage.

Materials and Methods

The experiment was carried out using a split-plot design with four replications. After the field was rototilled, 1.5 m × 6.0 m beds were formed. Individual plots consisted of three beds planted with Chinese cabbage; one skip-bed served as a border blank between plots. The replications were separated by a 1.5 m pathway. The treatments included 4, 6, 8, 10, 12 and 14 days' soil solarization and the check. Solarization was done by covering the beds with a clear 0.05-mm thick plastic sheet. All plastic sheets from solarization treatments were removed one day before transplanting. On 2-3 August 1988, 25-day old seedlings of soft rot-susceptible cultivar, Fong-Luh, and soft rot medium-resistant cultivar, Hybrid 62, were transplanted to beds with 50-cm spacing both between and within rows. Heavy rains of 418 mm occurred on 13 August (10 days after transplanting). To avoid any contamination, rain water was drained from one side of each plot and the other side was blocked. Total precipitation during the growing season was 691 mm and 718 mm, respectively, for Hybrid 62 and Fong-Luh. Hybrid 62 was harvested on 7 and 13 September while Fong-Luh was harvested 20 September. All clean heads were counted as marketable yield, and those infected by soft rot were regarded nonmarketable.

Results and Discussion

Solarization drastically increased soil temperature at a depth of 10 cm (Table 6). Temperature in the clear plastic mulch treatments was 49.4°C on a clear day and 36.2°C on a cloudy day. The check had 37.4°C on a clear day and 30.2°C on cloudy day.

During early-growing stage before head formation, all solarization treatments differed significantly from the check in plant fresh weight and mortality rate (Table 7). Due to heavy rains, contamination

inevitably occurred and mortality rate caused by soft rot, poor drainage and other factors increased drastically after the heading stage of Fong-Luh. The incidence from solarization tended to be the same as that for the check. There was no significant difference in mortality rate, yield and colony-formed unit at harvest (Table 8). There was a significant difference in plant mortality between Hybrid 62 and Fong-Luh at harvest.

All solarization treatments suppressed the disease in the field. For early-maturing varieties, if used in this kind of trial, contamination during the later stage may be avoided and benefits from solarization may result. Duration of solarization for different crops needs to be studied further.

Table 6. Effect of solarization on soil temperature at 10 cm depth.

Treatment	Soil temperature at 2 PM (°C)	
	Clear day	Cloudy day
Check	37.4	30.2
Solarization	49.4	36.2

Table 7. Plant fresh weight, and mortality of Chinese cabbage as affected by solarization period.[z]

Treatment (days solarized)	Plant fresh weight (g/plant)		% of dead plants at 19 DAT[x] (3 beds, 72 plants)
	3 WAT	4 WAT[y]	
Check	99 b	362 c	20.5 a
4	177 a	613 b	3.7 b
6	166 a	655 ab	1.9 b
8	236 a	791 a	1.9 b
10	204 a	778 a	2.1 b
12	233 a	684 ab	4.7 b
14	210 a	713 ab	2.4 b
Variety			
1	185 a	600 a	1.1 a
2	193 a	713 a	9.5 a

[z]Means within a column followed by the same letter are not significantly different at 5% level by DMRT. [y]WAT = Weeks after transplanting. [x]DAT = Days after transplanting.

Table 8. Plant mortality, cell units formed and yield of Chinese cabbage as affected by solarization period.[z]

Treatment (days solarized)	% plants died harvested bed at 19 DAT[y]	% plants died on harvested bed at harvest	Total plant fresh weight (t/ha)	Marketable yield (t/ha)	Colony-formed unit at harvest (1 g soil)	CFU[x] rating
Check	22.9 a	30.2 a	17.3 b	5.7 b	5.51×10^4	100
4	5.2 b	26.6 a	20.9 ab	7.5 ab	4.49×10^4	81
6	0.5 b	26.6 a	22.6 ab	8.4 ab	1.93×10^4	35
8	3.1 b	25.0 a	23.7 a	9.8 a	3.64×10^4	66
10	2.6 b	24.5 a	23.9 a	8.4 ab	1.55×10^4	28
12	3.1 b	23.4 a	23.7 a	8.1 ab	3.82×10^4	69
14	1.6 b	20.9 a	24.0 a	7.8 ab	3.41×10^4	62
Variety						
1	0.75 a	2.1 b	26.5 a	13.0 a		
2	10.42 a	48.5 a	18.0 a	3.0 b		

[z]Means within a column followed by the same letter are not significantly different at 5% level by DMRT. [y]DAT = Days after transplanting. [x]CFU = Colony-formed unit.

Effects of Mulching and Shading Materials on Sweet Pepper

Summary

The study aimed to evaluate the effect of shading on the development, yield and fruit quality of sweet pepper grown under summer conditions in the southern part of Taiwan, and the effect of mulching during dry and wet seasons. Black and silver-coated polyethylene sheets and rice straw were used as mulching materials for sweet pepper (*Capsicum annuum* L.) in winter and summer trials.

Introduction

Sweet pepper, *Capsicum annuum* L., is planted year-round in Taiwan. Sweet pepper yield is very low in both summer and winter. The limiting factors for the summer crop are high temperature and radiation, heavy rainfall, weed infestation and insect damage; whereas winter crops are affected by low temperature, broadleaf weed infestation, virus and insect damage. One way to solve these problems is through mulching and shading. This study was conducted to investigate the effects of mulching during dry and wet seasons, and shading during the hot-wet season, on the growth and yield of sweet pepper.

Materials and Methods

Experiments were carried out using a randomized complete block design replicated four and five times for winter and summer trials, respectively. After the field was rototilled, 1.5 m × 6.0 m beds were constructed: two beds per plot for the winter trial and one bed for summer. Before transplanting, the beds were mulched with 0.05-mm thick PE sheet (silver-coated face outside) and 5 t/ha rice straw, for the winter and summer trials, respectively. Blue Star cultivar was used in both trials. Watering was done when the field was dry. Soil temperature at 10 cm depth was monitored at 8:00 am and 2:00 pm for the winter trial, and at 2:00 pm for summer. Soil moisture was maintained and observed before each irrigation for the winter crop, while the summer crop was monitored every one and three days after irrigation. Data on weed infestation were taken 37 days after transplanting for the winter crop. Fruits were harvested five and three times for winter and summer crops, respectively.

The shading experiment was carried out in a randomized complete block design replicated three times. Each plot consisted of one bed measuring 1.5 × 6.0 m. The net or sheet was installed 13 days after transplanting. Plant height, fresh plant weight and number of stems were recorded. The fruits were picked, counted and weighed. Marketable and non-marketable fruits were recorded.

Results and Discussion

Soil temperature and moisture (before irrigation) of the mulch trial in winter is presented in Table 9 . Plots that were mulched maintained a higher soil temperature at night, higher soil moisture before irrigation, and less weed infestation compared to the check. Both rice straw and PE sheet mulching significantly produced more marketable, total fruit yield and fruit size than the check (Table 11).

In summer, soil temperature at 2:00 pm of the check and PE mulched plots rose to 34.5° and 37.0°C, respectively (Table 10). The high soil temperature must have retarded root growth and impaired water and nutrient uptake and photosynthesis which consequently resulted in stunted plant growth and mortality (especially for PE mulch treatment). Thus, soil temperature value of 37.0°C was considered supra-optimal for pepper. Mulching with rice straw significantly enhanced vegetative growth and fruit yield of pepper by retarding soil moisture depletion and keeping the soil temperature in the afternoon below supra-optimal levels. Mulching with rice straw produced significantly more marketable yield, total fruit yield and marketable fruit size than the check and PE sheet mulch (Table 12).

The result of mulching sweet pepper plants with rice straw and PE during winter and summer seasons is shown in Figure 7.

All shading materials gave lower air temperature (0.4 to 1.1°C) at 2:00 pm compared to the check, whereas light penetration was reduced from 26.1% to 59.7% (Table 13). Plants shaded with Murakis

plastic sheet (UV light filter) and green nylon net produced significantly higher marketable and total fruit yield compared to the check. All shading treatments had significantly greater pod size and larger fruits. Total fruit yield and total fruit size was a correlation coefficient of +0.5481*.

Table 9. Soil temperature and moisture of sweet pepper mulched during winter, 1987-1988.

	Soil temperature at 10 cm (°C)				Soil moisture before irrigation (%)
	8:00 am	Max. temp. difference with check	2:00 pm	Max. temp. difference with check	
Check	16.8		26.0		15.59
Rice straw mulch	17.5 (+0.7)	+2.3°C	22.3 (-3.6)	-6.1	17.40
PE sheet mulch	17.9 (+1.1)	+2.6°C	23.6 (-2.3)	-6.8	18.08

Table 10. Soil temperature and soil moisture of sweet pepper mulched during summer, 1988.

	Soil temperature at 10 cm (cm) at 2:00 pm	Soil moisture (%) days after irrigation		
		1	4	7
Check	34.5°C	24.75	20.42	18.34
Rice straw mulch	30.9°C	26.29	24.49	21.49
PE sheet mulch	37.0°C	26.25	23.81	22.45

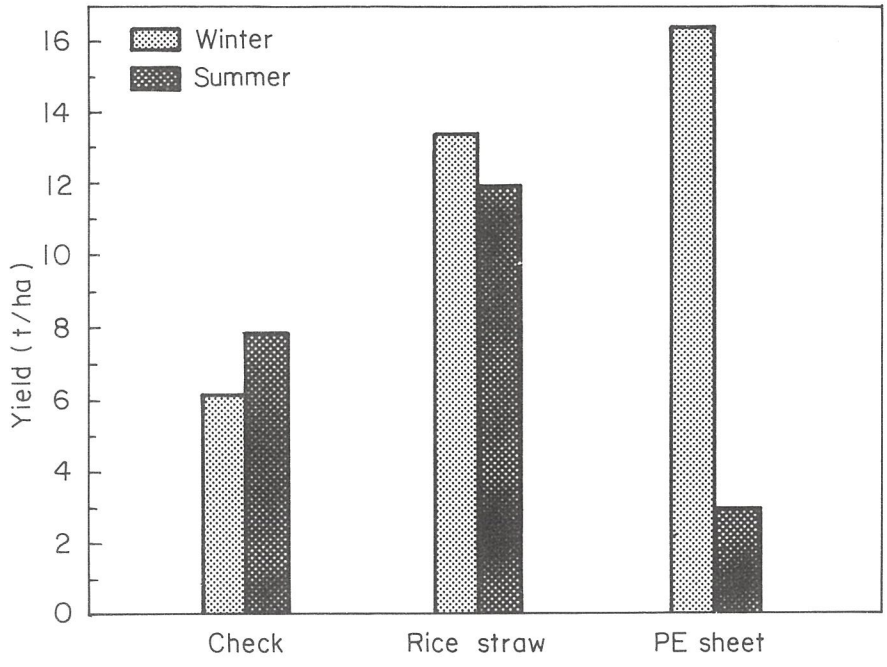

Fig. 7. The relationship between total fruit yield and the various mulching materials.

Table 11. Sweet pepper development and yield as affected by various mulching materials in winter, 1987-1988.[z]

Mulching material	Plant height at 49 DAT (cm)[y]	Weed weight at 37 DAT (t/ha)	Plant fresh weight at harvest (g/plant)	Dry root weight at harvest (g/plant)	Marketable fruit yield (t/ha)	Marketable fruit no. (no/m^2)	Pod size (Mkt + Non-Mkt) (g/pod)	Total fruit yield (t/ha)
Check	27.5 a	3.3 a	90 b	3.8 b	2.8 b	2.8 b	62 b	6.2 c
Rice straw	28.2 a	1.1 b	129 a	5.8 a	8.8 a	8.1 a	78 a	13.4 b
PE sheet	28.6 a	0.1 c	131 a	5.8 a	10.2 a	9.7 a	76 a	16.4 a

[z]Means within a column followed by the same letter are not significantly different at 5% level by DMRT. [y]DAT = Days after transplanting.

Table 12. Sweet pepper development and yield as affected by various mulching materials in summer, 1988.[z]

Mulching materials	Plant height (cm) at WAT[z]		Plant fresh weight at harvest (g/plant)	No. of plant harvested (no./9 m^2)	Marketable fruit yield (t/ha)	Marketable fruit size (g/fruit)	Marketable fruit no. (no./m^2)	Total fruit yield (t/ha)
	4	5						
Check	18.3 b	21.6 b	260 a	24.6 a	5.9 b	83 b	7.1 b	7.9 b
Rice straw	20.8 a	27.3 a	293 a	26.8 a	9.6 a	91 a	10.6 a	12.0 a
PE sheet	16.8 b	19.3 c	167 b	13.4 b	1.9 c	62 c	3.0 c	3.0 c

[z]Means within a column followed by the same letter are not significantly different at 5% level by DMRT. [y]WAT = Week after transplanting.

Table 13. Sweet pepper development and yield as affected by various shading materials in summer, 1988.[z]

Shading material	Plant height at 40 DAT[z] (cm)	Total number of branches (no./plant)	Marketable fruit yield (t/ha)	Marketable fruit size (g/fruit)	Total fruit weight (t/ha)	Total fruit size (g/fruit)	Light penetration (%)	Air temperature at 2:00 pm (°C)
Check	29.7 b	8.4 a	6.0 b	78 c	8.2 b	64 b	100.0	34.5
Black PE net	33.3 ab	7.2 a	9.2 ab	108 a	11.5 ab	90 a	40.3	33.4
White nylon net	31.5 b	6.8 a	13.4 ab	91 b	15.3 ab	85 a	73.9	34.0
Green nylon net	35.1 ab	7.3 a	14.6 a	96 ab	16.5 a	87 a	65.1	34.1
Murakis plastic sheet	38.7 a	6.8 a	15.4 a	95 ab	17.6 a	86 a	68.7	33.5

[z]Means within a column followed by the same letter are not significantly different at 5% level by DMRT. [y]DAT = Days after transplanting.

Cropping Systems

Collection and Testing of the Second Set of New Vegetables

Summary

A total of 595 varieties of vegetable crops were collected until December 1988. Trials of some of these crops were conducted during 1988. Results showed that seven entries of broccoli; five of big-fruited and six of small-fruited cucumbers; 10 of eggplant; eight and 12 each of lettuce for planting in summer, autumn and spring, respectively; and eight spinach outperformed other entries. These entries will be included in advanced yield trials for further confirmation and nutrition studies.

Introduction

This study aimed to gather more information on tropical vegetables for AVRDC and its cooperators' nutrition garden project and bilateral programs. The second set of new vegetables was selected in 1986. Commercially available cultivars of these 15 crops were collected to evaluate their yields, horticultural characteristics and nutrient contents under tropical environments. About 29 new varieties of these crops were collected in 1988, bringing the total collection to 595 varieties (Table 1). Observation trials of broccoli, cucumber, eggplant, lettuce and spinach were conducted during 1988.

Table 1. Collection of new vegetable crops.

Vegetables	Scientific name	No. of varieties received
Broccoli	*Brassica oleracea* var. italica	48
Carrot	*Daucus sativa*	83
Cucumber	*Cucumis sativus*	84
Eggplant	*Solanum melongena*	34
Hyacinth bean	*Dolichos lablas*	4
Kangkong	*Ipomoea aquatica*	24
Leaf amaranth	*Amaranthus* spp.	12
Leaf lettuce	*Lactuca sativa*	109
Malabar spinach	*Basella alba* and *rubra*	11
Nonheading Brassica		
Chinese kale	*Brassica oleracea* var. *acephala*	18
Paitsai	*Brassica campestris* var. *chinensis*	20
Rape green	*Brassica napus*	14
Onion	*Allium cepa*	62
Spinach	*Spinacia oleracea*	56
Yardlong bean	*Vigna unguiculata* var. *sesquipedalis*	
Total		595

Materials and Methods

A randomized complete block design with replications was used in all trials. A total of 37 broccoli, 84 cucumber, 34 eggplant, 92 lettuce and 51 spinach varieties were evaluated.

Results and Discussion

Broccoli. Among 37 entries, 27 yielded similarly, varying from 7.0 to 10.7 t/ha. However, there were significant differences in growth duration, from 46 to 61 days among entries. The top seven yielders are shown in Table 2. Except for BR#5, entries attained early maturity.

Cucumber. There were 24 big-fruited and 60 small-fruited cucumbers tested in spring and summer. In general, the spring trial had much higher yield than that of summer (Table 3) due to severe infection of downy mildew (*Pseudoperonospora cubensis*) in summer. In both types of cucumber, entries which performed well in spring also had higher yields in summer, except for a few entries which yielded high in spring but not in summer. This might have been related to their resistance to downy mildew, as well. Fruit maturity after the proper harvesting stage inversely affected the quality and yield of cucumber. The bigger the fruits, the poorer the quality they had, particularly the small-fruited cucumber. It was difficult to harvest fruits of so many different entries all at the proper stages because there was 220 indication on the right size for harvest. Hence, an evaluation of the standard size (in weight) for the first grade fruits for each entry was made for small-fruited cucumber. Fruit weight was defined as the average weight for the biggest fruits without any empty space inside. Results showed that although the average fruit weight was higher than the standard in each entry and yield of entries might have been overestimated, the relative performance among entries was not affected.

Table 2. Observation trial for broccoli, 1988.[z]

Acc. no.	Entry	Days to maturity	Plant wt. (kg)	Mean head wt. (g)	Yield (t/ha)
2	Comet F1 364	46	1.22	367	9.4
13	No. 443	47	1.26	463	10.6
14	No. 441	46	1.16	400	10.7
26	SG 1 (F1)	46	1.23	419	10.4
32	BR # 13	46	1.07	446	10.7
33	BR # 5	61	1.05	483	9.6
35	Hybrid Packman	46	1.18	418	9.3

Mean of yields and C.V. of 37 entries: 7.4 ± 2.2

[z]Sown 1 March 1988. Transplanted 29 March 1988. Harvested June 1988.

Table 3. Observation trials for cucumber, 1988.

Entry	Yield (t/ha)		Fruit no./m^2		Ave. fruit wt. (g)		
	Spring[z]	Summmer[y]	Spring	Summer	Spring	Summer	Standard[x]
Big-fruited							
Bumper 94	70.4	83.3	22	22	323	377	–
Jazzer EZ (F1)	86.0	43.8	21	13	414	338	–
Million Green	61.0	64.7	13	13	468	491	–
Luih Feng	70.7	46.9	14	10	506	448	–
Jway Cheng	69.3	40.6	13	9	520	456	–
Mean of yields and C.V. of 24 entries: Trial 1: 46.0 ± 18.2 Trial 2: 26.4 ± 22.1							
Small-fruited							
No. 4842	82.8	43.5	86	64	96.5	67.7	33.0
249 Hybrid	78.2	42.8	82	65	96.5	65.5	60.9
251 Hybrid	73.8	46.9	76	65	97.2	72.9	53.0
Fountain	73.8	37.4	74	57	97.9	67.7	67.7
Spring Swallow	69.6	41.1	76	54	89.8	78.0	68.9
Pao-Luh	61.4	45.4	62	59	97.5	76.6	55.3
Mean of yields and C.V. of 60 entries: Spring: 42.8 ± 17.6 Summer: 18.9 ± 13.8							

[z]Planted 11 March 1988. [y]Planted 21 July 1988. [x]Standard size for the first grade fruits.

Eggplant. Ten entries outyielded other entries during planting in spring (Table 4). There was no significant difference in days to maturity among these high-yielding entries. Their growth duration fell in the middle group, and significantly differed from either the late (101 days) or early (79 days) maturing entries. Their fruit size and shape were diverse, having significantly different fruit lengths and widths (Table 4).

Lettuce. There were 92 entries (49 leaf, 25 crisp head, 10 Cos and 8 butter head types) evaluated in summer and autumn 1987, and spring 1988. Low yields in summer indicated the lack of heat tolerance of the entries. There were strong interactions between entries and environment. The high yielding entries performed differently in different planting seasons (Tables 5-7). Among entries, Cos lettuce performed better in spring, and crisp head lettuce in summer and autumn. Two crisp head entries, Olimpo and Martha, performed particularly well in summer.

Table 4. Observation trial for eggplant, 1988.[z]

Acc. no.	Entry	Days to flowering	Days to maturity	Plant wt. (kg)	Mean fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Yield (t/ha)
3	No. 29 (F1)	69	90	6.45	392	12.3	12.8	77.4
7	Dona F1	68	91	6.81	322	13.8	10.2	81.7
10	Ingfrat	68	89	6.93	378	11.9	12.5	83.1
14	Agora	68	90	7.62	344	15.3	9.1	91.4
18	Bonesa F1	65	90	6.39	341	16.2	9.1	76.7
20	Murena F1	68	89	6.89	336	17.1	8.5	79.6
23	5223-2	68	90	6.90	448	14.6	9.8	79.2
25	F-100	65	90	7.62	307	14.3	10.6	91.4
26	Hybrid Nite King	65	88	7.19	417	15.4	9.5	86.3
30	Galine Hybride-F1	65	88	7.20	366	22.8	7.6	86.4

Mean of yields and C.V. of 34 entries: 61.0 ± 20.7

[z]Sown 1 March 1988. Transplanted 8 April 1988. Harvested 7 June – 4 August 1988.

Table 5. Observation trial for lettuce, summer 1987.[z]

Acc. no.	Entry	Yield (t/ha)	Days to maturity	Mean head wt. (g)	Leaf no. /plant	Type[y]
34	Martha	20.9	40	161	22.0	CH
35	Emilia	10.0	34	85	31.4	CO
39	Olimpo	25.7	44	211	23.4	CH
46	Martha	15.1	41	123	20.4	CH
48	Seme Ner	10.9	34	91	24.6	CO
67	Bounty M	10.5	39	75	17.1	CH
71	Narromar	13.6	44	129	21.7	CH
73	O.G.O. 86	10.8	39	102	17.5	CH

Mean yield and C.V. of 84 entries 5.3 ± 4.0

[z]Sown 10 June 1987. Transplanted 14 July 1987. Harvested 10-25 August 1987. [y]Type: CO: Cos; CH: Crisp Head.

Table 6. Observation trial for lettuce, autumn 1987.[z]

Acc. no.	Entry	Yield (t/ha)	Days to maturity	Mean head wt. (g)	Leaf no./plant	Type[y]
1	Celtuce	51.7	74	398	40.0	L
5	Local Improve No. 3	54.3	74	418	35.4	L
15	Sunny Lake	50.7	71	380	23.1	CH
19	Sunny Lake	50.7	74	507	25.3	CH
46	Martha	53.3	67	421	25.2	CH
73	O.G.O. 86	49.3	71	370	24.1	CH
74	BH 86	58.0	74	435	25.6	CH
76	Summergold	52.3	71	383	23.6	CH
82	Sunny Lake	59.0	71	443	25.6	CH
86	Georgia	58.7	71	451	24.0	CH
94	Alper	55.3	74	479	26.7	CH
95	Mark Ace	55.7	74	409	27.2	CH

Mean yield and C V. of 92 entries 28.9 ± 14.5

[z]Sown 5 October 1987. Transplanted 30 October 1987. Harvested 18 December 1987 – 12 January 1988. [y]Type: L: Leaf; CH: Crisp Head.

Spinach. Eight entries outyielded the other 43 in spring 1988 (Table 8). There were significant differences in growth duration, leaf number per plant, average leaf length, and average leaf width among entries. However, only the average leaf length had a significant correlation with yield (r = 654**).

Table 7. Observation trial for lettuce, spring 1988.[z]

Acc. no.	Entry	Days to maturity	Leaf no/plant	Plant wt. (g)	Yield (t/ha)	Type[y]
33	Catalogna	63	28.4	202	30.3	L
37	White Boston	36	31.5	241	33.7	CO
41	Gallega INTA	36	32.0	257	38.5	CO
48	Seme Nero	36	32.1	206	30.8	CO
50	Corsica	36	32.8	221	32.8	CO
52	Grand Rapids	36	25.9	204	30.7	L
55	Corsaro RS	36	44.7	274	40.7	CO
64	Brasil 221	36	34.4	221	33.2	CO
66	PSX 50182	36	34.8	253	38.0	CO
81	Great Wall	39	27.9	660	32.0	CH
84	Lattuga Reine D'ete	36	32.4	210	30.3	CO
85	Lattuga Toria S.V.	36	27.2	202	30.3	BH

Mean yield and C.V. of 90 entries 23.8 ± 5.6

[z]Planted 28 March 1988. Harvested 29 April – 29 May 1988. [y]Type: L: Leaf; CO: Cos; CH: Crisp head; BH: Butter head.

Table 8. Observation trial for spinach, 1988.[z]

Acc. no.	Entry	Days to maturity	Leaf no. /plant	Plant wt. (g)	Yield (t/ha)
4	Andros	47	21	132	16.3
9	Orient	41	33	113	17.0
17	Early hybrid #7	47	20	113	17.0
24	XPH 1444 (F1)	41	22	133	20.0
25	XPH 1511 (F1)	41	25	118	17.7
36	OE 3288 (Mirage F1)	41	27	113	17.0
37	Kir Kasprik	41	37	116	15.5
43	Movera RS	47	28	112	15.7

Mean of yields and C.V. of 51 entries: 11.7 ± 3.4

[z]Sown 9 February 1988. Transplanted 1 March 1988. Harvested 10-16 April 1988.

Garden Program

Summary

The garden research has focused on gathering information on individual crops and possible interactions between crops since 1987. The characteristics which might be used in the garden design for 146 varieties of 49 vegetables have been recorded from school and home gardens and stored in the Tropical Vegetable Data File (TVDF). The noncirculating hydroponic system was adopted for the urban home garden, and 57 varieties of 29 vegetables were tested; most of them were found suitable for this system. A pesticide-free garden and an aquatic garden were initiated in 1988.

Introduction

Initiated in 1981, the AVRDC garden program aimed to increase the nutrition intake and income of people in the tropics through vegetable production and consumption. Findings in the first phase of this program demonstrated that a 4 × 4 m^2 garden can supplement a significant percentage of the nutrition needs of a family of five on a year-round basis. The second phase, started in 1987, focused

on the methodology of garden designing and garden management. Since information on vegetable production in the tropics is often lacking and not easily accessible, a data base was developed using the data from these studies. In the meantime, the key characteristics of vegetables needed for garden planning in the tropics were identified through evaluation of the garden's productivity (weight of edible part, vitamin or mineral).

A pesticide-free garden was initiated to evaluate vegetable growing under these conditions, and in areas where high precipitation prevails, an aquatic garden was also established in 1988.

Materials and Methods

Home and school gardens. Four home gardens, each with 18 1.2 × 0.7 m plots and a school garden of 48 1.2 × 1.5 m plots were planted with different vegetables. The gardens were mainly used for data collection for individual crops and possible interaction between crops (i.e. effects of inter- and sequential cropping). Different vegetable varieties collected locally were grown in such a way that each variety can be planted in different seasons. Each plot in the gardens had a code number. The data collected were all keyed into the computer, analyzed and then stored in a data base.

Pesticide-free garden. A 6 m × 4.5 m garden was set up to evaluate the productivity of vegetables under pesticide-free conditions.

Aquatic garden. A 3 m × 3.5 m pond with 50-cm deep water was established to evaluate the growing of aquatic vegetables under this system.

Urban home garden. The noncirculating hydroponic system was adopted for the urban home garden. Observations focused on the suitability of different vegetables under this system. Some modifications on the hydroponic system established in 1987 were made during the year. For leafy vegetables, small plastic seedling pots were used to support the medium and plants (Fig. 1). The original design of the plastic basket was mainly for root crops (e.g. sweet potato, potato, carrot and radish).

Results and Discussion

Home and school gardens. Data on the characteristics of 146 varieties of 49 vegetables were collected. The coefficient of variation for each character of a variety and a crop was also calculated to estimate the possible variation among or within crops. With this information, yield can be estimated for a chosen group of vegetables in a garden of a certain size. These data were utilized to determine relationships between yield of a particular variety or a crop and climatic conditions. Data on yield were also used to calculate the production of nutrients by different vegetables using data on their nutrient contents (data shown in 1987 Annual Report). The data can also be used for selecting vegetables or varieties with specific nutrient requirements suited for a garden.

Pesticide-free garden. Amaranth, eggplant, jute, kangkong, lettuce, okra, perilla and vegetable soybean were tested in 1988. Results showed that there was no significant pest damage in any crop. Mites were the main pests found. Crop yields were comparable to those under protected conditions. However, these results need to be confirmed further.

Aquatic garden. Kangkong, taro, water caltrops and water chestnut were tested in the aquatic garden in July. These vegetables have relatively long growth duration and were still growing when this report was written. Hence, no final yield data were gathered yet.

Urban home garden. A total of 57 varieties of 29 vegetables were tested. This noncirculating hydroponic growing unit could save a lot of time for the daily production management of most leafy vegetables tested. Labor was needed only during sowing and harvesting. The nutrient solution in the container was sufficient for the entire growth period for most leafy vegetables tested; hence, no watering was needed. The growing units were covered by a screen net from sowing till harvesting. Therefore,

there was hardly any insect problem and no pesticide was applied. Several root and fruit vegetables (e.g. radish, potato and tomato) were also found suited to this system. However, there was a need to add the nutrient solution every day during the late growth stage of the crops when the level of nutrient solution dropped to 15 cm from the top of the box.

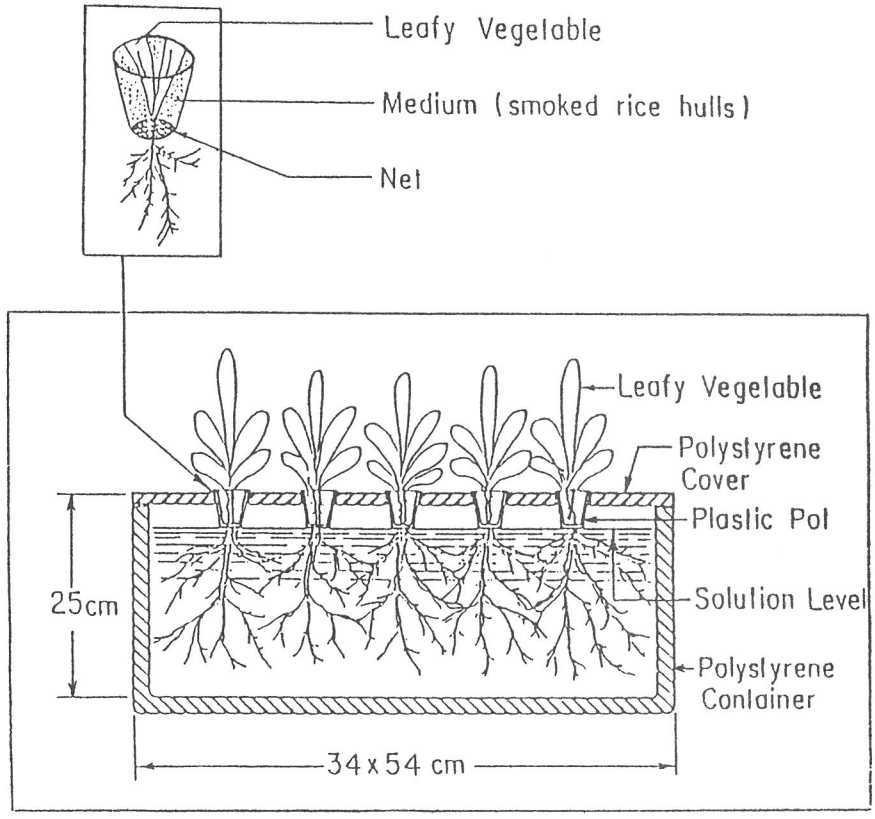

Fig. 1. Section of non-circulating hydroponic growing unit.

Development of Vegetable Grouping Methods for the Tropics

Summary

Vegetable grouping methodologies, based on their attributes for tropical areas, were studied. A rating method based on temperature range for heat tolerance levels of vegetable varieties tested in the Garden Program was evaluated. Results showed that this kind of classification should include details on variety level due to substantial varietal differences. A dry and hot environment would help build up a complete vegetable data base for the tropics.

Introduction

To compile information from the Garden Program for ready application in choosing a site-specific crop, vegetable grouping techniques based on their attributes for tropical areas were studied. Although the data were collected from small garden plots without traditional experimental designs, annual yield data still provided an insight on the relationship between vegetable performance and environment. A significant correlation between yield and mean daily air temperatures during growth period for several vegetables was established (Fig. 2).

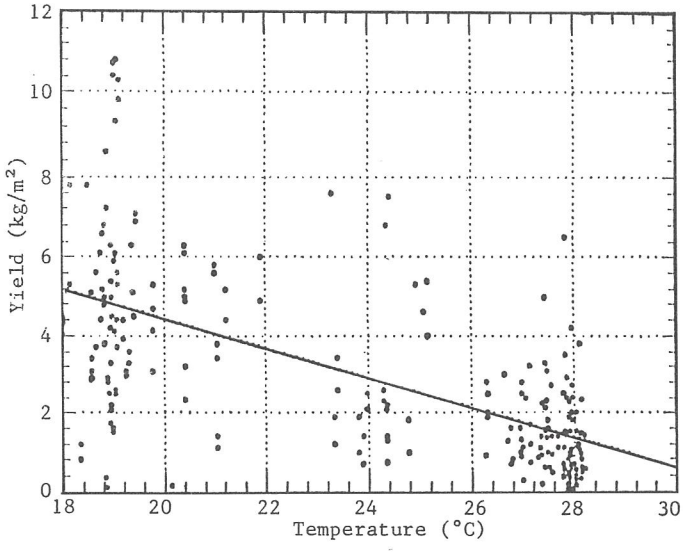

Fig. 2.
Effect of mean daily air temperature (°C) on vegetable yield in Garden Program.

Materials and Methods

The mean daily air temperatures of 30, 45 and 60-day periods from the 15th of each month were calculated. Those months with similar temperature ranges were grouped as one planting season. The average yield of each vegetable was compared with the other varieties planted in the cool, warm and hot seasons. Vegetables were grouped according to planting season when they attained the highest yield. Their heat tolerance levels, using a 1-4 rating, were decided based on the ratios (>75%, 75-50%, 50-25% and <25%) of their performances in hot season to their highest yield, respectively.

Results and Discussion

In mean temperatures of assumed vegetable growing durations, 30, 45 and 60 days from the 15th of each month in a year, there were distinct temperature ranges without great variation (Fig. 3 and 4).

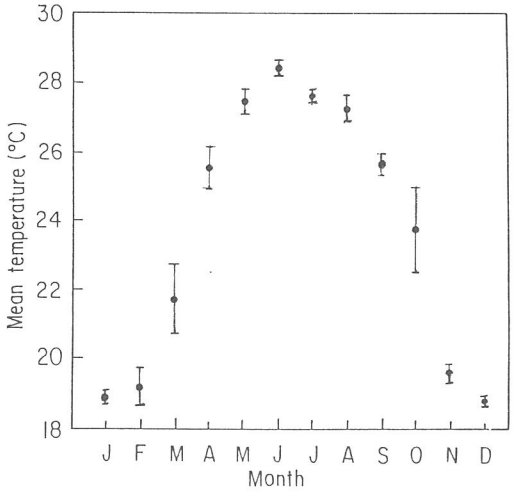

Fig. 3. Mean air temperature and variation of 30, 45 and 60-day periods in different months.

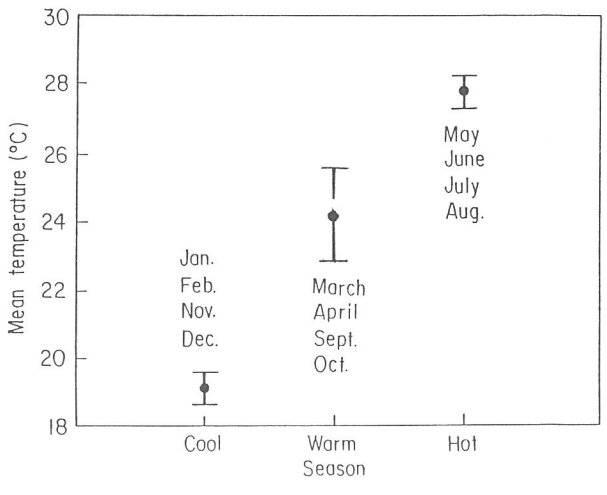

Fig. 4. Mean air temperature and variation of 30, 45 and 60-day periods in different months in three seasons.

Three planting seasons were identified, namely cool (January, February, November and December), warm (March, April, September and October) and hot (May, June, July and August) with mean temperatures of 19, 24, and 28°C, respectively.

Yields in kg/m^2 and also in $g/m^2/day$ were compared, because growth duration was affected by temperature. Furthermore, the latter was useful for garden designing. Amaranth, chingchiang paitsai, kale, lettuce, mustard and paitsai were tested and classified by this method (Table 9). However, the classification should be detailed and specify the variety due to substantial varietal differences. It appeared that grouping of planting seasons for data from the Garden Program improved through this method.

Results indicated that crop yields were also affected by rainfall (Fig. 5). Thus, resistance to rain damage provided another criterion for vegetable classification. However, this might have also confounded the effect of temperature on vegetable performances during the hot season because more rain occurred mainly in this season (Fig. 6). Thus a dry and hot environment should be helpful in building up a complete vegetable data base for the tropics.

Table 9. Yields of some vegetables in three seasons.

Vegetable	Season			Group	HT rating
	Cool	Warm	Hot		
		Yield (kg/m^2)			
Amaranth	–	1.71 (82)[z]	2.08 (100)	H	1
Chingchiang paitsai	5.62 (100)	2.71 (48)	1.26 (22)	C	4
Kale	1.61 (100)	1.23 (76)	0.62 (39)	C	3
Lettuce	2.76 (91)	3.04 (100)	0.92 (30)	W	3
Mustard	2.46 (100)	1.16 (47)	1.04 (42)	C	3
Paitsai	2.82 (100)	1.78 (63)	0.64 (23)	C	4
		Yield ($g/m^2/day$)			
Amaranth	–	41.9 (83)	50.7 (100)	H	1
Chingchiang paitsai	135.0 (100)	92.7 (69)	36.5 (27)	C	3
Kale	32.7 (100)	31.5 (96)	11.9 (36)	C	3
Lettuce	56.9 (77)	73.9 (100)	26.5 (36)	W	3
Mustard	60.4 (100)	36.7 (61)	25.5 (42)	C	3
Paitsai	74.3 (100)	59.2 (80)	19.1 (26)	C	3

[z]Figures in the parenthesis are ratios (%) of the highest yield in each vegetable.

Yield of Intercropped Sweet Potato and Soybean with Different Spatial Arrangements

Summary

This study was the second of a series of trials which examined the effects of genotype and spatial arrangements of sweet potato and soybean on growth intercropping system. Soybean varieties, AGS 66 and AGS 129, and sweet potato entries, TN 66 and TN 67, were studied in autumn. Results showed that effects of agronomic management on sweet potato and soybean yields under intercropping in autumn differed from those in summer. Sweet potato TN 66 and TN 67 had similar performance and soybean AGS 129 was more suitable than AGS 66 for intercropping. The number of soybean rows per bed did not affect the yield of either sweet potato or soybean. Sweet potato seemed dominant; however, it was also affected by the growth of soybean. Thus, it appeared that the potential for improving the total productivity of this combination in autumn is not great. Nevertheless, the vigorous growing type of soybean could be more suitable for intercropping in autumn.

Introduction

When intercropped, crops often compete with each other for growth resources such as light, nutrients and water. This competition can be minimized through cultural practices management, such as

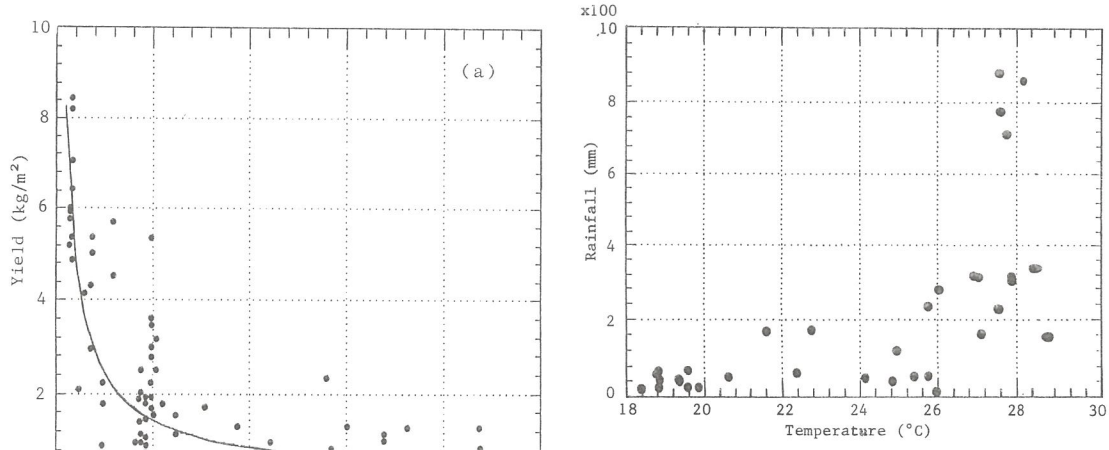

Fig. 6. Relationship between total rainfall and mean daily air temperature of 30, 45 and 60-day periods in months, August 1987-July 1988.

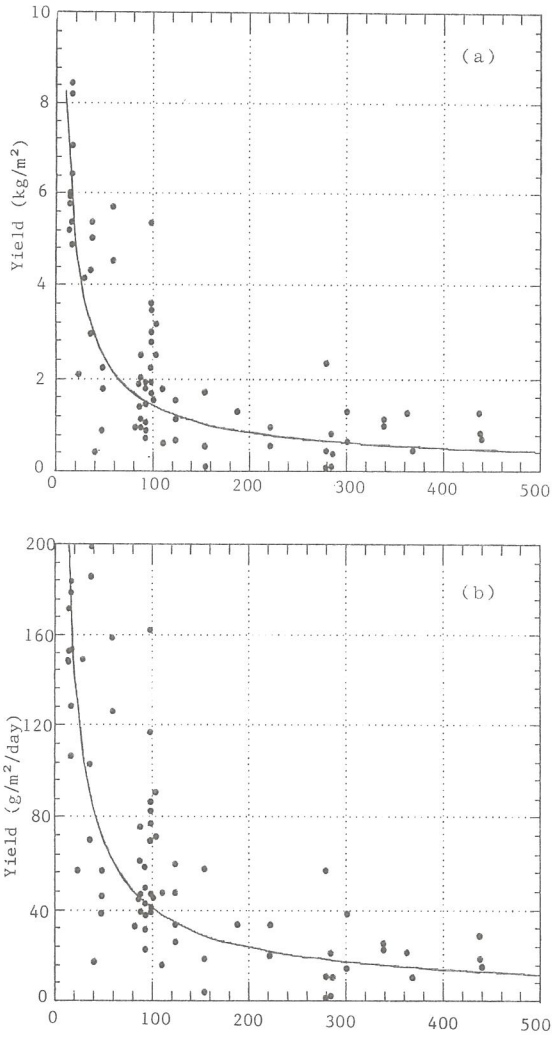

Fig. 5.
Relationship between amount of rainfall and yields, in kg/m^2 (a) and g/m^2/day (b) of Chingchiang Paitsai.

choice of genotypes, plant populations and spatial arrangements, and relative planting time. The second of a series of trials, the study examined the effects of agronomic management on growth competition between sweet potato and soybean under intercropping system. This trial was planted in autumn and compared with one planted in summer to look into the relationships of environmental condition and agronomic management on this intercrop.

Materials and Methods

There were eight intercropping treatments (a 2^3 factorial experiment with two replications), including two soybean genotypes (broad leaflet and early-maturing AGS 66 and narrow leaflet and late-maturing AGS 129), two sweet potato genotypes (semierect type TN 66 and spreading type TN 67). Two spacings (50 × 10 cm with one plant/hill, and 100 × 10 cm with two plants/hill for soybean) were employed. Four sole treatments were repeated twice in each replication. The plot size was 4 m × 6 m. The spacing for sweet potato was 100 × 25 cm. Both sweet potato and soybean were planted on 21 August. Soybean AGS 66 and AGS 129, and sweet potato were harvested on 13 and 24 November 1987 and 1 February 1988, respectively. Soybean yield and its components, and fresh

weights of sweet potato parts when soybean was harvested and when sweet potato attained maturity were recorded.

Results and Discussion

Effects of agronomic management on sweet potato and soybean yields under intercropping differed in two planting seasons. There was less rainfall and temperature was lower, particularly at the later stage of this trial than in summer (Fig. 7). Soybean cultivar AGS 129 had a significantly higher yield than AGS 66 in both cropping systems (Table 10) as was usually observed in other trials. Among cropping systems, AGS 66, when intercropped with a sweet potato cultivar, had 43% yield as in sole cropping, while AGS 129 had 48% and 44% yield when planted together with TN 66 and TN 67, respectively. These proportions were much lower than those in summer, indicating that soybean yields were significantly affected by intercropping with sweet potato in autumn.

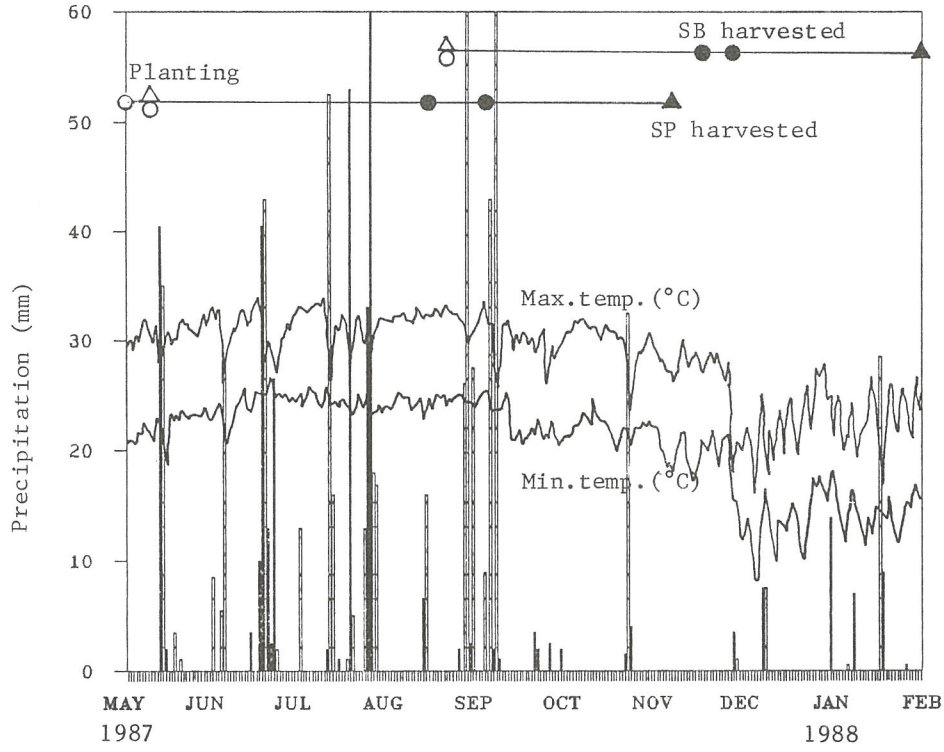

Fig. 7. Changes in maximum and minimum daily air temperature (°C) and daily rainfall (mm) during sweet potato/soybean intercropping.

Table 10. Yield (t/ha) and land equivalent ratio (LER) of sweet potato and soybean (mean of two spacings) under intercropping system.

Sweet Potato	Cropping	AGS 66		AGS 129	
		Sweet Potato	Soybean	Sweet Potato	Soybean
TN 66	Sole cropping	28.4	2.0	28.4	2.3
	Intercropping	21.7	0.9	19.4	1.1
	I/S	0.76	0.4	0.68	0.5
	LER	1.2		1.2	
TN 67	Sole cropping	33.3	2.0	33.3	2.3
	Intercropping	23.5	0.9	22.7	1.0
	I/S	0.7	0.4	0.68	0.5
	LER	1.1		1.1	

Sweet potato yield was much higher in autumn than in summer, and was significantly less affected by intercropping with soybean (Table 10 and Fig. 8). TN 67 had a significantly higher yield than TN 66 in sole cropping but both entries performed similarly in intercropping and had about 70% yield as in sole cropping.

The yield advantage in intercropping, indicated by Land Equivalent Ratio (LER), was only 12–19% in different combinations due to the dramatic reduction in soybean yield. Results showed that intercropping had higher percentage of light intercepted during the early growth stage up to 30 days after planting (Fig. 9). The light interception of intercropped sweet potato was about 10% lower than sweet potato planted solely when soybean was harvested.

Only the pod number per plant among soybean yield components was significantly reduced when soybean was intercropped with sweet potato (Table 11). In fact, seed number per pod and seed size of AGS 129 increased in intercropping due to the severe reduction in pod number. It appeared that pod setting of soybean coincided with the active growth of sweet potato, and the latter was more dominant.

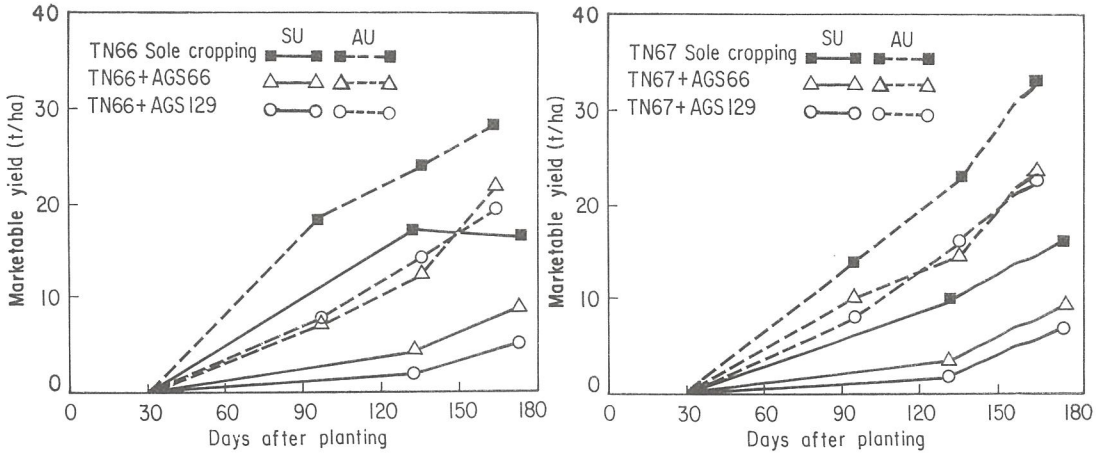

Fig. 8. Growth of storage roots of sweet potatoes in sole cropping and intercropped with soybean, AGS 66 and AGS 129, in summer (SU) and autumn (AU), 1988.

Table 11. Agronomic characters of soybean (mean of two spacings) in sole cropping and intercropping with sweet potato.[z]

Variety	Cropping	Plant ht. at flowering (cm)	Node no. /plant	Plant no./m^2	Pod no. /plant	Seed no. /pod	100-seed wt. (g)
AGS 66	Sole	27.8	12.0	22.3	49.9 a	1.78	11.5
	Inter-	29.4	12.1	20.6	27.3 b	1.77	10.9
	I/S (%)	105.8	100.8	92.4	54.7	99.4	94.8
AGS 129	Sole	30.0	15.9 a	21.0	40.3 a	1.88 b	15.0 b
	Inter-	29.0	13.0 b	20.6	16.0 b	2.18 a	16.5 a
	I/S (%)	96.7	81.8	98.1	39.7	116.0	110.0

[z]Means with different letters are significantly different at 5% level.

Soybean tended to yield higher when grown in two rows than in one row per bed (Table 12). Intercropping different sweet potato varieties had no significant effect on yield and yield components of soybean (Table 13).

The growth of sweet potato was affected when it was intercropped with soybean, particularly during the early stage (Table 14). However, this was not as pronounced as in summer, and it made up to some extent in total weight as well as storage root yield after soybean harvest. The storage root was the most affected part and the leaf was the least. The growth curve of the storage roots showed that TN 66 was an early-maturing cultivar as shown in the previous trial. However, it had a similar trend to that of TN 67 in intercropping, indicating that growth of its storage roots was faster during

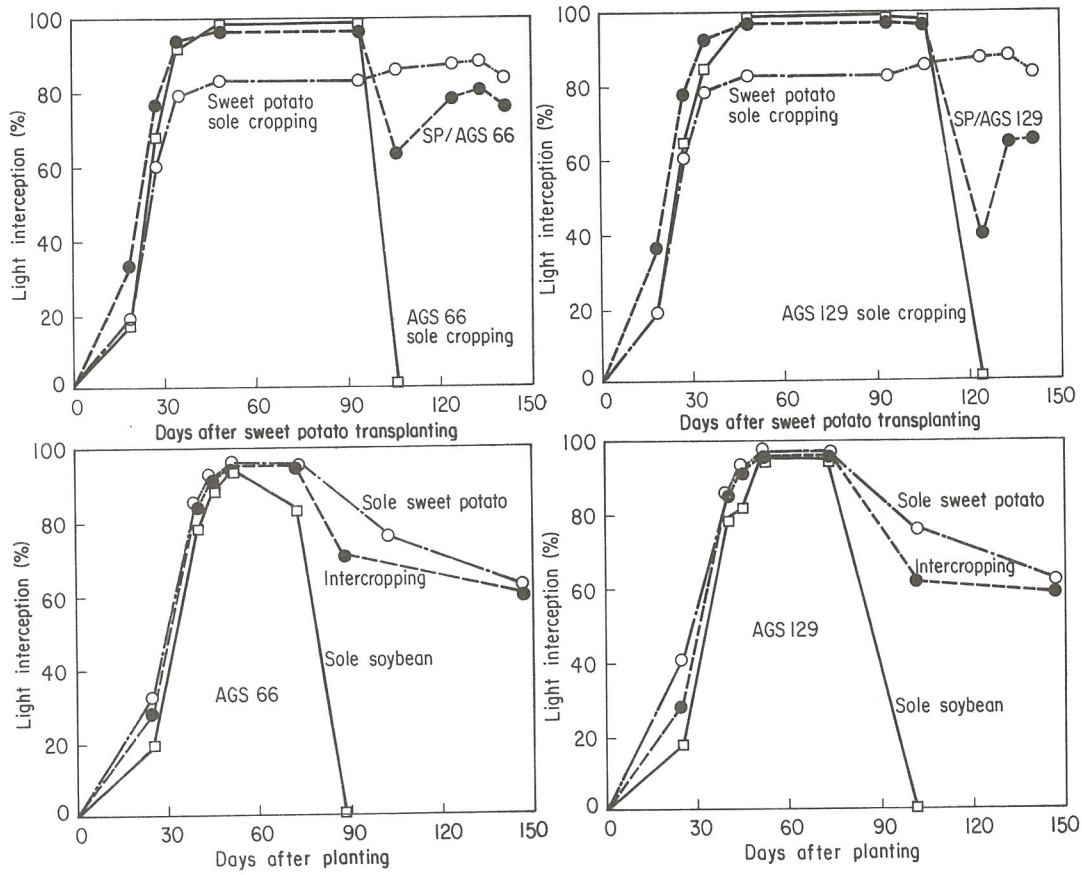

Fig. 9. Light interception of sole soybean, sweet potato and sweet potato/soybean intercropping in summer and autumn.

Table 12. Effect of number of rows per bed on soybean yield and agronomic character in soybean-sweet potato intercropping.[z]

Variety	No. of rows	Yield (t/ha)	Plant ht. at flowering (cm)	Node no. /plant	Plant no. /m^2	Pod no. /plant	Seed no. /pod	100-Seed wt. (g)
AGS 66	1	0.8	30.1	12.2	21.0	25.7	1.80	10.7
	2	0.9	28.8	12.0	20.3	28.9	1.74	11.1
AGS 129	1	0.9	29.5	12.5 b	19.0	13.7	2.15 b	16.9
	2	1.1	28.5	13.5 a	22.3	18.4	2.21 a	16.1
Different level between varieties		**	NS	**	NS	**	**	**

[z]Means with different letters are significantly different at 5% level.

Table 13. Effect of associated sweet potato varieties under intercropping system on soybean yield and agronomic characters.

Variety	Sweet potato variety	Yield (t/ha)	Plant ht. at flowering (cm)	Node no. /plant	Plant no. /m^2	Pod no. /plant	Seed no. /pod	100-Seed wt. (g)
AGS 66	TN 66	0.9	30.4	12.3	21.3	27.0	1.70	10.4
	TN 67	0.9	28.5	11.9	20.0	27.6	1.84	11.4
AGS 129	TN 66	1.1	29.0	12.7	20.8	16.6	2.18	16.1
	TN 67	1.0	29.0	13.3	20.5	15.5	2.18	16.9

Table 14. Agronomic characters of sweet potato when planted solely and intercropped with soybean.[z]

Variety	Cropping	Leaf weight (t/ha)	Stem weight (t/ha)	Total weight (t/ha)	Storage root no./m^2
		96 days after transplanting			
TN 66	Sole	11.3 a	7.7 a	37.4 a	34.0 a
	Inter-	8.4 b	6.0 b	21.7 b	17.4 b
	I/S (%)	74.3	77.9	58.0	51.2
TN 67	Sole	14.3 a	9.5 a	37.5 a	27.8
	Inter-	9.3 b	6.5 b	24.6 b	25.6
	I/S (%)	65.0	68.4	65.6	92.1
		164 days after transplanting			
TN 66	Sole	5.0	7.3 a	40.7 a	36.3 a
	Inter-	4.3	5.7 b	30.7 b	24.0 b
	I/S (%)	86.0	78.0	75.4	66.1
TN 67	Sole	6.2	7.3 a	46.8 a	41.1 a
	Inter-	4.8	5.9 b	33.9 b	31.0 b
	I/S (%)	79.4	80.2	72.4	70.0

[z]Mean of two spacings.

the late growing stage due to favorable environmental conditions, and it was also suitable for intercropping in this particular planting season (Fig. 8). The objective of improving the distribution ratio of assimilates to storage roots was not achieved as showed by the results of plotting tuber yield against total weight (Fig. 10). However, these results could have been confounded by the retranslocation of assimilates and leaf shedding during the late growth stage.

Within intercropping treatments, the yield and growth of both sweet potato entries showed that neither the associated soybean varieties (Table 15) nor the row number of soybean per bed (Table 16) had significant effect on the growth of sweet potato under intercropping in autumn. Again, it appeared that sweet potato was the dominant crop in the autumn trial.

Table 15. Effect of associated soybean varieties under intercropping system on sweet potato yield and agronomic character.[z]

Variety	Variety of associated Soybean	Yield (t/ha)	Leaf weight (t/ha)	Stem weight (t/ha)	Total weight (t/ha)	Storage root no./m^2
TN 66	AGS 66	21.7	4.7 a	6.3	32.8	24.1
TN 66	AGS 129	19.4	4.0 b	5.2	28.6	24.0
TN 67	AGS 66	23.6	4.7	5.9	34.1	32.6
TN 67	AGS 129	22.7	4.9	6.0	33.7	29.4

[z]Means with different letter are significantly different at 5% level.

Table 16. Effect of number of rows per bed of association soybean under intercropping system on sweet potato yield and agronomic character.[z]

Variety	Number of Soybean Rows	Yield (t/ha)	Leaf Weight (t/ha)	Stem Weight (t/ha)	Total Weight (t/ha)	Storage Root no./m^2
TN 66	1	21.9	4.2	5.4	31.6	24.1
TN 66	2	19.2	4.5	6.1	29.8	24.0
TN 67	1	23.8	4.5	5.6	33.9	31.7
TN 67	2	22.5	5.1	6.3	33.9	30.3

[z]Means with different letter are significantly different at 5% level.

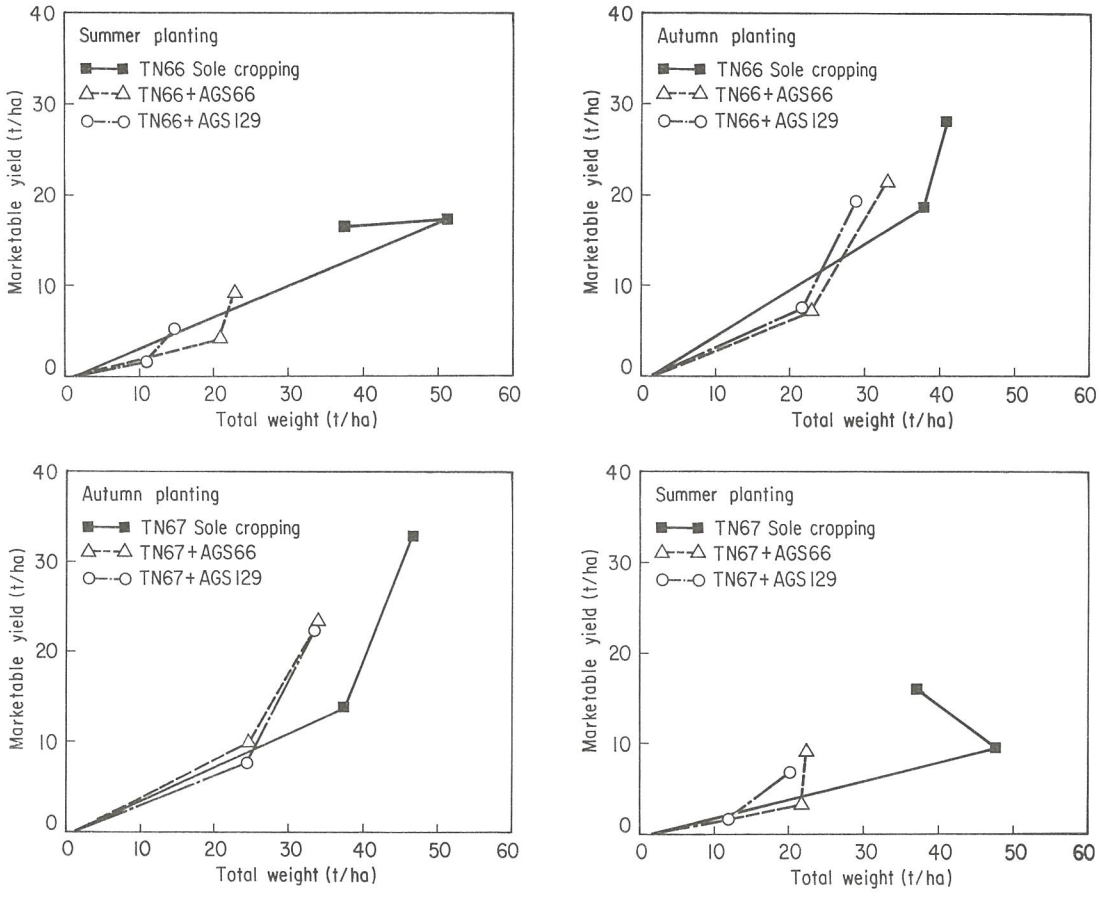

Fig. 10. Relationship between storage root and total weight of sweet potato in sole cropping and intercropped with soybean in summer and autumn.

It is concluded that sweet potato TN 66 and TN 67 had similar performance and soybean AGS 129 was more suitable than AGS 66 for intercropping in autumn. The row number of soybean per bed did not significantly affect the yield of either sweet potato or soybean in intercropping. It seemed that sweet potato was dominant in this intercropping system during autumn. However, it was also affected by soybean. Thus the potential for improving the total productivity of this combination in the autumn planting is not great. Nevertheless, the vigorously growing soybean could be more suitable for this combination in autumn.

Nitrogen Balance in Cropping Systems

Summary

Nitrogen is one of the most important elements affecting plant growth. Hence, nitrogen input-output analysis was included in the study of cropping patterns to develop efficient utilization of nitrogen through different crop sequences and management. Results of the improved cropping systems study from 1985 to 1987 were analyzed and compared for N balance in different cropping patterns. It was found that soybean had better N fixation ability than mungbean. However, mungbean seemed to have more contribution to N balance for the succeeding crop. The planting of sweet potato in summer contributed a great amount of N to the succeeding Chinese cabbage. The management practices, namely compost application and mulching might have improved the fertility of soil. Therefore, incorporating

vegetables in the cereal crop-based cropping systems could be an effective strategy for sustained agriculture.

Introduction

In cropping systems research, AVRDC aims to develop principles and methodologies for cropping systems with improved and stable productivity. In addition to yield, other results which might have relation to long term productivity were also studied. Nitrogen is one of the most important elements affecting plant growth. Hence, the nitrogen input-output analysis was included in the study of cropping patterns with the end view of developing methodologies for efficient utilization of nitrogen through different crop sequences and management.

Materials and Methods

Results of the improved cropping systems study from 1985 to 1987 were analyzed and the different cropping patterns compared for N balance. The N input was obtained by summing up the decrease in soil N during cultivation and N added as fertilizer, and the output was the N taken up by the plants. Input-output balance of nitrogen was calculated by subtracting the input from output. The positive values in the balance indicated N supplied from sources other than soil N or fertilizer.

Results and Discussion

The performance of crops in this three-year study was comparable to those in other studies. It was influenced mainly by seasonal effects, with greater variation in sweet potato, Chinese cabbage and tomato, than in other grain crops. There were significant differences in N balance among crops and cropping sequences. Legumes, like soybean and mungbean with the ability to fix nitrogen, had great positive values in the balance (Table 17). Soybean had much better ability in this concern than mungbean. However, mungbean seemed to contribute more to N balance for the succeeding crop. It appeared that although soybean fixed more nitrogen, most were taken away by soybean in its seeds. It was interesting to note that summer planting sweet potato contributed a great amount of N to the succeeding crop of Chinese cabbage. It was mentioned in the sweet potato/soybean intercropping report that sweet potato in summer reduced its total weight during the later growth stage. It might have been indicated that a substantial amount of sweet potato residues with relatively high nitrogen content was left in the field and had benefited the successive crop. This could be an important role for sweet potato in cropping systems under tropical conditions.

Table 17. Average yield and N balance of crops in different cropping sequences, 1985-1987.

Crop	Season	Previous crop	Yield (t/ha)	N balance (kg/ha)
Rice	Spring	Soybean	4.2	17.2
	Spring	Tomato	4.6	9.5
	Summer	Soybean	4.3	16.5
Mungbean	Summer	Rice	1.9	88.4
Sweet potato	Summer	Soybean	7.9	23.6
	Autumn	Rice	11.0	-4.3
Chinese cabbage	Spring	Soybean	18.3	-20.7
	Summer	Soybean	20.4	-17.4
	Autumn	Sweet potato	25.3	108.0
Soybean	Spring	Chinese cabbage	3.9	177.2
	Spring	Sweet potato	4.3	210.3
	Autumn	Corn	2.7	226.0
	Autumn	Tomato	2.8	205.2
Tomato	Spring	Soybean	50.7	-16.5
	Summer	Chinese cabbage	15.7	-4.2
	Autumn	Mungbean	46.9	63.2

Total nitrogen in soil monitored during the three-year period showed that apart from compost application, mulching also increased total nitrogen consistently within the same cropping pattern (Fig. 11). This suggests that cultural management needed for vegetable production, namely compost application and mulching, might have improved the fertility of the soil.

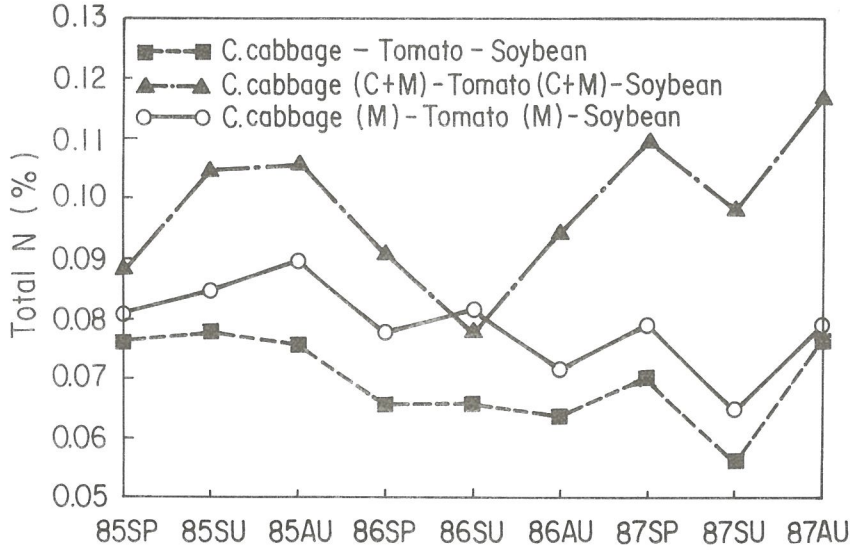

Fig. 11. Changes in total N in soil of Chinese cabbage-tomato-soybean cropping pattern under different cultural management practices.

On-Station Testing

Cooperative Projects with Local Institutes

Summary

Promising AVRDC materials and the selected varieties of new vegetables, including cauliflower, and snap bean were tested under different environments in Taiwan in cooperation with the national programs in Regional Yield Trials (RYT). In 1988, vegetable soybean AGS 292, which was released as Kaohsiung Selection No. 1, occupied 51% (3,919 ha) of total vegetable soybean hectarage, and soybean AGS 129 (Kaohsiung 10) contributed 41% of soybean hectarage (3,690 ha) in Taiwan. Entries which outperformed the check entries in RYT during 1987 and 1988 were soybeans — 208 and AGS 215; mungbean — VC 3738 A, VC 3890 A, VC 3853 A, VC3901 A and VC 3737 A; processing tomatoes — PT 4121, PT 4165 and PT 4172; fresh market tomatoes — FMTT 22, FMTT 33 and FMTT 3; Chinese cabbage — AVRDC 82-156; sweet potato — CN 1489-89; sweet pepper Gypsy; cauliflower — F1 451; mustard Chihsingly and Tender green; and snap bean Taichung 16.

Introduction

Promising AVRDC materials and the selected varieties of new vegetables (including cauliflower, and snap bean) were tested under different Taiwan environments in cooperation with the national programs in Regional Yield Trials (RYT). These trials were supported and mainly conducted by ROC national scientists in farmers' fields.

Materials and Methods

Regional yield trials and their sowing and harvesting dates are shown in Table 1. Trials were conducted in a randomized complete block design with four replications. About 66 regional yield trials in 1987-1988 are included in this report.

Results and Discussion

A. Performance of AVRDC lines in Taiwan

AVRDC introduced line, AGS 292 (Taishoshiroge) was released in Taiwan as Kaohsiung Selection 1 (KS 1) on 23 April 1987, after its outstanding performance in RYT. Its hectarage in 1987 autumn planting was nearly 800 ha which was 19% of the total hectarage for vegetable soybean during that season. These figures increased to 1,815 and 2,104 hectares, (45.5% and 56.0%) in spring and autumn plantings in 1988.

The lines AGS 129 and AGS 66, released as Kaohsiung 10 (KS 10) and Tainan 1 (TN 1) in 1985 and 1986, occupied 3,690 and 800 ha, respectively, in 1988. These areas covered 41% and 9% of the total hectarage for soybean.

Table 1. Number of locations, number of entries, planting (sowing) and harvesting dates of regional yield trials including AVRDC materials in Taiwan.

Year	Season	No. of Locations	No. of Entries	Sowing Date	Harvesting Date
			Soybean: Coordinated by Kaohsiung DAIS		
1987	Summer	11	12	7 May 7 - 19 Aug.	6 Aug. - 16 Dec.
1987	Autumn	3	12	22-30 Sept.	8 Dec. - 6 Jan.
1988	Spring	11	12	1 Feb. - 15 Mar.	14 Apr. - 3 July
			Mungbean: Coordinated by Tainan DAIS		
1988	Spring	4	10	23-26 Feb.	11 May - 20 June
1988	Summer	3	10	6-8 July	9 Sept. - 23 Oct.
			Processing Tomato: Coordinated by Tainan DAIS		
1987	Late summer	3	10	*28 Aug. - 3 Sept.	17 Nov. - 8 Jan.
1987	Autumn	3	10	*5 Oct. - 8 Oct.	4 Jan. - 13 Feb.
1987	Winter	3	10	*26 Nov. - 27 Nov.	5 Apr. - 28 Apr.
			Fresh Market Tomato: Coordinated by Taichung DAIS		
1988	Summer	6	4	*15 Mar. - 3 Aug.	18 May - 21 Nov.
			Chinese Cabbage: Coordinated by Taichung DAIS		
1988	Summer	4	7	*4 June 4 - 10 Sept.	16 Sept. - 5 Nov.
			Sweet Potato: Coordinated by Chiayi TARI		
1988	Summer	6	10	14 Apr. - 15 June	8 Sept. - 26 Oct.
			Sweet Pepper		
1987	Summer	1	8	*25 Sept.	2 Dec. - 23 Feb.
			Hot Pepper		
1987	Summer	1	6	*25 Sept.	2 Dec. - 23 Feb.
			Cauliflower		
1987	Summer	1	4	*25 Sept.	11-27 Nov.
			Snapbean: Coordinated by Taichung DAIS		
1987	Autumn	3	8	4 Sept. - 1 Oct.	7 Nov. - 24 Dec.
1988	Spring	3	8	5 Feb. - 10 Mar.	19 Apr. - 13 June

*Transplanting.

B. Seed production and distribution of AVRDC promising lines for testing in Taiwan

To demonstrate the yield potential of released and promising AVRDC lines with normal plot size in farmers' field in Taiwan, AVRDC multiplied and distributed a large amount of propagating material in 1988. Among them were the seeds of Chinese cabbage, fresh market tomato and soybean variety OCB.

C. Regional yield trials

Soybean. AVRDC lines AGS 208 and AGS 215 were included in RYT in summer and autumn 1987, and AGS 253 and AGS 301 in spring 1988. The performance of AGS 208 and AGS 215 in 1987 was similar to that in 1986. Although KS 8 was the best yielder among entries, AGS 208 and AGS 215 also had similar yield. Furthermore, there were seasonal effects. AGS 208 tended to have

higher yields in summer, but lower in autumn than KS 8. There was no significant difference in protein and oil contents among entries. Results of stability analysis using the data from 49 RYTs in 1986 and 1987 showed that most lines, except TARI 7 and HL 71-27, responded similarly to environments.

Mungbean. The mungbean breeding programs in Taiwan mainly aimed to develop high and stable yielding genotypes with a) dull seeds weighing more than six grams per 100 seeds, b) uniform maturity for mechanical harvest, c) pest resistance, and d) early maturity. Due to shortage and high cost of labor, mungbean should be mechanically harvested to reduce production cost. Therefore, the uniform maturing lines developed by AVRDC are particularly suitable for Taiwan.

There were eight dull seed type AVRDC lines with two check varieties in the completed two-year RYT in summer 1986 to spring 1988. V 2010 was the check variety for seed size, and the lustrous seed type TN 3 (VC 1628 A) for yield. All AVRDC lines performed as well as TN 3 in both spring and summer. VC 3543 A and VC 3580 A in spring, and VC 3857 A in summer had lower yields compared to TN 3 (Table 2). Results of stability analysis showed that VC 3738 A and VC 3890 A did not only yield higher in both seasons but also had higher stability than TN 3 under different environments. There was no significant difference in maturity among entries, and mungbean had a shorter growth duration in summer than in spring planting. No entry had larger seeds than the check variety V 2010 in either spring or summer planting. However, VC 3890 A had the largest seeds among other entries, and its seed size was not significantly different from that of V 2010. Hence, VC 3890 A was recommended for release in Taiwan in early 1989.

A new set of entries including nine dull type AVRDC mungbean lines with the check variety, TN 3 was evaluated in RYT in summer 1988. Initial results showed that all AVRDC lines performed as well as or better than the check variety, TN 3 (Table 3). Their growth duration was similar, varying from 65 to 80 days by planting dates. Except VC 3751 A and VC 3853 A, all other entries had similar seed sizes.

Table 2. Mean yield and stability of mungbean in 18 RYTs in Taiwan, summer 1986 to spring 1988.

Entry	Spring 1987 & 1988		Summer 1986 & 1987		Mean	
	yield (t/ha)	b	yield (t/ha)	b	yield (t/ha)	b
VC 3004A	1.3 bcd	0.9	1.3 bc	0.8	1.3 cd	0.8
VC 3116A	1.4 ab	1.1	1.3 bc	0.9	1.4	0.9
VC 3543A	1.3 cd	1.0	1.3	1.1	1.3 cd	1.0
VC 3580A	1.2dc	1.1	1.3 bc	1.1	1.2 d	1.1
VC 3678A	1.3 bcd	1.2*	1.4 ab	0.7*	1.4 bc	0.9
VC 3738A	1.5 a	0.8	1.5 a	1.1	1.5 a	1.0
VC 3857A	1.3 bcd	0.8	1.1 c	1.0	1.2 d	0.9
VC 3890A	1.6 a	0.9	1.4 ab	1.0	1.5 ab	1.0
V 2010	1.1 e	1.2	1.0	1.0	1.0 e	1.1
Tainan Sel. No. 3	1.5 ab	1.0	1.3 b	1.2	1.4 bc	1.1

*Significantly different from b = 1.

Table 3. Yield and agronomic characters of mungbean entries in Taiwan regional yield trials, summer 1988.

Entry	Mean yield (t/ha)	Index	Days to maturity	100 Seeds wt (g)	Plant height (cm)	Pods/plant	Seeds/pod
VC 3737A	1.42 a	131	70.3	7.3	70.5	9.2	9.3
VC 3751A	1.09 b	100	71.7	6.5	71.0	9.3	8.2
VC 3853A	1.48 a	136	73.3	6.6	66.8	10.7	9.1
VC 3885A	1.31 ab	120	70.3	7.9	71.5	8.3	8.5
VC 3888A	1.28 ab	118	73.0	7.8	77.0	9.2	7.9
VC 3901A	1.43 a	131	71.0	7.8	76.8	9.8	9.2
VC 3907A	1.34 ab	124	72.6	7.7	73.1	9.7	8.8
VC 3928A	1.13 b	104	71.3	7.1	67.3	9.3	8.1
VC 3890A	1.23 ab	113	71.0	7.9	61.5	8.1	8.5
Tainan Sel. No.3	1.09 b	100	71.0	7.3	67.5	8.4	8.2

Processing tomato. The processing tomato breeding program in Taiwan aimed to develop high and stable yielding genotypes with heat tolerance to prolong the production period of high quality processing tomatoes. Three RYTs were conducted in late summer, autumn and winter during 1987 to 1988. These trials, including eight AVRDC F_1 hybrid processing tomatoes, were evaluated mainly for Chianan area. In late summer, several AVRDC F_1 hybrids yielded as high as the heat tolerant check F_1 hybrid, TN 3 (PT 3027), and they had a significantly larger size than the latter, especially PT 4121 (Table 4). In autumn and winter, all AVRDC F_1 hybrids performed significantly better than check varieties, TN 2 and TK 18. Their color and solid soluble content qualities were similar to those of TK 18, but TK 18 had the biggest fruit size.

Fresh market tomato. These trials were conducted in the highlands, 500-600 m above sea level. Three AVRDC F_1 hybrids were compared with a major variety in Taiwan, Known You 301. To enhance the fruit-setting under summer conditions in the lowlands, the effect of tomatotone on these entries was also studied.

All three AVRDC F_1 hybrids had significantly higher yields in all locations than Known You 301 (Table 5). Similarly, these F_1 hybrids showed heat tolerance compared to Known You 301 particularly in the lowland areas of Shanhua and Fenglin. Among entries, FMTT 22 gave the highest average yield and the highest yields in most trials.

Table 4. Yield and horticultural characters of processing tomato entries in Taiwan regional yield trial, 1987-1988.

Entry	Yield (t/ha)	Days to maturity	Fruit size (g)	PH	Soluble solids (°Brix)	Titratable acidity (%)	Hunter color (a/b)
			- Late Summer -				
PT 4026	37.4 bc	97.4	63.8	4.03	4.21	0.38	2.59
PT 4060	40.7 ab	105.0	69.3	4.10	4.34	0.36	2.51
PT 4098	38.4 abc	101.1	61.2	3.96	4.05	0.38	2.53
PT 4121	41.3 ab	101.8	82.4	3.99	3.93	0.36	2.56
PT 4165	41.9 ab	98.2	78.4	4.19	4.38	0.43	2.57
PT 4172	39.6 abc	96.4	63.2	4.03	4.10	0.38	2.54
PT 4110	32.0 cd	100.0	83.9	4.06	4.33	0.35	2.44
PT 4071	40.1 abc	97.4	56.6	3.93	3.90	0.35	2.56
TN 3	46.4 a	98.1	58.7	3.98	4.17	0.32	2.57
Peto 933	28.4 d	106.2	74.4	4.20	4.15	0.34	2.67
			- Autumn -				
PT 4026	71.6 a	112.7	63.3	4.17	4.38	0.40	2.61
PT 4060	68.0 ab	116.3	63.7	4.20	4.69	0.39	2.53
PT 4098	67.9 ab	113.8	66.2	4.18	4.15	0.38	2.52
PT 4121	65.8 ab	115.1	78.9	4.25	4.17	0.37	2.53
PT 4165	71.3 a	113.7	80.2	4.19	4.52	0.44	2.54
PT 4172	69.3 a	111.3	56.3	4.17	4.22	0.39	2.51
PT 4110	54.4 cd	115.6	85.8	4.25	4.20	0.38	2.47
PT 4071	57.4 bc	111.3	51.7	4.18	3.79	0.36	2.53
TN 2	44.8 de	121.3	67.7	4.29	4.66	0.34	2.58
TK 18	42.8 e	116.6	101.0	4.31	4.26	0.84	2.66
			- Winter -				
PT 4026	104.6 bc	122.9	67.3	4.28	4.21	0.32	2.69
PT 4060	116.3 ab	127.7	74.9	4.27	4.30	0.33	2.63
PT 4098	110.0 ab	125.5	67.4	4.27	4.14	0.34	2.65
PT 4121	112.9 ab	127.5	80.7	4.26	4.05	0.33	2.60
PT 4165	119.3 a	123.7	79.1	4.23	4.03	0.37	2.51
PT 4172	106.6 ab	122.4	67.1	4.26	4.12	0.34	2.61
PT 4110	108.9 ab	126.9	95.5	4.28	4.18	0.32	2.58
PT 4071	108.0 ab	125.1	57.8	4.24	4.06	0.34	2.56
TN 2	92.8 cd	130.1	83.2	4.32	4.28	0.31	2.78
TK 18	82.8 d	124.8	123.6	4.30	3.91	0.34	2.71

Application of tomatotone dramatically increased the fruit yield of fresh yield of fresh market tomato, particularly AVRDC F_1 hybrids (Table 6). The fruit size also slightly increased.

Chinese cabbage. Yields of Chinese cabbage had substantial variations among locations in 1988 summer RYT. The average yields across entries varied from 12.1 t/ha in Tainan DAIS to 24.6 t/ha at AVRDC (Table 7). The former was direct seeded on 4 June, while the latter was transplanted on 10 September. The low yield of 82-156 in Tainan DAIS indicated the insufficiency of water and nutrients, considering that it is a high-yielding variety and requires high inputs. Low yield was also attributed to low heading rate (41%), compared to the higher rates (92, 95 and 97%) in the previous RYTs.

All four AVRDC lines performed similarly to the check variety, Kang-Ping *2, in all locations, except in Taoyuan and Tainan DAIS where 82-156 and Kang-Ping *2 had the highest yield, respectively. The internal rot/tip burn, found mainly in Taichung last year was a serious problem for Chinese cabbage production in Taoyuan this summer.

Table 5. Yield of fresh market tomato entries in Taiwan regional yield trials, 1988.

Entry	Yield (t/ha)							Mean	Index
	AVRDC		Yuchi B.S.		Yilan B.S.		Hualien DAIS		
	Shanhua (I)	Shanhua (II)	Yuchi	Hsinyi	Shanshin	Tatung	Fenglin		
FMTT 3	41.7 a	4.3	57.0 b	55.5 a	41.2 ab	48.4 ab	12.1 a	37.2	182
FMTT 22	46.3 a	5.6	63.8 a	61.4 a	42.4 a	50.0 a	20.2 a	41.4	202
FMTT 33	36.0 ab	4.4	56.5 b	57.9 a	40.5 b	47.8 ab	20.2 a	37.6	184
Known You 301	20.7 b	0.6	24.2 c	29.0 b	–	45.7 bc	2.8 b	20.5	100

Table 6. Yield and horticultural characters of fresh market tomato entries in spray tomatotone trial in AVRDC, summer 1988.

Entry	Treatment	Yield (t/ha)	Days to maturity	Fruit size (g)
FMTT 3	Without tomatotone	4.3 a	96.1	112.5 ab
FMTT 22	"	5.6 a	98.6	102.0 bc
FMTT 33	"	4.4 a	99.8	95.3 c
Know You 301	"	0.6 b	103.9	118.1 a
FMTT 3	With tomatotone	12.4 a	95.3	130.1
FMTT 22	"	9.7 ab	96.0	105.4
FMTT 33	"	8.0 b	96.8	106.4
Known You 301	"	3.2 c	100.3	122.2

Table 7. Yield and horticultural characters of Chinese cabbage entries in Taiwan regional yield trials, summer 1988.

Entry	Yield (t/ha)					Index	Days to maturity		Mean head wt. (g)
	AVRDC	Tainan DAIS	Taichung DAIS	Taoyuan DAIS	Mean		Direct seeding	Trans-planting	
86181	27.5 ab	11.3 c	24.3	14.8 bc	19.5	105	54	48.2	673
86182	25.4 abc	14.1 b	23.2	16.8 bc	19.9	107	54	51.1	623
86186	21.9 c	14.7 b	20.6	19.9 b	19.3	103	54	47.7	608
86187	23.7 bc	11.4 c	26.1	17.5 bc	19.7	105	54	48.0	648
82-156	26.3 abc	3.9 d	17.9	27.7 a	19.0	102	54	51.4	578
Kang-Ping #2	23.0 bc	17.4 a	17.0	17.2 bc	18.6	100	54	47.9	531
Mean	24.6	12.1	21.5	19.0	19.3				

Sweet potato. The sweet potato RYT had a new set of entries including three from AVRDC. The average yields in six locations and nutrient contents in storage roots of entries in the 1988 summer RYT are shown in Table 8. C 73-94 was the best yielder among entries. AVRDC lines yielded similarly to the check cultivar, TN 66. However, dry matter content of AVRDC lines increased, and their sugar content was reduced.

Sweet pepper. The summer planting had low yield similar to that in spring, and small fruits as that in autumn. This was attributed to severe virus infection. Among entries, Gypsy gave the highest yield in two cropping seasons, while Gypsy and Dalbon had smaller fruits than other entries (Table 9).

Hot pepper. Similar to sweet pepper, hot pepper in summer did not perform as well as in spring or in autumn because of a virus problem. There was no significant difference in marketable yield among entries. Farmer's Newcomer and Hungarian Yellow Wax were not only the earliest maturing cultivars, but also had the biggest fruits among entries.

Table 8. Yield and nutrient contents of sweet potato entries in Taiwan regional yield trials, summer 1988.

Entry	Mean marketable root yield (t/ha)	Index	Dry matter (%)	Protein	Sugar	Starch	Fiber
				(% DWB)			
C 71-60	14.4 abc	93	30.0	5.3	8.8	75.1	2.7
C 71-92	11.0 c	71	34.9	5.3	5.9	82.1	2.2
C 72-100	7.2 d	46	34.0	4.3	10.2	73.3	2.7
C 73-94	17.1 a	110	22.6	7.5	14.9	59.0	4.2
C 73-508	15.5 ab	100	23.0	8.2	14.0	57.9	4.4
CN 1489-89	15.9 ab	103	32.0	5.6	8.7	76.0	2.6
CN 1525-11	12.9 bc	83	30.9	5.5	9.1	74.8	2.9
CN 1517-142	12.2 bc	78	30.7	6.3	9.7	74.1	3.0
CN 66 (CK1)	15.5 ab	100	24.1	7.6	13.9	61.0	3.8
CN 1108-13 (CK2)	16.2	104	24.3	6.0	13.5	68.2	3.1
King-ming (CK2)	16.7	108	23.5	3.3	14.6	66.8	3.3

Table 9. Yield and horticultural characters of sweet pepper entries in Taiwan regional yield trials in AVRDC, summer 1987.

Entry	Marketable yield (t/ha)	Fruit size (g)	Days to maturity	Fruit length (cm)	Fruit width (cm)
Blue star	14.7 ab	93	95.7	10.6	6.0
Gypsy	17.1 a	50	94.5	10.0	4.2
Dalbon	12.3 bc	41	90.4	10.2	4.4
Green bell	14.1 ab	80	95.3	11.6	5.6
Giant bell	14.8 ab	92	97.8	12.3	5.5
VD Berg (0506)	14.2 ab	89	92.2	9.7	5.8
3856	12.3 bc	81	99.1	10.5	6.1
0329	9.1 c	92	96.7	9.7	5.9

Cauliflower. Transplanted on 25 September 1987, this RYT was a late summer planting. At growth stage, the mean air temperature was 25.1°C, which was higher than (24.8°C) in autumn 1986 RYT, but lower than (26.7°C) in late spring 1987 RYT. Yields of cauliflowers seemed to follow a reverse trend among seasons. There was no significant difference in yield among entries (Table 10). However, F_1 451 tended to have higher yield and mean head weight than other entries. Its significantly shorter head height and width than the check variety (45 days) seemed to indicate that F_1 451 had a denser head.

Mustard. Generally, the performance of entries in this autumn 1987 RYT was similar to that in 1986 autumn RYT, except that days to maturity increased a little in all entries and Tender green increased its yield. Both Chihsingley and Tender green had similar yields to the check variety, Ta Peng Pao (Table 11). The low yielding Gisilba had an extraordinarily greater number of leaves.

Snap bean. The snap bean RYTs were carried out with and without fungicides last year. However, results showed that there was no significant difference in yield of snap bean among treatments, although the fungicide-treated Witsa had the highest yield. Therefore, all entries had not been sprayed with fungicides this year, except Witsa and Paichia 7. Results showed that all entries outyielded the check cultivar, Thailand, and fungicide- treated Witsa in autumn (Table 12). There was no significant difference in yield among entries in spring. Taichung 16 was released as Taichung No.1 in Taiwan in November 1988.

Table 10. Yield and horticultural characters of cauliflower entries in regional yield trial in AVRDC, summer 1987.

Entry	Yield (t/ha)	Days to maturity	Mean growth (g)	Mean head wt.(g)	Head length (cm)	Head width (cm)	Plant length (cm)	Plant width (cm)
F_1 451	16.9	54.1 c	1107	677	11.1 b	13.8 b	42.6 b	20.6 b
Fengshan extra early	8.8	60.0 ab	1012	377	11.8 b	13.9 b	42.7 b	18.9 c
Chia Tai No. 1	13.0	57.0 bc	1146	515	12.6 a	13.8 b	44.1 b	17.3 d
45 days (CK)	10.9	60.8 a	1263	454	13.1 a	15.0 a	48.7 a	21.6 a

Table 11. Mustard yield trial in AVRDC, autumn 1987.

Entry	Days to maturity	Leaf no./plant	Leaf length (cm)	Leaf width (cm)	Plant wt.(kg)	Yield (t/ha)
Gisilba	37 b	189.6 a	14.1 d	4.8 c	0.4 c	10.5 b
Tender Green	35 b	58.2 b	63.1 a	24.1 b	1.6 b	40.5 a
Chihsingley	50 a	25.2 c	41.4 b	31.5 a	1.8 a	44.1 a
Ta Peng Pao	50 a	27.1 c	38.6 c	32.2 a	1.8 a	41.6 a

Date Sown: 17 Sept., 1987. Date Harvested: 21 Oct.- 5 Nov., 1987.

Table 12. Yield and horticultural characters of snap bean entries in Taiwan regional yield trials.

Entry	Autumn 1987			Spring 1988		
	Yield (t/ha)	Days to maturity	Pod length (cm)	Yield (t/ha)	Days to maturity	Pod length (cm)
Taichung #11	19.3 a	69.6	16.0	22.5	85.1	14.4
Taichung #12	16.0 a	73.3	16.4	20.9	84.6	15.0
Taichung #16	16.8 a	70.9	16.3	21.0	84.1	15.5
Black creasback	16.4 a	70.8	15.3	19.8	84.7	13.7
Thailand	11.3 b	63.9	17.2	17.5	79.2	15.6
*Witsa	12.5 b	68.7	19.2	21.3	81.5	19.4
*Paichia 7"	16.9 a	71.5	14.8	20.5	84.9	13.5

*Witsa and Paichia 7" with fungicides for rust in AVRDC.

Studies on Vegetable Soybean Seed Production

Summary

To improve the quality and supply of vegetable soybean in Taiwan, the influence of seed production techniques, including plant population density, seed drying and storage conditions, and size of seed sown, on pod and seed yields, were studied. It was found that a density of 40 plants per square meter should be maintained in all seasons; the seed drying temperatures of 30° or 45°C did not affect germination rate; seeds should be stored under low temperature (10°C); and it is not necessary to select the large- seeds within the same variety for vegetable soybean seed production.

Introduction

Vegetable soybean is an important export commodity in Taiwan. However, the seed supply for propagation depends mainly on importation from Japan, and the quality of seeds produced locally is not reliable. In cooperation with the Kaohsiung District Agricultural Improvement Station (DAIS), and supported by the Council of Agriculture (COA), AVRDC carried out this project to improve the quality and stabilize the supply of vegetable soybean in Taiwan. Three experiments including studies on population density, seeds drying and effect of seed size on seed and pod yields were conducted.

Materials and Methods

The soybean cultivars, KS 1 and Tzurunoko (205) were tested under three densities (40, 20 and 13 plants/m^2) with two levels of nitrogen (60 and 80 kg/ha) in summer and autumn 1987, and spring 1988. A split-split plot design with four replications was used. The sub-subplot size was 5 m × 3 m. Seed and pod yields and 100-seed weight were recorded at harvest.

In the seed drying experiment, KS 1, 205, and 305 were studied under two drying temperatures (30°C and 45°C) and two storage conditions (packaged in plastic bags and stored under room temperature and 10°C in a cold room). Seed germination rates under different treatments were observed before storage, one and six months after storage.

On the effect of seed size on seed and pod yields, seeds of 205 were grouped in four different sizes (100-seed weight of 36, 32, 28, and 22 gm) and grown in three planting seasons, i.e. summer and autumn 1987, and spring 1988. A RCB design with four replications was used. The plot size was 5 m × 3 m. Yields of fresh pods and dry seeds, and 100-seed weight were recorded.

Results and Discussion

Results of population density trials showed that marketable yields of vegetable soybeans were relatively low in three seasons (Table 13). This was caused mainly by the damage of typhoons in summer and autumn in 1987, and unusually low temperature in spring 1988. Nevertheless, KS 1 significantly outyielded 205 in all seasons. The highest density of 40 plants per square meter had the highest yield among densities tested. There was a significant interaction on cultivars and densities; KS 1 had a higher density than 205. There was no significant difference in yield between nitrogen treatments.

The germination rate of three vegetable soybeans sharply decreased after six-month storage under room temperature (Fig. 1). The cold storage (10°C) is an effective way to maintain the vigor of vegetable soybean seeds. The drying temperatures (30°C and 45°C) did not affect germination rate. The germination rates tested in petri dishes were highly correlated with those in the field ($r = 0.982^{**}$), though the latter were a little lower. The sizes of seeds sown did not affect the pod yield, nor the seed yield of 205. Hence it is not necessary to select large seeds within the same variety for vegetable soybean production.

Table 13. Effects of population density on total plant weight, total and marketable pod yields of vegetable soybean.

Treatment	Summer 1987 (t/ha)			Autumn 1987 (t/ha)			Spring 1988 (t/ha)		
	total plant wt.	total pod yield	marketable pod yield	total plant wt.	total pod yield	marketable pod yield	totat plant wt.	total pod yield	marketable pod yield
V1 (205)	11.4 b	6.8	1.1 b	12.4	6.5 b	2.1 b	16.2 a	10.1 a	2.8 b
V2 (KS 1)	13.9 a	7.4	2.2 a	12.8	7.0 a	3.0 a	13.3 b	8.5 b	4.1 a
D1 (10 cm 2 plants)	13.6 a	7.7	1.9	14.5 a	7.8 a	2.8 a	18.2 a	11.5 a	4.0 a
D2 (10 cm 1 plant)	12.8 ab	7.1	1.5	12.5 b	6.7 b	2.6 a	13.7 b	8.5 b	3.1 b
D3 (15 cm 1 plant)	11.5 b	6.5	1.6	10.9 c	5.7 c	2.3 b	12.3 c	7.9 c	3.1 b

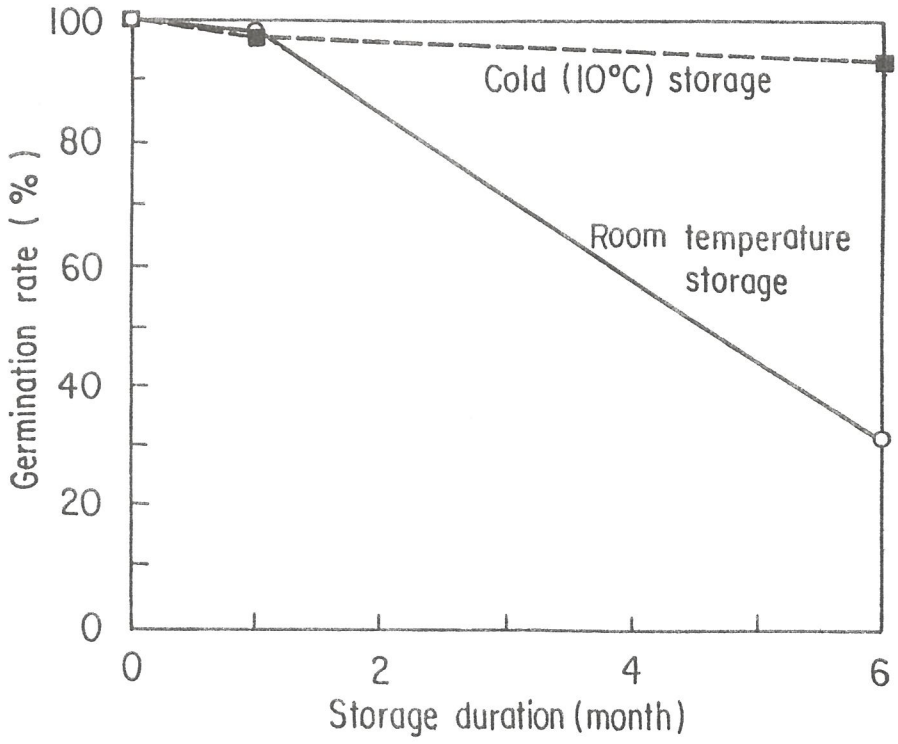

Fig. 1. Relationship of storage temperature and duration on germination rates of vegetable soybean seeds.

Mechanical Harvesting of Mungbean and Processing Tomato

Summary

Mechanical harvesting has the potential to reduce high labor cost in mungbean and processing tomato production in Taiwan. This project aimed to study the cost management of mechanical harvesting. It aimed to evaluate suitable defoliants and dosages for mungbean and proper population densities for tomato. It was concluded that 99% Sodium chlorate diluted 300 times should be sprayed on mungbean at 80% pod maturity if these were to be mechanically harvested and one-meter row width was found better than two meters for tomato to be harvested once-over in winter.

Introduction

High harvesting cost is one major factor limiting both mungbean and processing tomato production in Taiwan. In 1988, AVRDC, in cooperation with Tainan DAIS and supported by COA studied the management of its mandate crops for mechanical harvesting. The study on mungbean mainly aimed to evaluate suitable defoliants and dosages, since uniform maturity has been genetically improved. The effects of high population densities on tomato for harvest once-over were studied.

Materials and Methods

Mungbean. A preliminary experiment was conducted using Ethrel, Urea, Paraquat, Glyphosate, and Sodium chlorate, each in three dilutions and applied at two stages (50% and 100% pods maturity).

Seed yields, 100-seed weight, hard seed rate, seed germination rate, and leaf drying rates were investigated.

Glyphosate and sodium chlorate were selected for further testing in summer 1987 and spring 1988 on VC 1628 A and VC 3738 A. A split plot design with four replications and chemical treatments in the main plot was used. The plot size was 5 m × 2 m.

Processing tomato. Nema 1401 was transplanted on 30 September and 17 November 1987 with two in-between row spacings (1.5 and 1 m) and three within-row distances (15, 20 and 30 cm). A randomized complete block design with three replications was used. Plot size was 6 m × 3.6 m. Tomato yield and average fruit size were recorded.

Results and Discussion

Mungbean. Preliminary results showed that there were no significant differences in yield, 100-seed weight, hard seed rate or germination rate among chemical treatments and control. Glyphosate, Sodium chlorate, and Paraquat were more effective for leaves drying on the vine than Ethrel and Urea. However, Paraquat had a much lower LD50 (153 mg/kg) than the others (about 5,000 mg/kg). Hence, Glyphosate and Sodium chlorate were selected for further testing.

Compared to the control, the application of Sodium chlorate and Glyphosate did not affect the yield and 100-seed weight of mungbean. Sodium chlorate was found more effective in drying mungbean leaves on the vine than Glyphosate. The former took about two days, while the latter took four days to have more than 90% of the leaves dried. Sodium chlorate was registered in USA as a harvest-aid for sorghum, cotton, rice and soybean. Its cost is not much different from that of Glyphosate. Hence it was recommended that 99% Sodium chlorate diluted to 300 times of volume should be sprayed on mungbean at 80% pod maturity if these would be mechanically harvested. This technique had been validated in farmer's fields and was found promising.

Processing Tomato. Tomato yield was relatively low in the autumn trial. Spacing did not significantly affect tomato yield, and fruit size. This was mainly attributed to the severe infection of bacterial spot during the early growth of the plant. In winter, row width significantly affected tomato yield, while an increase in the number of plants per hill reduced fruit size. It seemed that decreasing the row width is the best arrangement to increase population density. If mechanical harvesting is possible, one meter row width is better than two meters in winter planting.

Soil Science

Soybean Continuous Cropping

Summary

From 1983 to date, soybean has been cultivated two or three times a year in spring, summer and autumn on the same land. Total yield per year of AGS 129 and KS 8 reached 10.6 and 9.0 t/ha, respectively, in 1987. But in spring 1988, charcoal rot disease developed in all experimental plots, causing a decrease in yield particularly in KS 8 which was severely affected.

Introduction

This project aimed to establish an adequate fertilization and soil management technique for soybean in continuous cropping, and to determine how long soybean can be continuously cultivated on the same land without a great decrease in yield.

Materials and Methods

Soybean has been cultivated successively on the same land twice a year, in spring and autumn, since autumn of 1983. In summer, all experimental plots were covered with rice straw to save labor on weeding and protect the soil from rain. Just before cultivation in autumn, rice straw was plowed into the soil of the experimental plots. Only the pods were harvested; the rest of the plants were plowed. In 1986 and 1987, soybean was cultivated in spring, summer and autumn. In summer 1988, all experimental plots were submerged in water and later covered with clear plastic sheets for solarization. The cropping sequence is presented in Figure 1.

The experiment was conducted using a split-plot design with two replications. The main plot consisted of Kaohsiung #8 (KS 8) as a check (a broad-leaf dominant cultivar in Taiwan) and AGS 129, an AVRDC advanced line (narrow leaf type). Details of the subtreatment are summarized in Table 1.

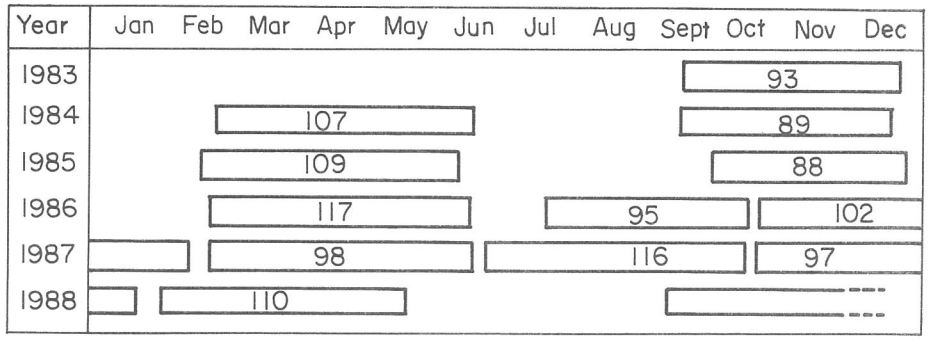

Fig. 1. Cropping sequence of soybean. Numerals in the figure indicate days of growth duration.

Table 1. Treatments in continuous cropping of soybean.

Main plot: Cultivars AGS 129 and Kaohsiung 8 Subplot : Compost application (50 t/ha) w/wo Fertilization (kg/ha)	N	P_2O_5	K_2O
Basal	60	90.0	60
Top 1[z]	30	7.5	30
Top 2[y]	30	7.5	30
Total	120	105.0	120

[z]10 days after R_1. [y]10 days after R_4.

Results and Discussion

The yield of each cultivar in continuous cropping is presented in Figures 2 and 3. Soybean plants showed symptoms of continuous cropping hazards after 10 successive cultivations.

In spring 1988, charcoal rot (*Macrophomina phaseolina*) developed widely. Infected plants suffered from light brown discoloration of the internal tissues in the lower stems and upper taproots, after which leaves became chlorotic and wilted. Thus, yield of infected plants decreased.

Charcoal rot control was done by solarization in summer 1988. The yield in autumn 1987 was 2.4 t/ha for both cultivars. AGS 129 and KS 8 attained yields of 2.9 and 3.9 t/ha, respectively, in spring 1988.

The total yield in spring, summer and autumn of AGS 129 and KS 8 reached 10.6 and 9.0 t/ha in 1987, respectively.

Evaluation of Soybean Yield Increase

Introduction

Soybean yield in AVRDC has increased yearly, more than double in 14 years from 1.9 t/ha in spring 1973 to 4.6 t/ha in spring 1987.

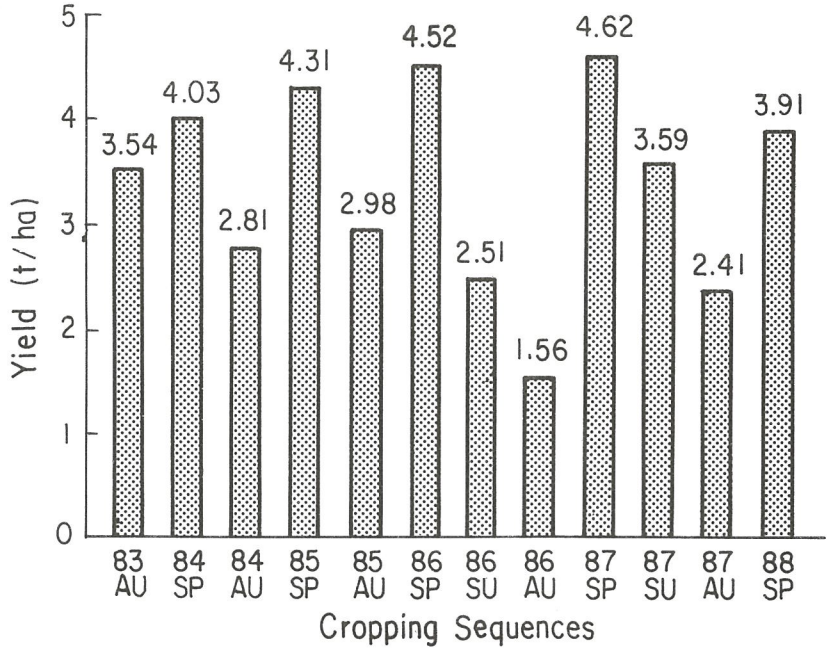

Fig. 2. Changes in yield of continuous cropping soybean AGS 129 from autumn 1983 to spring 1988. Numerals in the figure show yield (t/ha). SP = spring planting, SU = summer planting, AU = autumn planting.

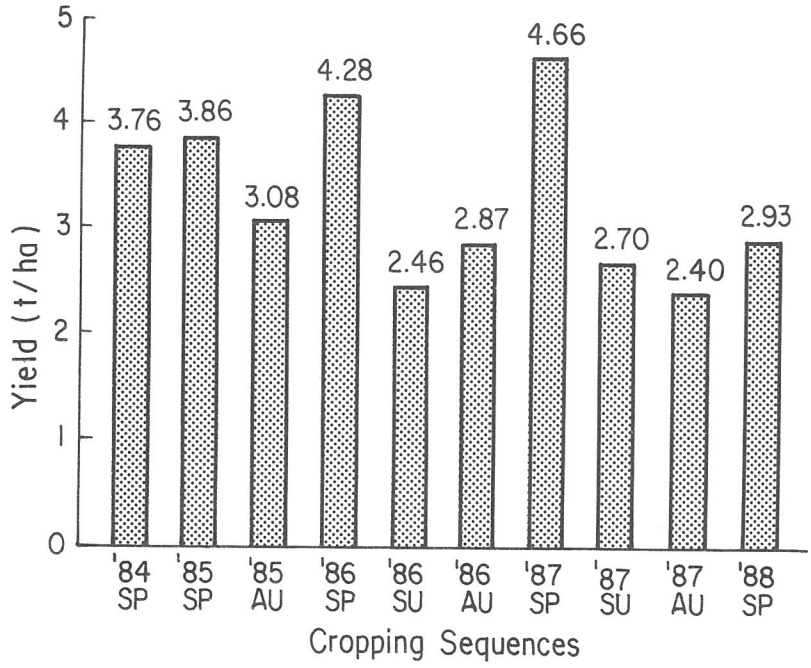

Fig. 3. Changes in yield of continuous cropping soybean KS 8 from spring 1984 to spring 1988. Abbreviations are the same as in Fig. 2.

This experiment evaluated the efficacy of various techniques such as disease and pest control, fertilizer application and varietal improvement in increasing soybean yield under AVRDC conditions.

Materials and Methods

The experiment was conducted in spring 1988. A split-split plot design with two replications was used. The main plot adopted disease and pest control by chemical spraying at one week to 10 day intervals for the improved method and four times through growing period for the traditional method. The subplot used basal fertilizer application for the improved ($N:P_2O_5:K_2O$ = 80 (40+20+20): 100:120 kg/ha) and traditional methods ($N:P_2O_5:K_2O$ = 40:60:80 kg/ha). The sub-subplot made use of AGS 129 and ordinary Shi-shi.

The plot size was 16 m^2. Population density was 40,000 plants/ha. All plots were sown on 26 January and harvested on 17 May for Shi-shi and 1 June 1988 for AGS 129.

At R_2, R_4 and R_6 stages, plant samples were randomly collected from an area of 0.5 m^2 in each plot. Yield and yield component were surveyed at the R_8 stage.

Results and Discussion

The selected growth parameters, dry matter accumulation and yield components of soybean in different stages are shown in Tables 2-10. There was no significant difference between the yield of treatments using the improved method and the traditional disease pest control method. The same tendency was observed on the effect of fertilizer applications. However, there was a significant difference in yield between the two different cultivars. The yields of improved cultivar AGS 129 and ordinary cultivar Shi-shi were 5.0 and 3.2 t/ha, respectively. Also, AGS 129 had a different growth rate and pattern from Shi-shi.

The yield of soybean in AVRDC has increased gradually every year. The yield reached 4.6 t/ha in spring 1987, more than twice the 1.9 t/ha in spring 1973.

Table 2. Selected growth parameters at R_2 stage, spring 1988.

Treatment	Plant height (cm)	Leaf no.	Flower no.	Node no.	Branch no.
Main plot					
Disease-pest control					
Recommended	28.1 a*	13.7 a	2.5 a	8.3 a	2.3 a
Ordinary	27.9 a	13.0 a	2.4 a	8.1 a	2.2 a
Sub-plot: Fertilizer					
80-100-120	28.5 a	13.3 a	2.3 a	8.1 a	2.3 a
40-60-80	27.6 a	13.4 a	2.7 a	8.2 a	2.2 a
Sub-subplot					
AGS 129	28.7 a	14.7 a	2.3 a	8.6 a	2.5 a
Shi-shi	27.4 a	12.0 b	2.7 a	7.7 b	2.0 b

*Numbers with the same letter are not significantly different at 5% level by DMRT.

Table 3. Dry matter accumulation in each plant part at R_2 stage, spring 1988.

Treatment	Root dry wt.	Stem dry wt.	Leaf dry wt.	Petiole dry wt.	Total dry wt.
Main plot		plant			
Disease-pest control					
Recommended	0.44 a*	0.83 a	1.96 a	0.42 a	3.64 a
Ordinary	0.41 a	0.82 a	1.84 a	0.38 a	3.45 a
Sub-plot: Fertilizer					
80-100-120	0.43 a	0.81 a	1.90 a	0.40 a	3.54 a
40-60-80	0.42 a	0.84 a	1.90 a	0.40 a	3.56 a
Sub-subplot					
AGS 129	0.47 a	0.97 a	2.00 a	0.42 a	3.86 a
Shi-shi	0.40 b	0.68 b	1.80 b	0.37 b	3.23 b

*Numbers with the same letter are not significantly different at 5% level by DMRT.

Table 4. Selected growth parameters at R_4 stage, spring 1988.

Treatment	Plant height (cm)	Leaf no.	Node no.	Branch no.	Pod no. < 2 cm	Pod no. < 2 cm
Main plot						
Disease-pest control						
Recommended	47.4 a*	19.4 a	11.1 a	2.8 a	5.0 a	12.7 a
Ordinary	46.9 a	19.5 a	11.0 a	3.0 a	5.7 a	12.5 a
Sub-plot: Fertilizer						
80-100-120	47.9 a	19.4 a	11.1 a	2.9 a	5.2 a	13.0 a
40-60-80	46.4 a	19.5 a	11.0 a	2.9 a	5.5 a	12.1 a
Sub-subplot						
AGS 129	51.5 a	21.9 a	12.2 a	3.4 a	3.8 b	13.7 a
Shi-shi	42.8 b	17.1 b	9.9 b	2.4 b	6.9 a	11.5 a

*Numbers with the same letter are not significantly different at 5% level by DMRT.

Table 5. Dry matter accumulation in each plant part at R_4 stage, spring 1988.

Treatment	Root dry wt.	Stem dry wt.	Leaf dry wt.	Petiole dry wt.	Pod dry wt.	Total dry wt.
Main plot			**plant**			
Disease-pest control						
Recommended	0.86 a*	2.42 a	3.81 a	1.35 a	0.144 a	8.59 a
Ordinary	0.84 a	2.41 a	3.96 a	1.26 a	0.157 a	8.62 a
Sub-plot: Fertilizer						
80-100-120	0.87 a	2.44 a	3.90 a	1.31 a	0.149 a	8.67 a
40-60-80	0.84 a	2.39 a	3.88 a	1.29 a	0.151 a	8.54 a
Sub-subplot						
AGS 129	0.91 a	2.74 a	4.07 a	1.37 a	0.118 b	9.20 a
Shi-shi	0.79 b	2.10 b	3.70 b	1.24 b	0.183 a	8.01 b

*Numbers with the same letter are not significantly different at 5% level by DMRT.

Table 6. Selected growth parameters at R_6 stage, spring 1988.

Treatment	Plant height (cm)	Leaf no.	Node no.	Branch no.	Pod no.
Main plot					
Disease-pest control					
Recommended	61.4 a*	21.4 a	13.6 a	2.6 a	30.0 a
Ordinary	60.1 a	21.8 a	13.5 a	2.6 a	31.1 a
Sub-plot: Fertilizer					
80-100-120	60.7 a	21.6 a	13.5 a	2.5 a	30.1 b
40-60-80	60.9 a	21.7 a	13.6 a	2.6 a	31.0 a
Sub-subplot					
AGS 129	79.4 a	25.5 a	16.0 a	2.8 a	35.7 a
Shi-shi	42.1 b	17.8 b	11.1 b	2.3 b	25.4 b

*Numbers with the same letter are not significantly different at 5% level by DMRT.

Table 7. Dry matter accumulation in each plant part at R_6 stage, spring 1988.

Treatment	Root dry wt.	Stem dry wt.	Leaf dry wt.	Petiole dry wt.	Hull dry wt.	Seed dry wt.	Total dry wt.
Main plot			**plant**				
Disease-pest control							
Recommended	1.01 a*	4.06 a	4.59 a	1.71 a	3.80 a	6.51 a	21.67 a
Ordinary	0.99 b	3.86 a	4.62 a	1.53 a	3.98 a	6.50 a	21.48 a
Sub-plot: Fertilizer							
80-100-120	1.05 a	3.98 a	4.61 a	1.62 a	3.89 a	6.58 a	21.74 a
40-60-80	0.95 a	3.95 a	4.59 a	1.62 a	3.88 a	6.43 a	21.42 a
Sub-subplot							
AGS 129	1.08 a	5.16 a	5.28 a	1.87 a	4.39 a	6.66 a	24.43 a
Shi-shi	0.93 b	2.76 b	3.93 b	1.37 b	3.38 b	6.36 a	18.73 b

*Numbers with the same letter are not significantly different at 5% level by DMRT.

Table 8. Selected growth parameters at R_8 stage, spring 1988.

Treatment	Plant height (cm)	Node no.	Branch no.	Pod no.	Seed no.
Main plot					
Disease-pest control					
Recommended	60.4 a*	13.3 a	2.1 a	27.5 a	53.4 a
Ordinary	59.2 a	13.2 a	2.2 a	27.1 a	53.3 a
Sub-plot: Fertilizer					
80-100-120	58.7 a	13.3 a	2.2 a	27.7 a	54.7 a
40-60-80	60.8 a	13.2 a	2.1 a	26.9 a	52.1 a
Sub-subplot					
AGS 129	78.0 a	15.9 a	2.5 a	32.4 a	65.7 a
Shi-shi	41.5 b	10.6 b	1.8 b	22.2 b	41.1 b

*Numbers with the same letter are not significantly different at 5% level by DMRT.

Table 9. Dry matter accumulation in each plant part at R_8 stage, spring 1988.

Treatment	Root dry wt.	Stem dry wt.	Leaf dry wt.	Petiole dry wt.	Hull dry wt.	Seed dry wt.	Total dry wt.
Main plot			plant				
Disease-pest control							
Recommended	0.92 a*	4.06 a	3.35 a	1.18 a	3.51 a	10.66 a	23.67 a
Ordinary	0.87 a	3.77 a	2.41 a	0.87 a	3.44 a	10.18 a	21.53 a
Sub-plot: Fertilizer							
80-100-120	0.94 a	3.95 a	2.85 a	1.03 a	3.54 a	10.72 a	23.02 a
40-60-80	0.86 a	3.87 a	2.91 a	1.02 a	3.41 b	10.12 a	22.19 a
Sub-subplot							
AGS 129	1.14 a	5.32 a	3.07 a	1.21 a	4.02 a	12.80 a	27.56 a
Shi-shi	0.66 b	2.51 b	2.68 a	0.83 b	2.92 b	8.04 b	17.64 b

*Numbers with the same letter are not significantly different at 5% level by DMRT.

Table 10. Yield components of soybean at R_8 stage, spring 1988.

Treatment	Pod no.	Seed no.	Seed dry wt (g/pl)	100-seed weight (g)	Seed /pod	Yield (t/ha)
Main plot						
Disease-pest control						
Recommended	27.5 a*	53.4 a	10.66 a	19.70 a	1.93 a	4.2 a
Ordinary	27.1 a	53.3 a	10.18 a	18.73 a	1.96 a	4.0 a
Sub-plot: Fertilizer						
80-100-120	27.7 a	54.7 a	10.72 a	19.42 a	1.96 a	4.0 a
40-60-80	26.9 a	52.1 a	10.12 a	19.01 a	1.93 a	4.0 a
Sub-subplot						
AGS 129	32.4 a	65.7 a	12.80 a	18.91 a	2.03 a	5.0 a
Shi-shi	22.2 b	41.1 b	8.04 b	19.52 a	1.86 b	3.2 b

*Numbers with the same letter are not significantly different at 5% level by DMRT.

Effects of Silicate Potassium, Uniconazole and Methionine on Soybean Yield

Summary

The effects of silicate potassium, uniconazole and methionine on soybean yield were tested in spring 1988.

There were no significant differences in yield between plots using the slow releasing potassium fertilizer K_2SiO_2 and KCl. Likewise, no significant difference between treatments was observed on soybean growth and yield using methionine as an ethylene precusor.

Uniconazole retarded plant height of soybean and prevented lodging effectively. It increased soybean yield but no significant differences were observed among yields.

Introduction

This trial aimed to establish the maximum attainable yield of soybean in the tropics by controlling the yield limiting factors. Silicate potassium as a slow releasing fertilizer, uniconazole as a growth retardant preventing lodging, and methionine as an ethylene precursor, were tested to increase soybean yield in spring 1988.

Materials and Methods

The experiment was conducted in a split-split plot design with two replications. The main plot consisted of two potassium fertilizers, KCl as a check and K_2SiO_2 as a slow releasing fertilizer. Details of the subtreatment are summarized in Table 11.

All plots were sown on 26 January 1988 and harvested on 19 May 1988. At R_2, R_4 and R_6 stage, plant samples were collected from a 0.5 cm^2 area in each plot. The yield and yield components were also surveyed.

Table 11. Treatment in soybean yield trial, spring 1988.

Treatment				
Main plot: KCl and K_2SiO_2				
Sub plot: Check and spray 1000 ppm of methionine from R_1 stage, once a week for 3 weeks.				
S-sub plot: Check and spray 30 ppm of uniconazole at R_2 stage.				
Plot size: 40 m^2				
Cultivar: AGS 129				
Population: 40,000 plant/ha				
Fertilization (kg/ha)				
	N	P_2O_5	K_2O	Remark
Basal	40	100	60	30 t/ha compost
Top at V_5	20		60	
Top at R_5	20			
Total	80	100	120	

Results and Discussion

Effect of K_2SiO_2 fertilizer. The growth of soybean in K_2SiO_2 fertilized plot was better than in the KCl plots but there was no significant difference in yield between plots receiving the two different kinds of potassium fertilizers.

Effect of Methionine. Foliar spray of methionine slightly reduced plant height during growth stage but there was no significant difference in either growth or yield between treatments.

Effect of Uniconazole. With the foliar spray of 30 ppm of uniconazole at R_2 stage, there were differences in plant height, leaf, node and branch number between treatments. Uniconazole reduced growth significantly. Four weeks before harvesting, all plots were lodged by heavy rains, but plots applied with uniconazole were less lodged (30%) than check plots (80%). Yields and yield components of uniconazole plots were a little better than check plots, but there were no significant differences.

Effect of Methionine on Tomato Yield

Introduction

This experiment evaluated the effect of methionine, an ethylene precursor, on tomato yield.

Materials and Methods

The experiment was conducted during cropping of tomato in winter 1987. A randomized complete block design with eight replications was adopted. The seeds of TK No. 10 were sown on 25 September 1987. The seedlings were transplanted to the field on 21 October 1987. Fertilizer was applied at different rates (Table 12). Foliar application of methionine was carried out at four weeks after transplanting.

Table 12. Fertilizer application on tomato (kg/ha).

	N	P_2O_5	K_2O	Remarks
Basal	90	135	90	#39 (12-16-12)
Top 1	60	15	30	* 1 (20-5-10)
Top 2	60	60	60	* 43 (15-15-15)
Total	210	210	180	

*Basal was applied before transplanting, top 1 at three WAT, and top 2 at six WAT.

Results and Discussion

Foliar application of methionine four weeks after transplanting caused highly significant increase in yield. The increase in yield was mainly due to an increase in fruits at later harvesting (Table 13).

Fruit-setting was surveyed 11 weeks after transplanting (Table 14). There was no significant difference among treatments in the number of fruits and clusters on the main stems. However, there was a significant difference among treatments in primary tillers; plots applied with methionine had larger fruits and more clusters. The number of clusters on the secondary tillers also increased significantly with methionine application.

It is clear that methionine application at four weeks after transplanting of processing tomato increased the yield of primary tillers.

Table 13. Effect of foliar application of methionine on processing tomato yield, winter 1988.

Item	Treatment	Date of harvest					Total
		12 Jan. 12	21 Jan.	1 Feb.	8 Feb.	23 Feb.	
Fruit (10^3/ha)	Check	87.6 a	106.5 a	172.3 b	191.5 b	141.0 b	699 b
	Methionine	96.3 a	103.8 a	223.0 a	264.3 a	164.7 a	852 a
Fruit wt. (g/fruit)	Check	106 a	105 a	83 a	64 a	60 a	84.4 a
	Methionine	105 a	104 a	83 a	66 a	57 a	83.0 a
Marketable yield (t/ha)	Check	9.3 a	11.1 a	14.2 b	12.1 b	8.5 a	55.1 b
	Methionine	10.1 a	10.8 a	18.5 a	17.3 a	9.4 a	66.0 a

*Methionine was applied by foliar spray at concentration of 1000 ppm (1500 l/ha) at four WAT. **Numbers with the same letter are not significantly different at 5% level by DMRT.

Table 14. Effect of methionine on the number of fruits and clusters of processing tomato, winter 1988.

Treatment	Main stem		Primary tiller		Secondary tiller		Total	
	Fruit	Cluster	Fruit	Cluster	Fruit	Cluster	Fruit	Cluster
Check	17.2 a	4.2 a	48.5 b	14.1 b	6.9 a	2.4 b	72.6 a	20.6 b
Methionine	14.0 a	4.0 a	56.5 a	17.1 a	8.9 a	3.6 a	79.4 a	24.7 a

*Survey was made at 11 weeks after transplanting; numbers were average of 48 plants. **Numbers with the same letter are not significantly different at 5% level by DMRT.

Development Program

Training

Enrollment

During the year under review, 121 training participants from 12 countries were enrolled under the six training categories, namely; research fellowship (RF), research scholarship (RS), research internship (RT), production training (PT), special purpose training (SPT), and undergraduate student training (UST).

The enrollees contributed to an aggregate training time of 386.25 man months or 32.18 man years (Table 1). The scholars participated in three types of training activities, namely; research, production and agricultural development (Fig. 1).

Table 1. Distribution of trainees by country and period of scholarship, 1988.

Countries	RF	RS	RI	PT	SPT	UST	Total	MM
Hongkong					3		3	3.0
India			1				1	6.0
Indonesia				15			15	90.0
Korea			4				4	23.5
Malaysia			1				1	3.0
Malawi				1			1	7.0
Papua New Guinea				1			1	4.0
Philippines	1			10	38		49	87.25
Taiwan, ROC			2	1	5	26	34	73.0
Thailand				8	2		10	41.5
USA	1						1	24.0
West Germany		1					1	24.0
Total	**2**	**1**	**8**	**36**	**48**	**26**	**121**	**386.25**

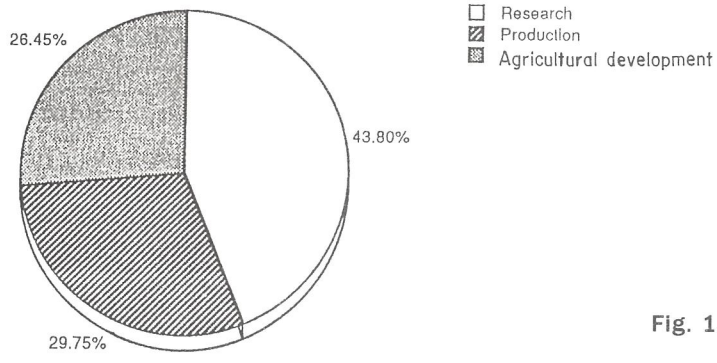

Fig. 1. Nature of training at AVRDC.

The participants were basically distributed in the three major programs: Crop Improvement, Production Systems and the Development Program (Table 2). Twenty-nine scholars (23%) were enrolled

in four disciplines under the Crop Improvement Program while 14 (11%) were enrolled in four disciplines under the Production Systems Program. The highest enrollment during the year was recorded in the Development Program; 73 participants (60%) registered in three subject matter areas such as Vegetable Production Technology, Training Management and Agricultural Development. The Support Units had 4% of the total enrollment.

Among principal crops, pepper appears to be the most popular among the research trainees (Table 3). Production and special purpose trainees opted for a variety of crops which included not only the AVRDC priority crops but other vegetables in the leguminous, cruciferous and solanaceous families.

Table 2. Distribution of trainees by program/discipline and period of training, 1988.

Program/Discipline	RF	RS	RI	PT	SPT	UST	Total	MM
Crop Improvement Program								
Plant Breeding			3		1	3	7	26
Plant Pathology			1		1	4	6	15.5
Plant Physiology			2			5	7	22
Entomology		1	1		2	5	9	38.5
Subtotal		**1**	**7**		**4**	**17**	**29**	**102**
Production Systems Program								
Ag. Chemistry						6	6	12
Soil Science						1	1	2
Cropping Systems			1		5		6	9.5
Crop Management					1		1	1
Subtotal			**1**		**6**	**7**	**14**	**24.5**
Developement Program								
Production Technology				36			36	196
Agricultural Development					33		33	20
Training Management	2				2		4	37.5
Subtotal	**2**			**36**	**35**		**73**	**253.5**
Support Units								
Seed Technology (GRSU)					2	2	4	6
Farm Management					1		1	0.25
Subtotal					**3**	**2**	**5**	**6.25**
Grand Total	**2**	**1**	**8**	**36**	**48**	**26**	**121**	**386.25**

Table 3. Distribution of trainees by commodity, 1988.

Commodity	RF	RS	RI	PT	SPT	UST	TOTAL
Chinese cabbage		1	2			2	5
Pepper			2		1	9	12
Tomato						4	4
Sweet potato					2	5	7
Soybean			2			4	6
Mungbean						1	1
Multi-crop	1		2	36	10		49
Others	1				35	1	37
Total	**2**	**1**	**8**	**36**	**48**	**26**	**121**

Training Sponsors

There were 15 other training sponsors in addition to AVRDC (Table 4) which provided financial support to 144 participants. The Japan Shipbuilding Industry Foundation (JSIF) (Table 5) was the major contributor providing funds to support 111 man months or 9.25 man years of training. The Development Innovations International, a consulting company administering ADB funds for Indonesian participants, financially supported 90 man-months of training. The Second Laguna de Bay Irrigation Project, an ADB funded project, provided funds for 40 participants who spent 59.5 man months of training at AVRDC.

Table 4. Distribution of grantees by sponsors, 1988.

Sponsor	RF	RS	RI	PT	SPT	UST	TOTAL	MM
JSIF	2		2	13			17	111.0
SLBIP/Philippines				8	32		40	59.5
DII/GOI/Indonesia				15			15	90.0
AVRDC			1			26	27	57.0
AVRDC/TOP					2		2	1.5
COA			2		3		5	15.0
DSE/Philippines					4		4	5.0
GTZ/Germany		1					1	24.0
CIP/Philippines					1		1	0.5
IPB/Philippines					1		1	0.25
RDA/Korea			1				1	6.0
CITC/ROC					2		2	1.0
University of Hongkong					1		1	1.0
Pillsbury Co./Hongkong					2		2	2.0
Hung Nong Seed Co./Korea			1				1	6.5
Nath Seeds Private Ltd./India			1				1	6.0
Total	**2**	**1**	**8**	**36**	**48**	**26**	**121**	**386.25**

JSIF-Japan Shipbuilding Industry Foundation
SLBIP-Second Laguna de Bay Irrigation Project
DII-Development Innovations International
COA-Council of Agriculture
DSE-German Foundation for International Development
GTZ-German Agency for Technical Cooperation
CIP-Centro Internacional dela Papa
IPB-Institute of Plant Breeding
RDA-Rural Development Administration
CITC-Council on International Technical Cooperation

Table 5. Distribution of grantees by country supported by the Japan Shipbuilding Industry Foundation.

Country	RF	RI	PT	Total	MM
Korea		1		1	6
Malawi		1		1	7
Malaysia		1		1	3
Papua New Guinea			1	1	4
Philippines	1		2	3	22
Taiwan, R.O.C.			1	1	5
Thailand			8	8	40
USA	1			1	24
Total	**2**	**3**	**12**	**17**	**111**

Tropical Vegetable Information Service

The Tropical Vegetable Information Service (TVIS) is a multidisciplinary, multicomponent information activity initiated in 1984. So far, the project has prepared 25 publications. TVIS publications constituted 40% of AVRDC's entire publication program (1985-88). At project end, the TVIS literature data base consisted of 7,949 computerized records, of which 4,271 had been abstracted. During 1988 over 3,500 copies of AVRDC's TVIS publications were distributed worldwide and 114 documents were delivered by the library on request.

The Tropical Vegetable Information Service (TVIS) was initiated on 1 July 1984 with a project grant from the International Development Research Centre (IDRC) of Canada. TVIS aims to strengthen and expand AVRDC's existing specialized information activities on vegetables in the tropics specifically, mungbean, soybean and Chinese cabbage.

Accomplishments

TVIS Documents published. A total of 25 formal publications were published by the end of the first phase of the project in February 1989 (Table 1). These TVIS publications constituted approximately 40% of AVRDC's entire publication program from 1985 to 1988. These varied information sources had been distributed worldwide through AVRDC's direct distribution system and through its international commercial distribution network.

Status of TVIS literature data base. The AVRDC Library has established a computerized information retrieval system using the MINISIS program and collected, stored and analyzed documents on mungbean, soybean rust and Chinese cabbage. The Library has also been responsible for compiling the bibliographies of mungbean (diseases and pests) and soybean rust. The total number of TVIS literature records in the Library's bibliographic data base is 7,955, of which 4,271 (54%) records are accompanied by an abstract. Hard copy documents are available for all of the 7,949 records. Information concerning the status of the TVIS literature data base is provided in Table 2.

TVIS Information Services. AVRDC announced the TVIS project under the heading "Services at AVRDC" in its *Centerpoint* newsletter, Volume 6. As a result, the Center received many requests on specific information.

The AVRDC Library delivered 174 documents, including 13 on soybean, 99 on mungbean and 7 on Chinese cabbage. The documents were sent as 1,012 pages of photocopy to seven countries (Bangladesh, Cuba, Indonesia, Singapore, Thailand, the UK and the USA). It also received three requests for retrospective search for mungbean and soybean rust from India and the USA.

Table 1. TVIS publications released by project completion, February 1989.

Publication line	Title	Date published
Bibliography	Annotated Bibliography of Diamondback Moth (Chinese cabbage)	February 1985
	Bibliography of Soybean Rust	September 1987
	Mungbean/Black Gram Bibliography	April 1988
Newsletter	TVIS News, Vol. 1, No. 1	February 1985
	TVIS News, Vol. 1, No. 2	November 1985
	Soybean Rust Newsletter, Vol. 7	October 1985
	TVIS News, Vol. 2, No. 1	March 1987
	Soybean Rust Newsletter, Vol. 8	April 1987
	TVIS News, Vol. 2, No. 1	July 1987
	TVIS News, Vol. 3, No. 1	January 1988
	TVIS News, Vol. 3, No. 2	June 1988
	Soybean Rust Newsletter, Vol. 9	February 1989
Technical Report/ Extension Manual	Agromyzid Flies of Some Native Legume Crops in Java	September 1984
	AVRDC Soybean Evaluation Trial (ASET)	December 1985
	International Mungbean Nursery (IMN)	December 1985
	TB 16: Assessing Rainy Season Vegetable Production Alternatives	April 1987
	Chinese Cabbage Symposium (reprint)	April 1987
	Int. Cooperators Guide: Cultural Practices for Chinese Cabbage at AVRDC	August 1987
	Soybean Varietal Improvement	June 1987
	Catalog of Mungbean Cultivars	April 1988
State-of-the-Art	TB 17: Chinese Cabbage Breeding & Seed Production	May 1988
Directory of Research Personnel	Directory of Chinese Cabbage Researchers	July 1988
	Mungbean and Soybean Directory	February 1989
Proceedings	Symp. Program, Abstracts & Information	November 1987
	Proceedings of the 2nd Int. Symp. on Mungean	January 1989

Table 2. TVIS literature data base by project completion, February 1989.

	Records	Records abstracted
Soybean rust	363	342
Soybean	2,206	1,463
Mungbean	4,036	1,386
Chinese cabbage	1,350	1,080
Total	**7,955**	**4,271**

AVRDC-Indonesia Vegetable Research Program

Chinese Cabbage Multilocation Yield Trial

Introduction

Eleven Chinese cabbage hybrids/OP varieties and two hybrid parent materials were evaluated for yield potential in three lowlands and two medium elevations in Java during the wet season of 1987 and dry season of 1988 in five locations. This multilocation trial aimed to identify varieties with high marketable head yields adapted for lowland tropics.

Material and Methods

In 1987 wet season (September-November) and in the 1988 dry season (April/May June/July) 6 and 10 accessions, respectively, with Talaud as check, were planted in five locations: three in the lowland (below 400 m a.s.1) and two in medium elevation (400-600 m a.s.1). The locations were: (1) Banjarsari (BJS, 2 m a.s.1) in East Java, (2) Purwokerto (PWK, 55 m a.s.1) and (3) Magelang (MGL, 512 m a.s.1) in Central Java, and (4) Subang (SBG, 100 m a.s. 1) and (5) Cicalengka (CCL, 500 m a.s.1) in West Java. The seedlings were planted in a raised bed of 1 m × 4.8 m with plant distance of 40 cm × 50 cm and mulched with rice straw. RCBD was applied with three replications. Stable manure was applied at the rate of 20 t/ha, and fertilizers at 190 kg/ha of N, 125 kg/ha of P_2O_5, and 125 kg/ha of K_2O. P and K were applied at planting time while N was applied two and four weeks after transplanting (WAT).

Results and Discussion

In Indonesia, Chinese cabbage is normally cultivated in the highlands. Therefore, there are no local varieties which can be used as checks. The local variety included in PWK was mustard. Released as lowland Chinese cabbage, Talaud, an open-pollinated variety, was used as check in each location. In the wet season trial in Cicalengka, observations showed that B-40 was a variable population in all locations. Although Talaud is an OP variety, it had better uniformity than the two varieties mentioned earlier.

Significant differences were found among accessions in each location either in yield potential or head weight. But there was no significant difference compared to Talaud, except in Subang. However, scoring of yield superiority showed that Hybrid 82-46 performed best, followed by Hybrid 82-157 and Hybrid 62 (Table 1). In relation to head weight, Hybrid 62 performed best followed by Hybrids 58, 82-46 and 82-157.

In the dry season trial, more accessions were evaluated, including two hybrid parent lines, B-18 and E-7. The trial conducted in Subang failed due to the high leafhopper damage. Significant differences in yield potential as well as in head weight were observed between Talaud and the accessions. In the lowland, all accessions performed better than Talaud; even both hybrid parents, B-18 and E-7. Scoring of yield potential superiority showed that Hybrid 59 performed best this season, followed by Hybrids 58 and 82-46. On head weight basis, these three hybrids were also the best performers. However, since Hybrid 59 was tried in one season only it needs to be re-evaluated. From the two season trials over five locations, the accessions performed better in dry season than in wet season. Medium elevation was found more favorable for growth than the lowland. On yield potential and head weight,

Table 1. Scoring of high yield potential of selected accessions in 1987 wet and 1988 dry seasons.

Accessions	Location[z]					Average		
	BJS	PWK	SBG	MGL	CCL	Lowland[y]	Medium[x]	All locations
				Wet season				
Talaud	3.5	3.5	2.0	3.5	–	3.0	3.5	3.1
Hybrid 62	3.0	3.5	3.5	4.0	–	3.3	4.0	3.5
Hybrid 58	3.5	4.0	3.5	2.0	–	3.7	2.0	3.2
82-46	4.0	3.5	3.5	4.0	–	3.7	4.0	3.7
82-157	3.5	3.5	3.5	4.0	–	3.5	4.0	3.6
83-2	2.0	4.0	3.5	4.0	–	3.2	4.0	3.4
B-40	3.5	3.5	2.0	2.5	–	3.0	2.5	2.9
Local	–	3.0	–	1.0	–	3.0	1.0	2.0
				Dry Season				
Talaud	1.0	2.0	–	2.0	3.5	1.5	2.7	2.1
Hybrid 62	3.5	1.0	–	2.5	2.5	2.2	2.5	2.4
Hybrid 58	4.0	2.0	–	4.0	3.0	3.0	3.5	3.2
Hybrid 82-46	3.5	1.0	–	3.5	4.0	2.2	3.7	3.0
82-157	1.5	1.5	–	2.0	2.5	2.5	2.2	2.4
83-2	2.5	1.5	–	1.0	2.5	2.0	1.7	1.9
Hybrid 59	3.0	4.0	–	4	3.5	3.5	3.7	3.6
82-156	2.5	2.2	–	2	2.0	2.3	2.0	2.4
77M(3)-27	2.5	2.0	–	3	2.5	2.2	2.7	2.5
77M(4/3)-35	2.5	–	–	3	–	2.5	3.0	2.7
77M(2/3)-43	–	2.0	–	–	3.5	2.0	3.5	2.7
8-18	3.5	–	–	2.5	3.5	3.5	3.0	3.2
E-7	3.0	–	–	1.5	2.5	3.0	2.0	2.3

[z]Location abbreviations, see text. [y]Lowland average = (BJS + PWK + SBG): 3 [x]Medium average = (MGL + CCL):2

four accessions performed better than Talaud, i.e. Hybrids 58, 82-46, 62 and 82-157. These accessions will be recommended for release in 1989.

Tomato Multilocation Yield Trial

Introduction

Ten promising tomato lines consisting of four local selections, four from AVRDC accessions, and two check varieties, were tested in 1987 wet season in Banjarsari (BJS, 2 m a.s.l), Purwokerto (PWK, 55 m a.s.l), Subang (SBG, 100 m a.s.l), Magelang (MGL, 512 m a.s.l) and Cicalengka (CCL, 600 m a.s.l). The first three locations were lowlands and the other two were of medium elevation.

Materials and Methods

The seedlings of 10 accessions and one local variety were planted (in PWK and MGL) in a randomized complete block design with three replications. Berlian, a lowland variety, and Gondol, a highland variety were used as checks. Plant spacing was 60 × 50 cm with 24 plants/plot. Stable manure was applied at the rate of 30 t/ha and fertilizer at the rate of 150 kg each of P_2O_5, K_2O and N/ha.

Results and Discussion

Wet season trial. Significant differences were found among accessions. Three local selections and four AVRDC selections performed better in terms of yield than Berlian and Gondol. Scoring of yield potential superiority (Table 2) showed that five accessions were better than Berlian in the lowland, but not in medium elevation. In latter location, all accessions did not show significant differences with Berlian. AVRDC selections yielded better than local varieties in the lowland. The

Table 2. Scoring of high yield potential of selected accessions in 1987 wet and 1988 dry seasons.

Accessions	Location[z]					Average		
	BJS	PWK	SBG	MGL	CCL	Lowland[y]	Medium[x]	All locations
Wet season 1987								
Berlian	2.5	4.0	1.5	5.0	5.0	2.7	5.0	3.6
Berlu-6	2.5	5.0	4.0	5.0	5.0	3.8	5.0	4.3
Gondol	2.0	2.0	1.0	5.0	3.0	1.7	4.0	2.6
Cr. 4210	3.0	5.0	2.5	5.0	5.0	3.8	5.0	4.1
LG 153-553	4.0	2.0	2.0	5.0	–	2.7	5.0	3.2
LG 154-858	4.0	2.5	1.5	5.0	4.5	2.7	4.7	3.5
CL 1131-0-0-7-20-11	3.5	5.0	4.0	5.0	5.0	4.2	5.0	4.5
CL 1131-0-0-43-8-1	4.5	5.0	1.5	5.0	5.0	4.0	5.0	4.2
CL 5915-93-D4-1-0	4.0	4.5	2.5	5.0	4.5	3.7	4.7	4.1
CLN 95-280-D5-4-0	5.0	5.0	1.5	5.0	5.0	3.8	5.0	4.3
Local	–	3.0	–	5.0	–	–		
Dry season 1988								
Berlian	3.0	5.0	3.0	2.5	4.0	3.7	3.2	3.5
Berlu-6	4.0	5.0	3.0	5.0	4.0	4.0	4.5	4.2
Gondol	1.0	5.0	3.0	3.0	3.5	3.0	3.2	3.3
Cr 4210	4.5	5.0	4.5	3.0	4.0	4.7	3.5	4.2
LG 153-553	2.5	5.0	4.5	–	4.5	4.0	4.5	4.1
LG 154-858	3.0	5.0	3.0	4.0	3.5	3.7	3.7	3.5
CL 1131-0-0-7-20-11	5.0	5.0	3.0	3.0	5.0	3.7	4.0	4.2
CL 1131-0-0-43-8-1	4.0	5.0	3.0	4.5	3.0	4.0	3.7	3.9
CL 5915-93-D4-1-0	3.0	5.0	3.0	2.0	2.0	3.7	2.0	3.0
CLN 95-280-D5-4-0	2.0	5.0	3.0	3.0	3.5	3.3	3.2	3.3
Local	–	–	–	3.0	–	–	–	–

[z]Location abbreviations, see text. [y]Lowland average = (BJS + PWK + SBG):3 [x]Medium average = (MGL + CCL):2

five best performers in the lowland in this season were: CL 1131-0-0-7-20-11, CL 1131-0-0-43-8-1, Berlu-6, Cr 4210 and CLN 95-280-D5-4-0.

Significant differences were also found in fruit size. All accessions bore small fruit less than 70 g. The fruit size was the same for lowland and medium elevation. For lowland, CLN 95-280-D5-4-0 had the heaviest fruit (± 40.4 g/fruit).

Dry season trial. Significant differences were found among accessions. The performance of Berlian in dry season was better than in the wet season. Two local selections, Cr 4210 and LG 153-553 performed better than Berlian in Subang but CL 1131-0-0-7-20-1 was better than Berlian in Banjarsari.

Scoring of high yield potential showed that Cr 4210 performed best in the lowland followed by Berlu-6, LG 153-553 and CL 1131-0-0-43-8-1. In different locations, the overall best performers were Berlu-6, Cr 4210, CL 1131-0-0-7-20-11 and LG 153-553.

These accessions gave the best yield potentials; CLN 95-280-D5-4-0, however had the heaviest fruit.

AVRDC-Korea Bilateral Program

Breeding of Heat-tolerant Chinese Cabbage Varieties

Every year promising combinations of Chinese cabbage for lowland summer cultivation are selected for their heading form, disease resistance and harvest ratio. Usually harvest ratio is not reproduced due to the fluctuation of weather conditions among trial years. The weather condition from July to September at 10-day intervals was measured as precipitation of about 100 mm, maximum temperature higher than 26°C and average humidity higher than 80% (Fig. 1). In 1987, in spite of heavy rains and long rainy days during the field stage, two combinations were selected for high harvest ratio and good performance among trial combinations with different sowing times.

In 1988, 13 combinations derived from crosses among eight inbred lines were tested at two different sowing time, 25 June and 15 July. Among parents, three were the parental lines of the selected combinations in 1987 and two were the lines introduced from AVRDC and selected in the previous years. The last three were derived from anther culture of commercial F_1 hybrids. One of them (An 111) originated from the famous high quality Samjin and the other two from Junseong (An 603, An 619), was known to be resistant to virus.

Characteristics of eight parental lines are presented in Table 1. The heading type of five HES lines varied from non-heading to joined-up but the three lines from AVRDC showed overlapping form. Maturity of HES lines varied from middle to late, but AVRDC lines turned out early to extremely early. Three AVRDC lines showed lower plant weight and fewer number of leaves than HES lines.

After 55 days from sowing (first seedtime), HES lines except SSD31-2 showed very strong resistance to virus but three lines from AVRDC proved to be very susceptible (Table 2). After 70 days, all parental lines of the first seedtime were seriously infected by virus. In the second seedtime, it was not possible to find out surviving plants without virus infection even at early stage in the field.

After 55 days from sowing (first seedtime) almost all combinations were found very healthy and were not seriously infected by soft rot and virus (Table 3). However, immediately virus symptom appeared and finally the number of surviving plants decreased drastically.

Two combinations selected in 1987 which showed high harvest ratio in spite of heavier rainfall and longer rainy days during field growth stage of Chinese cabbage in summer compared with an average year seemed very resistant to soft rot or bacterial rot. In 1988, on the contrary, there was very little rain and dry weather continued to predominate during field growth stage except in the middle of July. As a result, soft rot infection remained at low level, while virus infection seriously spread. It has been known that virus infection is closely associated with the density of aphids which are influenced by the amount of precipitation. Therefore, it was assumed that heavy rain and long rainy days in previous years decreased the density of aphids to negligible level and consequently virus infection was not serious. This year, virus infection ratio after 55 days from the first sowing was not so high. However, after 70 days all combinations were subjected to serious virus infection. It was assumed that diminution of aphid density by a heavy rain during transplanting and the incubation of virus made the virus symptom remain latent, and continuance of abnormal dry weather after the middle of July accelerated the virus infection. Especially all entries of the second seedtime were seriously infected by virus from early field stage; there was nothing left for harvest.

Hence, it was assumed that some selected combinations were resistant to soft rot but not to virus. Summer Chinese cabbage hybrids must have resistance to soft rot and virus as well as heat tolerance

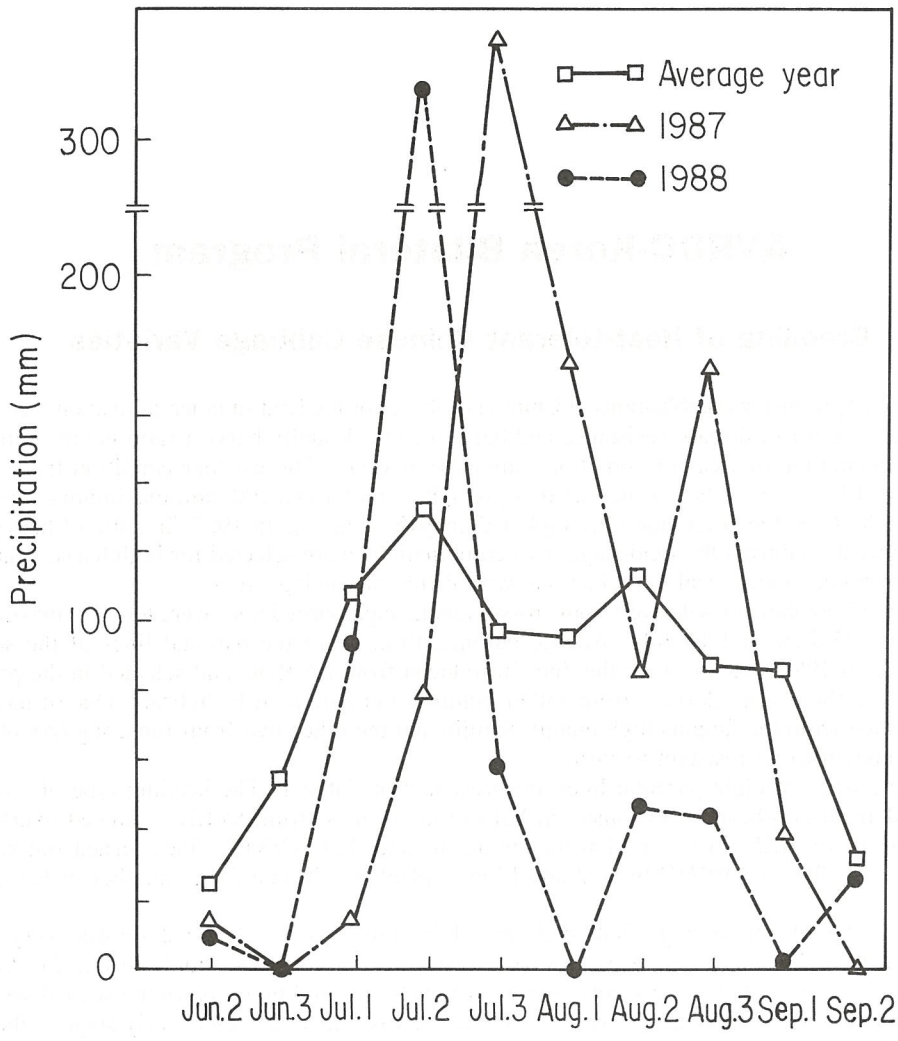

Fig. 1. Accumulated precipitation of average year, 1987 and 1988 at 10-day intervals during cultivation of Chinese cabbage in summer.

Table 1. Characteristics of eight parent line combinations under lowland summer condition, 1988.

Line code[z]	Heading[y] form	Maturity[x]	Plant wt.[w] (kg)	No. of leaves
An 111-9-3	NH	L	1.0	52.0
An 603-2	JU	L	1.1	44.8
An 619-1	SH	L	1.1	54.0
SSD31-2-2-1-1	JU	M	0.6	49.1
SSD139-3-2-1-3	NH	L	1.1	50.2
B-18-1-2-3-1	OL	EE	0.4	24.0
76M(2)...1	OL	EE	0.6	30.0
77M(3)...1	OL	E	0.5	23.0

[z]76M(2)...: 76M(2)-18-3-4-8-4-8-2-, 77M(3)...: 77M(3)-35-18-LT-1-2-3-Overlapping [x]L: Late, EE: Extremely early, E: Early, M: Medium [y]NH: Non-heading, JU: Joined-up, SH: Semi-heading, OL: [w]First seedtime record of 60 days after sowing.

Table 2. Soft rot and virus infection ratio (%) of eight parent lines under lowland summer condition at different sowing times, 1988.

Line code[z]	Soft-rot	Virus		
	25 June(A)[y]	25 June(A)	25 June(B)	15 July(C)
AN 111-9-3	3.4	0.0	100.0	100.0
AN 603-2	0.0	3.4	100.0	90.0
AN 619-1	0.0	0.0	87.5	100.0
SSD31-2-2-1-1	0.0	53.6	100.0	90.5
SSD139-3-2-1-3	3.6	0.0	100.0	90.5
B-18-1-2-3-1	0.0	84.2	100.0	100.0
76M(2)...1	0.0	96.0	100.0	100.0
77M(3)...1	0.0	89.7	100.0	100.0

[z]76M(2)...: 76M(2)-18-3-4-8-4-8-2-, 77M(3)...: 77M(3)-35-18-LT-1-2-3- [y]Date of observation: A (18 Aug.), B (2 Sept.), C (15 Sept.)

Table 3. Virus infection ratio (%) of some combinations under lowland summer condition, 1988.

Combination	Sowing time		
	25 June		15 July
	A[z]	B	C
An 111-9-3 x B-18-1-2-3-1	5.6	100.0	82.9
An 603-2 x B-18-1-2-3-1	16.1	96.6	75.0
An 619-2 x 76M(2)-18-3-4-8-4-8-2-1	12.5	84.3	58.7
SSD31-2-2-1-2 x SSD139-3-2-1-2*	0.0	82.4	86.5
SSD139-3-2-1-1- x B-18-1-2-3-1*	8.1	90.2	70.7
Junseung (control)	7.2	100.0	93.1
Tambok (control)	9.0	30.2	62.3

[z]Date of observation: A (18 Aug.), B (2 Sept.), C (15 Sept.) *Selected in 1987.

to achieve a stable harvest ratio. Further intensive studies on virus per se and survey for resistant breeding material should be emphasized.

Cytoplasmic Male Sterility

In 1988, the field test on CMS lines which originated from *Raphanus* and *B. juncea* was not carried out. However, some plants of each CMS line were selected according to leaf color at seedling stage and were grown in the greenhouse for crossing.

CMS Originated From *Raphanus*

In 1988, no back crossing was carried out because in the previous year CMS 60 days and CMS Cheongbang were considered not isogenic to their recurrent parents even in BC_8F_1 and BC_7F_1 generations. Seed setting of CMS 60 days was improved compared with last year's record and was almost the same as that of recurrent parent (Table 4). CMS 60 days gave lower germination ratio than recurrent parent, but the seeds of CMS Cheongbang as parent did not germinate at all.

Table 4. Seed yield of CMS line originated from *Raphanus* and recurrent line of Chinese cabbage.

Line[z]	No. of flowers pollinated (A)	No. of seeds (B)	B/A	
			1988	1987
CMS 60 (BC9F1)	128	270	2.11	0.31
Recurrent	164	397	2.42	1.25

[z]CMS 60 : CMS 60 days.

CMS Originated from *B. juncea*

The seed yield of CMS and recurrent lines in 1988 increased compared with that in 1987 (Table 5). The germination ratio of each CMS line still remained lower than that of their recurrent parents.

Table 5. Seed yield of CMS lines originated from *B. juncea* and recurrent lines of Chinese cabbage.

Line[z]	No. of pollinations (A)	No. of seeds (B)	B/A	
			1988	1987
CMS NB (BC_5F_1)	163	48	0.29	0.06
Recurrent	151	1,417	9.38	4.52
CMS DK (BC_4F_1)	105	574	5.47	0.00
Recurrent	105	840	8.00	1.70

[z]CMS NB: CMS Naebyeong 60 days. CMS DK: DMS Daehyeong karack.

Breeding of Processing Tomato

Domestic cultivation of processing tomato in Korea has not been established despite continuous breeding efforts since 1976. It was thought that meteorological condition such as long rainfall followed by high temperature and humidity during harvest of tomato was one of the major constraints.

This year, a yield test of eight processing tomato entries was carried out with three different culture methods: nonstaking, staking with pinching and staking without pinching. The materials used in the experiment were F_1 hybrid varieties of Jinhong, TM 103 and TN #3 and four cross combinations made from the parental lines of the former three hybrids and the previous combination, 79078 × ARC.

On the whole, varietal yield pattern showed a similar tendency among culture methods. An introduction from AVRDC, TN #3, showed high yield regardless of culture method used. TM 103 and CL1080 × UC134, however, showed high yield in staking culture with pinching but not in other culture methods. UC134 × CLCL 5915 A and CL5915 B × CL1080 had excellent fruit-set ability but very small fruit, whereas, TN #3 was not so outstanding for each character but relatively uniform. Consequently yield for TN #3 was stable. On the other hand, Jinhong had larger fruit but gave very low yield because of low fruit-set especially in nonstaking culture. It is assumed that TN #3 is a potential material for regional adaptability test in 1989.

AVRDC-MARDI Vegetable Research Program

Intermediate Tomato Yield Trial

A total of 21 AVRDC tomato lines selected from earlier yield trials (15 for processing and 6 for fresh use) were tested against two local varieties, MT 1 and MT 11, at Jalan Kebun Peat Station to determine their potential under local environments. Four lines, namely, PT 862, PT 870, PT 858 and PT 913, were found to have met the selection criteria for processing, and CL 5915-206 D4-2-2, CL 5915-206 D4-2-5, CL 5915-136 D4-1-0, CL 5915-223 D4-2-1 and CLN 95-280 D5-1-1, were short-listed as promising lines for fresh consumption. All these lines showed acceptable survival rate (55 to 67.7%) and good yield under lowland conditions.

Intermediate Chinese Cabbage Yield Trial

At Jalan Kebun Peat Station, 10 varieties were selected from a preliminary yield trial in 1987 testing 25 varieties. The yields obtained were generally lower compared to the first-season trial. Green Sun, Autumn Pride, Autumn Queen, 77M (2/3-46) and No 82-156 outyielded the control varieties, Saladeer and Hybrid 62. Green Sun produced the highest heading efficiency ratio as well as large, compact and heavy heads. Green Sun and 77M (3)-27 showed relatively higher tolerance to soft rot disease than the other varieties.

A combined analysis of the data in two seasons indicated significant yield differences among varieties and between seasons, and a significant interaction of seasons with varieties (Table 1). Chinese cabbage varieties, Autumn Queen (33.4 t/ha) and Green Sun (32.4 t/ha), significantly outyielded the local check, Saladeer, (23.2 t/ha) and the AVRDC check, Hybrid 62 (23.2 t/ha). There was no significant difference in solidity of heads although Green Sun was reported to have a more roundish shape and was more compact than Autumn Queen.

Sweet Potato Yield Trial

A total of 32 superior varieties from AVRDC and MARDI were tested in a yield trial at Serdang in 1988. Four varieties, viz. CN 1181-32, CN 1232-19, AIS 0122-2 and CN 1229-16, had the highest fresh root yields. CN 1232-19 and CN 1229-16 also had the highest dry matter content. Varieties AIS 0122-2 and CN 1229-16 were also among the highest yielders in trials conducted in the previous two seasons.

Vegetable Soybean Yield Trial

Two vegetable soybean lines from AVRDC short-listed on the basis of dry seed yield were tested in a replicated trial at Jalan Kebun Peat Station. Line G 81083-63 gave acceptable green pod and green seed yields. The pods were also attractive and tasted good when boiled and eaten as a snack or when the green seeds were prepared in soup.

Table 1. Yield trial on 12 potential Chinese cabbage varieties in two seasons.

Variety	Days to maturity	Total hill harvested	Total plant weight (kg)	Total head yield (kg)	Yield (t/ha)	Harvest rate	Mean growth (kg)	Mean head weight (kg)	Mean non wrapper leaf weight (kg)	Heading efficiency ratio	Head length (cm)	Head width (cm)	Head shape index	Solidity (g/cc)	Soft rot (%)
Autumn Queen	43.1	7.4	12.5	7.5	33.4 a	82.1	1.7	1.0 a	0.7 a	1.6	25.4	12.3	2.1	0.5	11.7 a
Green Sun	34.3	9.6	13.5	9.3	32.4 a	96.9	1.4	1.0 a	0.4 bc	2.3	16.6	12.1	1.4	0.8	4.2 c
Autumn Pride	41.9	7.3	11.7	6.5	30.5 ab	75.1	1.6	0.9 ab	0.7 a	1.4	26.6	11.0	2.4	0.6	17.1 abc
No. 82-156*	43.9	10.0	12.8	8.7	29.1 abc	100.0	1.3	0.9 abc	0.4 bc	2.1	16.8	11.5	1.5	0.7	7.5 bc
77M (2/3-46)*	43.4	9.4	12.6	8.0	28.6 abc	94.3	1.3	0.9 abc	0.5 bc	2.0	18.5	11.3	1.7	0.7	8.3 bc
No. 82-157*	44.4	10.0	11.4	7.8	25.9 bc	10.0	1.1	0.9 abc	0.4 bc	2.1	16.8	11.5	1.5	0.7	7.5 bc
77M (3)-40*	42.6	7.3	10.8	5.4	25.1 bc	79.2	1.2	0.7 c	0.5 bc	1.6	17.5	10.9	1.6	0.7	20.2 ab
Mingko	43.9	6.0	7.4	4.5	24.8 bc	67.0	1.2	0.7 c	0.5 b	1.6	25.6	10.2	2.5	0.5	26.4 a
Hybrid 62 (AVRDC Control)*	42.4	8.0	8.6	5.7	24.5 bc	86.1	1.1	0.7 c	0.4 bc	2.2	17.6	11.7	1.5	0.6	17.3 abc
Summer Sun	42.3	8.3	13.7	5.9	23.3 c	87.1	1.1	0.7 c	0.4 bc	1.7	16.2	11.1	1.5	0.7	10.2 bc
Saladeer	49.9	8.7	9.9	5.9	23.3 c	89.7	1.2	0.7 c	0.5 b	1.5	19.2	11.0	1.8	0.6	4.0 c
77M (3)-27*	41.9	9.7	10.3	6.7	23.3 c	97.1	1.1	0.7 c	0.4 c	1.9	18.5	10.6	1.7	0.6	4.0 c
[z]Mean x	43.0	8.5	11.3	6.8	27.0	87.9	1.3	0.8	0.5	1.8	19.6	11.3	1.8	0.6	13.0
CV (%)	5.2	22.5	30.9	25.4	18.5	16.6	15.7	0.0	0.0	21.7	8.1	8.5	8.7	18.8	81.1
Sig. level															
Variety	ns	**[y]	*	**	**	**	**	**	**	**	**	**	**	**	*
Season	ns	ns	ns	**	**	ns	**	**	**	**	**	**	ns	ns	*
Season x variety	*	ns	*	ns	*	ns	**	*	**	**	**	ns	*	ns	ns

[y] Significant, ns not significant. [z]Combined analysis in two seasons. Means followed by the same letter(s) within a column are not significantly different at 5% level.

Evaluation of Cauliflower Varieties from Several Countries

Eleven commercial varieties from Japan, Taiwan, Holland, United States of America and Thailand were short-listed from 20 varieties tested in 1987. These varieties were evaluated on peat soil at Jalan Kebun. There was no significant difference in yield between the varieties. The five highest yielding varieties were Green Harmony, Mikado (Meigetsu 45 days), Snow Top, Snow Queen and Chai Tai #1. Three of these, Snow Top, Snow Queen and Chai Tai #1 gave the highest yields in a trial in 1987. However, Snow Queen and Chai Tai #1 were preferred because of their shorter maturity period.

Other Vegetable Research

Research on vegetable breeding and selection focused on the screening of varieties to evaluate their performance both in the lowlands and highlands. Among the vegetables tested were chili, potato, tomato, asparagus, cabbage, Chinese cabbage, cucumber, vegetable soybean, shallots, okra, long bean, French bean and egg plant.

Ten accessions of chili showed potential for use as dried chili, having yields comparable to MC 4 and MC 5 while displaying conversion rates from fresh to dry ranging from 15.9 to 28.7%.

After four seasons of testing in the highlands, the asparagus lines, CAS 85106 and #81085 emerged as higher yielding (6.1 to 6.6 t/ha) than Poletum and Mary Washington.

Multilocational trials on four selected cabbage varieties showed Autumn Hero and Good Season to be the highest yielders (39.7 to 47.6 t/ha) on peat in Pontian while Best Watanabe was more productive in mineral soils in Bertam.

The F_1 cucumber hybrid of MTi 2 × Hokoshin showed improved shelf life (4 to 7 days) and attained higher yield than the checks. It also has a crispy texture. However, the hybrid is not well accepted by consumers because of its unfamiliar dark green color and slightly rough skin surface.

AVRDC-Philippine Outreach Program

Tomato Single-Seed-Descent Trial

Summary

In 1987-88, 91 AVRDC lines/hybrids were evaluated during the dry season and 29 F_1 hybrids during the wet season. The F_1 processing tomato, PT-4052, significantly outperformed the check, Mapula, and several F_1 fresh market tomatoes significantly outyielded the check variety. All lines evaluated under the SSD in both seasons were very susceptible to bacterial wilt, TMV and Cercospora leaf spot diseases.

Introduction

F_1 hybrids, open-pollinated fresh market and processing tomato lines from AVRDC were advanced through SSD (single-seed-descent) trial. Screening of entries was based on yielding ability and resistance to pests, diseases and physiological disorders. Hybrids/lines derived from SSD with heat tolerance, good quality fruits and resistance to pests and diseases were advanced to the PYT for further screening.

Materials and Methods

In 1987-88, 91 test entries were divided into three sets of planting: (1) 17 F_1 processing tomatoes, (2) 53 open-pollinated fresh market and (3) 23 F_1 fresh market tomatoes. The processing tomato lines/hybrids were compared to BPI TmP-1 or Mapula and the fresh market lines to the check, Pope.

In both seasons, all entries were planted in 1-row plots, 5 m long, with 1 m between rows and 12 plants per row. The entries were distributed in a randomized complete block design with two replications.

Fresh market and indeterminate-type tomatoes were provided with trellis. All entries were mulched with rice straw in both seasons. The crops were grown following the AVRDC recommended cultural practices for tomato.

Yield and other horticultural characters and observations on pests, deseases and physiological disorders were recorded.

Results and Discussion

The yield performance and some horticultural characters of F_1 processing tomato lines in Set I are presented in Table 1. The entries gave a marketable grand mean yield of 7.8 t/ha. The low yield was attributed to soil moisture stress. Total rainfall in February and March during flowering and fruit formation was only 33.8 mm. Line PT-4052 showed significant yield difference over the check, Mapula. Nonmarketable yield did not show any significant difference among entries. Line PT-4141 was latest to flower (34 days); however all entries matured almost at the same time with a grand mean of 68.5 days. On fruit shape, the check Mapula was oval while majority of the test entries were round.

Table 1. Yield and some horticultural characters of the F_1 processing tomato lines evaluated under the SSD during the DS 1987-88.[z]

Entry	Yield (t/ha)		Days to		Fruit diameter (cm)	
	Marketable	Nonmarketable	Flowering	Maturity	Polar	Equi.
PT-4052	18.0 a[y]	2.3	22 b	67.0	3.7	4.1
PT-4142	15.8 ab	2.6	29 ab	68.5	3.9	4.1
PT-4141	11.7 a-c	2.0	34 a	67.0	4.0	4.0
PT-4126	9.4 a-d	2.3	27 ab	74.0	3.2	3.4
BPI TmP1 (ck)	8.5 b-d	2.8	22 b	78.0	4.9	3.4
Grand Mean (17 entries)	7.8	2.1	25.2	68.5	3.7	3.7
CV (%)	45.5	36.9	5.7	7.1	12.1	27.0

[z]Transplanted 14 January 1988 and harvested 6 times from 21 March to 8 April 1988. [y]Means followed by the same letter in each column are not significantly different at 5% level using DMRT.

All entries were equally susceptible to bacterial wilt, TMV, Cercospora leaf spot and cracking.

Among 53 open-pollinated fresh market tomato lines, CLN 698 BC, F2-288-0-7 with marketable yield of 37.7 t/ha outyielded the check, Pope, but the difference was insignificant. Nonmarketable yields showed a grand mean of 4 t/ha. The high nonmarketable yield was due to fruit cracks. Mean flowering was 32.9 days and maturity, 78.5 days. Entries generally had round fruits.

The results from Set III trial on the evaluation of 23 F_1 fresh market tomato lines showed that marketable and culled yields varied among entries but the differences were not significant. The grand mean number of days to flower and mature were 37.8 and 76.3 days, respectively. Line FMTT-72 produced the biggest fruit (78 g). Reactions to fusarium wilt, Cercospora leaf spot and bacterial wilt were not significant among entries.

In a trial of F_1 fresh market tomato during the wet season, five highest yielding entries which produced 14.8 to 23.7 t/ha, significantly outyielded the check Pope (5.1 t/ha). Nonmarketable yield varied, but differences were insignificant. The hybrids produced significantly bigger fruits than the check. Fruit worms and foliar diseases (specially Cercospora leaf spot) were prevalent during the cropping season.

Preliminary Yield Trial on Tomato

Summary

During 1987-88 dry season, 10 F_1 fresh market and 12 open-pollinated fresh market lines were evaluated. The yields of F_1 processing tomatoes were comparable to the check, Mapula. Eight F_1 fresh market lines performed better than the check and 12 open-pollinated fresh market line significantly outyielded the check.

The wet season preliminary trial composed of 66 open-pollinated fresh market lines were planted in five sets. Of the 66 lines, 13 showed higher yield over the check, Pope. The general low yield of the test lines was attributed to high incidence of Cercospora leaf spot, excessive rain during the crop season and nonmulching of the trial.

Introduction

Selections from the SSD trial based on yield performance and fruit qualities were evaluated in the PYT to identify heat and moisture tolerant lines that will produce good marketable yields during the wet season. Emphasis was also given to lines with tolerance to tropical foliar diseases.

Materials and Methods

A total of 32 test entries were evaluated during the 1987-88 dry season divided into three sets of trial. Set I was composed of 10 AVRDC F_1 processing lines, compared to check, BPI TmP-1; Set II with 10 F_1 fresh market tomatoes and Set III, with 12 open-pollinated fresh market tomato lines. All sets of plantings were transplanted on 14 January 1988.

Twelve entries under Set III were again evaluated during the wet season for final screening. Selections from the previous open-pollinated fresh market tomato SSD trial were divided into sets of planting: Set IV with 17 lines; Set V with 16 lines; and, Set VI with 10 lines. The trials were planted on 16-20 June.

The indeterminate type tomato was provided with bamboo trellis. Unlike in the dry season trial, the wet season planting was not mulched due to the absence of mulching materials.

The PYT's were laid out in a randomized complete block design with three replications. Twelve seedlings were transplanted per row of 5 m^2 subplots. The AVRDC recommended cultural practices for tomato trials were followed.

Yield, horticultural characteristics and observations on pests, diseases and physiological disorders were recorded.

Results and Discussions

Dry season PYT. The yield and some horticultural characters of F_1 processing tomatoes evaluated during the dry season (Set I) are shown in Table 2. Marketable yields ranged from 1.9 t/ha (PT-4073) to 7.95 t/ha (PT-4148). There was no significant yield difference among entries. The low yield was attributed to moisture stress, non-heat tolerance of processing tomatoes and late planting. Small and cracked fruits classified as nonmarketable were not significantly different among the entries. The grand mean number of days to flower and to mature were 26 and 64 days, respectively. Fruit size varied with the biggest (46 g) from PT-4062 and PT-4049. However, there was no significant difference on fruit size among hybrids.

Table 2. Yield and some horticultural characters of F_1 processing tomato lines evaluated under the PYT during the DS 1987-88, Set I.[z]

Entry	Yield (t/ha)		Days to		Fruit size (g)
	Marketable	Nonmarketable	Flowering	Maturity	
PT-4058	5.1	1.5	26	58	31
PT-4027	5.1	1.4	26	58	24
PT-4073	1.9	0.6	26	69	33
PT-4063	3.6	0.8	27	63	40
PT-4064	6.8	1.5	26	63	50
PT-4062	4.7	1.2	26	63	46
PT-4148	8.0	1.2	26	62	32
PT-4057	4.7	1.7	26	63	25
PT-4049	5.2	1.7	27	64	46
PT-4147	6.3	1.4	26	72	31
Mapula	4.9	0.7	26	72	44
Grand Mean	5.1	1.2	26.3	64.4	36.5
CV (%)	23.6	28.2	2.7	9.3	19.4

[z]Transplanted 14 January 1988, harvested 5 times from 29 February to 24 March 1988.

In set II (DS fresh market tomato PYT), eight hybrids significantly outyielded the check, Pope. The highest yielding entry was FMTT-19 with 14.4 t/ha (Table 3). Culled yields ranged from 1.4 t/ha (Pope) to 5.1 t/ha (FMTT-16). Fifty percent flowering was obtained 28.1 days and maturity of fruits 70.9 days from transplanting. Fruit sizes ranged from 22 g (Pope) to 43 g (FMTT-16). Differences in reaction to Fusarium wilt was significant among the entries and the most susceptible was FMTT-3. All hybrids were susceptible to sunscald due to less foliage of the crop.

In a trial conducted on 12 open-pollinated fresh market tomatoes during the dry season 1987-88 and wet season 1988 (Set III), N-65-349-D5-2-0 (26.9 t/ha) gave the highest marketable yield.

Wet season PYT. The same set of 12 open-pollinated fresh market tomatoes evaluated during the dry season was compared to the check, Pope in the wet season. Only CL 5915-206 (G) D4-2-2-0 with 14.6 t/ha marketable yield significantly outperformed the check, Pope. Nonmarketable yields varied among entries but the differences were not significant.

Table 3. Yield and some horticultural characters of F_1 fresh market tomato lines evaluated under the PYT during the DS 1988, Set II.[z]

Entry	Yield (t/ha)		Days to		Fruit size (g)	Rating[y]	
	Marketable	Nonmarketable	Flowering	Maturity		Fus. wilt	SS
FMTT-3	9.7 bc[x]	3.2	32	71	29	3.0 a	4.0 a
FMTT-14	11.3 ab	2.8	25	67	33	2.3 ab	3.3 ab
FMTT-16	11.5 ab	5.1	28	72	43	1.0 b	3.0
FMTT-18	14.0 a	3.4	26	66	32	1.0 b	2.0 b
FMTT-19	14.4 a	3.9	27	69	38	1.0 b	2.3 b
FMTT-21	10.1 bc	3.4	32	72	32	1.0 b	2.7 ab
FMTT-22	2.5 e	1.9	30	71	33	2.0 ab	2.7 ab
FMTT-13	9.8 bc	3.4	27	68	37	1.7 ab	3.3 ab
FMTT-4	6.7 cd	2.0	27	72	40	1.7 ab	4.0 a
FMTT-23	5.3 de	3.2	30	71	37	1.3 b	4.0 a
Pope (ck)	5.3 de	1.4	25	81	22	1.0 b	4.0 a
Grand Mean	9.1	3.1	28.1	70.9	34.2	1.5	3.2
CV (%)	21.4	34.2	13.22	9.1	23.35	46.98	23.8

[z]Transplanted 14 January 1988, harvested 18 March to 18 April 1988. [y]Ratings from 1 to 5 with the increasing order of severity. [x]Means followed by the same letter in each column are not significantly different at 5% level using DMRT.

The reactions of the 12 entries to fruit worms, sunscald, fruit cracking, Fusarium wilt, TMV and Cercospora leaf spot were similar in both seasons' trials. CLS was the most destructive disease among entries in both seasons.

Comparing 14 open-pollinated fresh market tomatoes to the check, Pope, three entries CLN 657 BC1 F3-215-0-17 (5.8 t/ha), CLN 657 BC1 F3-274-0-10 (4.6 t/ha) and CLN 520 BC1 F3-200-2-16 (4.2 t/ha) significantly outyielded the check. The grand mean for the nonmarketable yields was 0.8 t/ha. Fruit size was significantly different among entries; the biggest (51 g/fruit) was produced by CLN 500 BC1 F3-200-2-16. So far, CLN 657 BC1 F3-274-0-10 was the most susceptible to fruit worm and CLN 452 BC1 F3-65-22-1 to sunscald. The highest incidence of TMV was on Pope with a 4.3 rating. The five promising lines including the check were not much affected by bacterial wilt.

Line CLN 698 BC1 F3-517-OP-12 produced the highest marketable yield of 5.1 t/ha which was significant over the check, Pope. Differences in nonmarketable yields among entries were likewise significant; the highest was observed on CLN 457 BC1 F3-230-2-1 (1.3 t/ha). There was no significant difference in fruit size; the grand mean was 27.2 g/fruit.

Poor fruit setting and small fruit size were attributed to bad weather conditions and high incidence of foliar diseases. The total rainfall during the crop season was about 367 mm.

Of the 15 open-pollinated fresh market lines evaluated, three significantly outyielded the check. Nonmarketable yields varied but were not significantly different among entries.

The highest yielder, CLN 729 BC1 F3-74-OG-17 produced the biggest fruits (38 g/fruit). Among diseases of tomato, CLS was the most prevalent in all entries. The highest marketable yield of 7.2 t/ha was obtained from CLN 229 BC1 F3-12-5-3-12-10. The promising lines significantly outyielded the check, Pope, which produced 1.43 t/ha yield. Nonmarketable yield produced by the check was comparable to the promising lines. The biggest fruit (33 g/fruit) was produced by the highest yielding line.

The reactions of the entries to fruit worms and tomato diseases were comparable to the check. TMV and CLS were the most prevalent diseases in all lines with grand mean scores of 2.52 and 2.61, respectively.

The low yields of the entries were again attributed to heavy rainfall and severe foliar disease infections during the crop season.

General Yield Trial on Tomato

Summary

Fourteen AVRDC open-pollinated fresh market tomatoes were evaluated during the dry and wet seasons of 1987-88. Yield varied significantly in both seasons with CL 5915-223 (G) D4-2 and

CL 5915-206 (G) D4-2 producing the highest yields during the dry and wet seasons, respectively. The entries flowered in 24 days and matured in 59 days during the dry season, while during the wet season, flowering was observed after 24.5 days and maturity at 66.4 days. Fruit setting was higher during the dry season (4.3 score) with bigger fruits (31.2 g/fruit). Entries showed various reactions to sunscald, cracking and bacterial wilt incidence.

Introduction

Lines found promising after four seasons in the PYT were evaluated in the GYT to screen further entries with high marketable yield, potential desirable fruit characters and resistance to tropical diseases. Seeds of outstanding entries from GYT are then increased for submission to the national cooperative testing (NCT) for vegetables for regional evaluations.

Materials and Methods

Fourteen open-pollinated fresh market tomatoes were compared to the check varieties Marikit and Pope. The dry season trial was transplanted on 1 December 1987 and the wet season on 10 June 1988. The entries were distributed in a randomized complete block design with four replications in subplots of 5 m^2. In both seasons, each plot was mulched with rice straw. All cultural requirements of the crop as recommended by AVRDC were observed.

Data on yield and other horticultural characters as well as observations on pests, diseases and physiological disorders were recorded.

Results and Discussion

Both marketable and nonmarketable yields of the 14 AVRDC open-pollinated fresh market lines compared to the checks Pope and Marikit are presented in Table 4. During the dry season trial, eight lines significantly outyielded both check varieties. The highest yield of 17.0 t/ha was produced by CL 5915-223 (G) D4-2. During the wet season, CL 5915-206 (G) D4-2 with 18.8 t/ha and CL 5915-222-D6-0-5 with 17.9 t/ha outyielded the higher yielding check Marikit (15.5 t/ha) but the differences were not significant. There were significant differences among entries on culled yields during

Table 4. Yield of tomatoes under the GYT during DS 1987-88 and WS 1988.[z]

Entry	Marketable Yield (t/ha)		Nonmarketable Yield (t/ha)		Total Yield (t/ha)	
	DS	WS	DS	WS	DS	WS
CL 1131-0-0-7-2-0	7.6 e-g[y]	16.1 ab	3.3 a-d	3.3	10.9	19.4
CL 1131-0-43-4-12	14.6 a-c	15.1 a-c	4.7 a-c	3.9	19.3	19.0
CL 1131-0-43-8-1	15.5 ab	19.9 ab	4.8 ab	3.2	20.3	23.1
CL 5915-197 (G) D4-1	12.7 b-d	13.6 ab	4.1 a-c	2.9	16.8	16.5
CL 5915-223 (G) D4-2	17.0 a	15.8 ab	3.6 a-d	3.4	20.6	19.2
CL 5915-153 (G) D4-2	10.0 d-f	10.3 bc	2.4 cd	3.5	12.4	13.8
CL 5915-217 (G) D4-1	8.0 e-g	11.1 bc	2.6 b-d	2.8	10.6	13.9
CL 5915-362 (G) D4-1	6.9 g	13.0 ab	2.8 b-d	3.8	9.7	16.8
CL 5915-222 (G) D4-0	15.7 ab	14.6 ab	4.4 a-c	2.9	20.1	17.5
CL 5915-369 (G) D4-1	12.6 b-d	15.0 ab	5.5 a	3.7	18.1	18.7
CL 5915-455 (G) D4-1	10.2 de	13.4 ab	3.5 a-d	3.5	13.7	16.9
CL 5915-206 (G) D4-2	15.4 ab	18.8 a	4.2 a-c	3.7	19.6	22.5
CL 5915-229 D6-1-4	3.3 h	11.7 b	1.5 d	2.5	4.8	14.2
CL 5915-222 D6-0-5	12.9 b-d	17.9 a	4.7 a-c	3.4	17.6	21.3
Marikit (ck)	7.1 fg	15.5 ab	3.3 a-d	3.6	10.4	19.1
Pope (ck)	8.6 e-g	6.1 c	2.9 b-d	2.3	11.5	8.5
Grand Mean	11.1	14.3	3.7	3.3	14.8	17.1
CV (%)	16.8	24.8	37.2	40.9		

[z]DS trial transplanted 1 December 1987, harvested 4 times from 27 January to 15 February 1988; WS trial transplanted 10 June 1988, harvested 8 times from 2 August to 26 1988. [y]Means followed by the same letter in each column are not significantly different at 5% level using DMRT.

the dry season and none during the wet season. The entries flowered from 22 to 27 days during the dry season and from 22 to 29 days in the wet season. Fruit maturity was attained at 56 to 67 days for the dry and 59 to 76 days for the wet season.

On fruit size, there were significant differences among entries with the biggest from lines CL 5915-455 (G) D4-1 and CL 5915-217 (G) D4-1 with 39 and 38 g/fruit, respectively during the dry season. For the wet season, the biggest fruit (48 g/fruit) was observed from line CL 5915-229 D6-1-4 which was comparable to Pope but significantly different from Marikit.

Fruit setting was relatively high (mean score of 4.3) during the dry season with no significant differences among entries. However, the wet season showed varying fruit setting score. The highest score of 4.2 was observed on CL 5915-222 D6 6-5 which was significantly different from the two checks.

On physiological disorders, sunscalding was more pronounced during the day compared with the wet season (Table 5). There were significant differences among variations in reaction to sunscald. The incidence of fruit cracking was slightly higher on some entries during the dry season compared to the wet season, although the grand means of both seasons were closely similar. The same observations were noted on the reaction of the entries to bacterial wilt infection.

Table 5. Physiological disorders and bacterial wilt rating of GYT entries, DS 1987-88 and WS 1988.[z]

Entry	Sunscald		Fruit cracking		Bacterial wilt	
	DS	WS	DS	WS	DS	WS
CL 1131-0-0-7-2-0	3.5 a-c[y]	3.0	1.2 cd	1.5	1.0 c	1.2
CL 1131-0-43-4-12	2.7 b-e	2.8	1.5 b-d	1.0	1.2 c	1.2
CL 1131-0-43-8-1	2.0 e	2.5	2.7 a	1.8	1.0 c	1.0
CL 5915-197 (G) D4-1	2.7 b-e	3.0	2.0 a-c	1.3	1.0 c	1.2
CL 5915-223 (G) D4-2	3.0 a-e	2.3	1.5 bc	1.5	1.5 bc	1.2
CL 5915-153 (G) D4-2	2.7 b-e	1.8	1.2 cd	2.5	1.0 c	1.2
CL 5915-217 (G) D4-1	3.7 ab	2.0	1.7 b-d	1.0	1.2 c	1.5
CL 5915-362 (G) D4-1	4.0 a	2.0	1.2 cd	1.5	1.5 ab	1.5
CL 5915-222 (G) D4-0	2.5 c-e	2.3	1.5 b-d	1.8	1.5 bc	1.7
CL 5915-369 (G) D4-1	2.5 c-e	2.3	1.5 b-d	1.3	1.0 c	1.2
CL 5915-455 (G) D4-1	2.5 c-e	1.8	1.5 b-d	1.3	1.2 c	1.2
CL 5915-206 (G) D4-2	2.2 de	2.8	2.2 ab	1.3	1.2 c	1.7
CL 5915-229 D6-1-4	4.0 a	1.8	1.0 d	2.3	3.5 a	1.0
CL 5915-222 D6-0-5	2.2 de	2.0	1.7 b-d	1.3	1.8 bc	1.0
Marikit (ck)	3.2 a-d	2.3	1.2 cd	1.5	1.2 c	1.5
Pope (ck)	2.7 b-e	2.3	1.0 d	1.5	1.0 c	2.0
Grand Mean	2.9	2.3	1.6	1.5	1.4	1.3
CV (%)	21.8	37.7	34.2	41.8	45.2	43.8

[z]Rating from 1 to 5 with increasing order of severity. [y]Means followed by the same letter in each column are not significantly different at 5% level using DMRT.

Preliminary Yield Trial on Chinese Cabbage

Summary

Five hybrids and two open-pollinated lines were compared to the check Reyna Elena (ASVEG #1) during the dry and wet seasons. Hybrids 85-202 and 85-216 attained 20.2 t/ha and outyielded the check ASVEG #1 (17.8 t/ha) during the dry season but the differences were not significant. In the wet season, there was not much difference in yield among entries except for 77M (3)-40. Five entries with 13.2 t/ha to 15.9 t/ha outyielded the check Reyna Elena (10.9 t/ha).

Introduction

A preliminary yield trial was conducted on five F_1 hybrids and two open-pollinated lines to determine their marketable head yields and resistance to major pests and diseases during the dry and wet seasons of 1987-1988.

Materials and Methods

The test entries and the check were each planted in 1 m × 4.8 m raised subplots distributed in a randomized complete block design and replicated three times. Two furrows 50 cm apart were set in each subplot. One seedling was planted 40 cm between hills within the furrows and the subplots were mulched with rice straw. The plants were fertilized with 60-35-33 kg/ha of N, P_2O_5 and K_2O, respectively, at planting. Side dressing of 20 kg/ha N was done one WAT and two subsequent applications of 20-0-25 kg/ha N and K_2O were done two WAT and at head initiation, respectively.

Results and Discussion

In the dry season, Hybrids 85-202 and 85-216 (both with 20.2 t/ha) outyielded the check Reyna Elena (17.8 t/ha) but the difference was not significant (Table 6). There were no significant differences in all other characters except on mean head weight wherein the highest was produced by the check (659.6 g). Total precipitation during the crop season was 450.5 mm and mean temperature was 28.75°C maximum and 23.15°C minimum.

The grand mean yield for the eight entries was 12.73 t/ha in the wet season (5). There was not much fluctuation in yield between entries except for 77M (3)-40 which produced 5.7 t/ha. Five entries with yields ranging from 13.2 t/ha to 15.9 t/ha significantly outyielded the check Reyna Elena (10.9 t/ha). The highest mean head weight of 729.1 g was produced by hybrid 85-216. So far, Hybrid 82-157 was least infected by soft rot (12.7%). Total precipitation during the crop season was 378.88 mm and mean temperature was 31.82°C maximum and 24.29°C minimum.

Table 6. Yield performance of the AVRDC Chinese cabbage lines in the preliminary yield trial (1987-1988).

Entry	Computed yield (t/ha)		Mean head wt. (kg)		Harvest rate[X] (%)		Solidity[W] (g/cc)		Soft Rot rating	
	DS[Z]	WS[Y]	DS	WS	DS	WS	DS	WS	DS	WS
77m (3)-40	13.1[V]	5.7 d	0.6 bc	0.6 cd	67.0	28.7 d	0.57	0.61	19.7	44.0 a
77m (2/3)-46	17.3	13.2 ab	0.6 ab	0.7 a-c	80.3	60.0 bc	0.74	0.56	17.7	33.3 ab
Hybrid 82-156	15.7	14.9 a	0.5 d	0.6 d	90.7	80.0 a	0.47	0.49	4.7	13.3 d
Hybrid 82-157	16.1	15.9 a	0.5 cd	0.6 b-d	88.3	77.7 ab	0.64	0.53	5.0	12.7 d
Hybrid 83-20	18.7	10.3 b-d	0.6 ab	0.6 cd	90.7	53.3 c	0.67	0.63	1.0	26.7 bc
Hybrid 85-202	20.2	15.1 a	0.6 ab	0.7 ab	96.0	65.0 a-c	0.48	0.58	0.7	20.0 cd
Hybrid 85-216	20.2	15.9 a	0.6 ab	0.7 a	95.3	65.3 a-c	0.60	0.63	4.7	19.0 cd
Reyna Elena (ck)	17.8	10.9 bc	0.7 a	0.6 a-c	80.7	50.3 cd	0.61	0.57	16.0	34.3 ab
Grand Mean	17.4	12.7	0.6	0.6	86.1	60.0	0.60	0.58	8.7	25.4
CV (%)	19	21.2	7.7	9.6	17	21	19	15		

[Z]Dry season transplanted 25 November 1987; harvested 8 January 1988. [Y]Wet season transplanted 31 May 1988; harvested 4-13 1988. [X]Percentage of harvestable stand. [W]An approximate measurement of head firmness expressed in g/cc. [V]Mean separation within columns was determined using DMRT at 5% level.

General Yield Trial on Chinese Cabbage

Summary

Further evaluation of four promising selections was conducted during the dry and wet season. Hybrid #58 with 15.9 t/ha outperformed the check (Reyna Elena, 15.1 t/ha) although no significant difference was observed. In general, the test entries were comparable to the check in terms of marketable head yield and almost all other parameters measured.

Introduction

After the dry and the wet season trials under the PYT, promising lines with high marketable head yield were further evaluated in the general yield trial.

During the 1987-1988 crop year, four stable hybrids were compared to the check Reyna Elena (ASVEG #1).

Materials and Methods

The entries were transplanted in double-row 1 × 4.8 m^2 raised beds distributed in a randomized complete block design and replicated four times. The rows were set 50 cm apart and the hills 40 cm apart within the rows. The plants were fertilized at the rate of 60-35-33 kg/ha N, P_2O_5 and K_2O, respectively at planting; side dressed with 20 kg/ha N one WAT and two subsequent applications of 20-0-25 kg/ha N and K_2O done two WAT and at head initiation, respectively. Standard AVRDC cultural practices were followed.

Results and Discussion

In the dry season, no significant differences in marketable head yield were observed among entries. The grand mean yield was 15.2 t/ha. Hybrid #58 obtained the highest yield of 15.9 t/ha and mean head weight of 672.2 g.

During the crop season, total precipitation was 487.54 mm and mean temperature was 28.61°C maximum and 23.1°C minimum.

So far, the test entries appear to be comparable to the check Reyna Elena on head yield, mean head weight and solidity.

In the wet season, the results on computed head yield, mean head weight, harvest rate and solidity obtained during the dry season were similar to those of the wet season.

Total precipitation was 260.8 mm and mean temperature was 32.2°C maximum and 24.3°C minimum.

Sweet Potato Germplasm Collection and Maintenance

Summary

One hundred-thirty sweet potato lines/accessions from local and foreign sources (mostly from AVRDC) are maintained in the station. This gene pool serves as source of research materials for POP and other private and government research organizations.

Introduction

The sweet potato improvement program at the AVRDC Philippine Outreach Program (POP) is carried out in collaboration with AVRDC. New sweet potato hybrids and accessions selected at AVRDC for high marketable root yield, resistance to major pests and diseases and high dry matter content are periodically received at POP, Economic Garden. The introduced materials together with those collected from local sources are maintained and evaluated at the station. Promising lines are further evaluated in replicated trials (PYT and GYT), and finally in the national cooperative trial before they are approved by the Philippine Seedboard for national and/or regional recommendation.

Materials and Methods

Newly introduced sweet potato lines/accessions from AVRDC or materials collected from local sources were planted and maintained in 12-inch clay pots under screenhouse condition for quarantine and multiplication purposes. The materials were then planted in 6 m^2 nursery plots in the field for initial observation of the morphological and agronomic characters and for propagation for replicated trials.

Results and Discussion

One hundred-thirty sweet potato lines/accessions are presently maintained at POP. A total of 2,002 cuttings of promising lines/accessions were given free to different institutions for research purposes.

Field Performance Tests (PYT and GYT)

Summary

Promising sweet potato lines/accessions selected from the germplasm study were further evaluated in the PYT and later in the GYT to determine their marketable yield potentials, reaction to scab and dry matter content.

Twenty-five entries in the PYT and 16 in the GYT were evaluated against the check BPI-Sp2 during the dry and wet seasons of 1988. No valid results were obtained from the dry season trials due to the unusually heavy rainfall that prevailed in June and July before the crops were harvested. The adverse conditions caused most developing roots to rot, thus affecting the yield. The wet season trials are still in progress.

Introduction

The promising sweet potato lines/accessions initially selected from the germplasm collection study were tested in replicated trials under the PYT and GYT to evaluate their marketable root yield potential, reaction to scab infection and dry matter content.

Materials and Methods

In the PYT, 25 test entries were evaluated against the check BPI-Sp2 during the dry season (planted 17 February 17 1988) and wet season (planted 20 June 1988). The GYT evaluated 16 test entries against the check BPI-Sp2 during the dry season (planted 2 March 2 1988) and wet season (planted 10 August 1988).

In both trials, each entry was planted in double rows 6 m^2 subplots distributed in a randomized complete block design and replicated three times for the PYT and four times for the GYT. Fertilizers at 90 kg/ha each of N, P_2O_5 and K_2O were applied at planting. The AVRDC recommended practices for sweet potato were followed.

Results and Discussion

The dry season plantings for both the PYT and GYT were overtaken by heavy rainfall which occurred at the start of the rainy season in June and July. In two months, it rained for 30 days with total precipitation of 472.9 mm. These adverse conditions affected the fleshy root development stage of the crop, thus causing most roots to rot in the field. Data from the two trials therefore were not valid. The wet season trial is in progress.

Use of Sex Pheromone to Control Sweetpotato Weevil

Summary

A trial on the new practical IPM approach developed by AVRDC was conducted to determine its effectiveness for weevil control. The field, cleared of sweet potato debris and alternate hosts of the weevil, was planted to insecticide-treated BPI-Sp2 cuttings on 14 September 1988, on subplots of 5 m × 6 m each, distributed in a randomized complete block design and replicated three times.

Three sex pheromone traps were placed in the field two weeks after planting to capture male weevils. Daily counts of trapped weevils were done.

Initial results showed that a total of 2,527 weevils were trapped after 25 samplings. The study is in progress and weevil counts will be made from the fleshy food samples at harvest.

Introduction

Screening of sweet potato lines/accessions for resistance to weevil (*Cylas formicarius* F.) so far showed all materials tested were susceptible to weevil damage. A new practical IPM approach developed by AVRDC has been adopted at POP to control weevil infestations on sweet potato in the field. The method involved removal of sweet potato debris preceding harvest, dipping of cuttings in insecticide solution prior to planting and setting sex pheromone traps in the sweet potato field after planting.

Materials and Methods

The field previously cleared of sweet potato debris and alternate hosts of the weevil was planted to insecticide-treated BPI-Sp2 cuttings on 14 September 1988. Planting was made in the 10-row subplots at 25 cm between hills and 50 cm between 6-m long rows. The 12 5 × 6 m subplots were distributed in a randomized complete block design and replicated three times.

Three sex pheromone traps were placed in the field about two weeks after planting. The design of the pheromone traps and procedures in conducting the study were based on the AVRDC guide on practical IPM approach for the control of sweetpotato weevil.

Results and Discussion

For a period of 37 days (from 13 October to 18 November 1988), initial results showed that the three sex pheromone traps caught a total of 2,527 male sweetpotato weevils. It was also noted that the number of weevils trapped per day depended on the prevailing weather conditions and wind direction.

The study is still in progress and weevil counts will be made from the fleshy root samples at harvest.

Preliminary Yield Trial on Soybean

Summary

The study aimed to evaluate and identify soybean lines with high bean yield potentials, resistance to common pests and diseases and other desirable attributes. Nineteen promising accessions from AVRDC and other sources were evaluated during the dry and wet seasons of 1987-88. Each entry was planted in 5 and 6 m^2 plots during the dry and wet seasons, respectively, and distributed in randomized complete block design with three replications. The entries were evaluated using the AVRDC recommended practices on soybean.

During the dry season, five entries outyielded the highest yielding check BPI-Sy4, but yield differences were not statistically significant.

During the wet season, seven lines surpassed the highest yielding check, but only lines GC 90086 (2.7 t/ha) and GC 90050 (2.6 t/ha) showed significant differences over the check.

Introduction

Promising selections from the early breeding line study were evaluated under the PYT for four seasons. The study aimed to identify lines/accessions with high bean yield potentials, resistance to common pests and diseases and other desirable agronomic attributes.

Materials and Methods

Nineteen test entries were evaluated against the standard checks, BPI-Sy4 and UPL-Sy4. The dry season trial was planted on 20 November 1987 and wet season on 8 June 1988. In each trial, the entries were planted in four-row subplots, distributed in a randomized complete block design and replicated three times. Complete fertilizer 30-30-30 kg/ha of N, P_2O_5 and K_2O, respectively, was applied at planting. Cultural management and data collection were based on the standard cultural practices suggested by the AVRDC International Cooperators Guide for Soybean Evaluation Trial.

Results and Discussion

Of the entries evaluated during the dry season, five outperformed the highest yielding check BPI-Sy4 (Table 7). However, the yield differences were not significant. All entries were rated susceptible to highly susceptible to soybean rust.

During the wet season trial, seven lines outperformed the highest yielding check variety UPL-Sy4 with bean yields of 2.1 t/ha. However, only G 90086 and G 90050 were significantly better than the check variety. Line GC 90089 gave the highest seed size of 24.1 g per 100 seeds. All entries were rated moderately susceptible to susceptible to soybean rust during the dry season.

General Yield Trial on Soybean

Summary

The selected lines from the preliminary yield trial were evaluated in the general yield trial to further verify their yield potentials, resistance to common pests and diseases, and identify their desirable agronomic characters.

Low bean yields were obtained during the dry crop season due to severe drought. However, GC 50095-7-0-9 with 0.8 t/ha significantly outyielded the higher yielding check BPI-Sy4 (0.5 t/ha).

Of the 18 entries evaluated against the two standard checks during the wet season, three entries with yields ranging from 2.5 to 2.7 t/ha outyielded the higher yielding check BPI-Sy4 with 2.4 t/ha, but the difference was not significant.

Introduction

Promising lines selected from the PYT were elevated to GYT to further test their yield potentials, reaction to major pests and diseases and to identify their other desirable agronomic characters. The selections from the GYT are finally evaluated in the RYT for regional evaluation and possible regional and/or national recommendation.

Materials and Methods

Eighteen entries were planted in 10 m^2 subplots, distributed in a randomized complete block design with four replications during the dry (planted 20 November 1987) and wet (planted 1 June 1988) seasons. The plants were fertilized at 30 kg per hectare each of N, P_2O_5 and K_2O at planting. Cultural management and data collection were based on the standard cultural practices suggested by the AVRDC International Cooperators Guide for soybean evaluation trial.

Results and Discussion

The 18 test entries evaluated in the dry season produced a grand mean yield of only 0.46 t/ha due to severe drought and early infection of soybean rust. However, entry GC 50095-7-0-9 with 0.79 t/ha significantly outyielded the highest yielding check BPI-Sy4 with 0.51 t/ha. The other yield parameters measured showed significant differences among entries.

Table 7. Mean bean yield and other agronomical characters of soybean lines under regional yield trial during the dry and wet seasons, 1987-88.

No.	Entry	Yield (t/ha)		Days to flowering		Days to maturity		100-Seed wt. (g)		Seed quality		Productivity kg/ha/day		Rust rating[y]	
		DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
1.	BPI-Sy4 (ck)	.7 a-d[z]	1.9 a-c	29	34	77	91	9.5	13.7	2.0	2.5	9.3	21.6	5.0	3.0
2.	EG Sy 19-37	.4 f-h	1.7 c	33	36	83	97	7.8	13.9	2.0	2.5	4.8	18.0	3.7	3.0
3.	PI 7000	.8 ab	2.1 a-c	29	35	78	90	12.4	15.0	2.0	2.7	10.1	23.3	3.3	2.0
4.	PI 6973	.5 d-g	2.0 a-c	29	38	76	93	9.3	13.9	2.2	2.5	6.6	21.7	4.3	3.3
5.	GC 60062-9-2	.7 a-d	1.5 cd	36	42	77	94	6.5	8.6	2.0	3.0	9.5	16.3	4.0	3.3
6.	GC 90040	.3 gh	1.5 cd	29	30	82	96	9.3	16.5	2.2	2.5	3.5	16.1	3.7	3.3
7.	PI 7395	.3 gh	2.2 a-c	32	32	78	93	9.1	14.5	2.0	2.0	3.7	23.6	4.0	4.0
8.	AGS 135	.6 b-f	2.0 a-c	29	36	73	92	9.8	14.9	2.0	2.5	7.7	21.9	4.7	3.7
9.	SJ 5	.5 c-g	2.1 a-c	31	38	79	97	12.6	12.8	2.0	2.3	6.4	22.2	4.3	3.7
10.	GC 90089	.4 f-h	2.3 a-c	30	35	80	95	13.5	24.1	2.0	3.0	4.9	24.7	3.7	4.0
11.	GC 90086	.4 e-h	2.7 a	31	34	79	95	9.4	15.8	2.5	2.5	5.6	28.9	4.0	3.0
12.	GC 0062	.8 ab	2.4 a-c	31	40	82	102	15.3	18.4	2.0	3.0	10.2	23.2	3.0	3.3
13.	GC 90050	.8 a	2.6 ab	38	43	83	96	7.2	10.4	2.5	2.5	10.2	27.6	3.7	3.3
14.	GC 90088-2	.5 d-g	1.8 bc	31	32	81	95	13.1	19.5	2.0	2.8	6.2	19.3	3.7	4.0
15.	GC 90088-8	.4 f-h	2.1 a-c	31	31	81	93	12.6	20.1	2.0	3.0	4.8	23.1	4.3	4.0
16.	PI 6977	.3 h	.8 d	30	33	77	94	10.0	18.9	2.5	2.5	3.4	8.9	4.7	3.7
17.	UPL-Sy2	.7 a-e	1.8 bc	31	33	77	93	12.5	15.1	2.0	2.7	8.7	19.3	4.0	3.0
18.	PI 7413	.7 a-c	1.9 a-c	29	34	76	92	9.4	14.8	2.0	2.5	9.7	21.5	5.0	3.7
19.	UPL-Sy4 (ck)	.6 b-f	2.1 a-c	29	35	80	96	10.9	16.6	2.0	2.5	7.6	22.1	4.3	3.3
Grand Mean		.5	2.0	31	35	79	94	10.5	15.7	2.1	2.6	7.0	21.2	4.1	3.4
C.V.		15.21	15.30	2.14	1.31	1.03	1.68	8.32	10.23						

[z]Means within a column followed by the same letter are not significantly different at 5% level by DMRT. [y]Rating of 1.5 with 1 = highly resistant and 5 = highly susceptible.

During the wet season, the bean yield ranged from 1.5 t/ha for GC 50225-1-6 to 2.7 t/ha for G 5425. The grand mean was 2.2 t/ha. Three entries with bean yields of 2.5 to 2.7 t/ha performed better than the highest yielding check BPI-Sy4 (2.4 t/ha), although the difference was not statistically significant. Significant differences were also obtained in other yield components measured.

All entries were rated moderately susceptible to highly susceptible to soybean rust during the dry and wet season trials.

Regional Yield Trial on Soybean

Summary

Eight and 10 promising lines were evaluated in the regional yield trial against two standard checks during the dry and wet seasons, respectively. The study was designed to verify the performance of the promising strains/varieties in different regions of the Philippines in terms of bean yield potentials and reactions to major pests and diseases.

Results showed that during the dry season, only TGX 888-48C with 1.0 t/ha significantly outyielded the highest yielding check BPI-Sy4 (0.8 t/ha); AGS 208 ranked third. While during the wet season trial, four out of 10 entries significantly outperformed the highest yielding check BPI-Sy4 with 1.9 t/ha. Line AGS 208 ranked first followed by AGS 133 with bean yields of 3.1 and 2.9 t/ha, respectively.

Introduction

The regional yield trial for soybean under upland monoculture condition was conducted in cooperation with IPB and other institutions involved in soybean varietal improvement. Coordinated by the Technical Working Group for Field Legumes of the Philippines Seedboard, promising entries from various national breeding programs were evaluated for four seasons in 8-12 cooperating stations using a common standard procedure. The study was designed to identify high yielding varieties with desirable agronomic attributes adapted to the different regions of the country. Recently, to regionalize varietal recommendation especially for soybean, promising entries in the RYT in a given region were further evaluated for two seasons in the technology adaptation (TA) trial before a variety is released in the region.

Materials and Methods

The promising lines/varieties selected from the PYT by the breeding agencies/institutions were submitted to the National Legume Technical Committee of the Philippines Seedboard for inclusion in the RYT.

For crop year 1987-88, 12 entries including the two standard checks (1 national and 1 regional) were evaluated during the dry and set seasons. Each entry was planted in 12 m 4-row plots, distributed in a randomized complete block design with four replications. Rows were spaced 50 cm (DS) and 60 cm (WS) apart with about 15 plants per linear meter maintained. The standard procedure for evaluating soybean described in the Upland Crop National Cooperative Trial (UCNCT) of the Philippine Seedboard was followed by all cooperating stations in conducting the test. Only the results from the Economic Garden are presented in this report.

Results and Discussion

Of the eight test entries evaluated during the dry season, only TGX 888-48C with 1.0 t/ha significantly outyielded the highest yielding check BPI-Sy4 by 14.4% (Table 8). Line AGS 208 ranked third. Significant differences in 100-seed weight, days to flowering and maturity were also noted among entries. All entries were rated moderately resistant to susceptible to soybean rust.

During the wet season, four out of 10 test entries evaluated significantly outperformed the highest yielding check BPI-Sy4 with 1.9 t/ha (Table 8). Line AGS 208 with 3.1 t/ha ranked first;

Table 8. Mean bean yield and other agronomical characters of soybean lines under regional yield trial during the dry and wet seasons, 1987-88.

Entry	Yield (t/ha)		Days to flowering		Days to maturity		100-seed wt (g)		Seed quality		Productivity kg/ha/da		Rust rating[y]	
	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS	DS	WS
UPL-Sy4 (ck)	.5 def[z]	1.7 de	31	36	81	93	11.4	13.7	2.0	3.2	6.3	18.6	3.2	4.0
BPI-Sy4 (ck)	.8 ab	1.9 c-e	29	34	76	91	10.6	13.8	2.2	3.6	10.9	21.2	4.5	4.0
LG Sy 1-13	.4 f	2.4 a-d	28	30	79	85	8.9	16.4	2.0	2.6	4.7	28.7	3.7	4.0
LG Sy 1-24	.4 ef	2.0 c-e	28	31	78	94	10.2	13.7	2.0	2.6	5.4	21.5	4.0	4.0
LG Sy 5-17	–	1.7 de	–	32	–	92	–	13.7	–	3.5	–	18.9	–	3.0
TGX 239-17E	.6 cd	–	37	–	85	–	8.0	–	2.5	–	7.6	–	3.0	–
TGX 780-2F	.4 ef	–	40	–	83	–	8.7	–	2.0	–	5.3	–	3.2	–
TGX 888-48C	.9 a	–	37	–	83	–	7.2	–	2.2	–	11.4	–	3.0	–
AGS 133 (EGSy133)	.6 de	2.9 ab	29	33	72	89	11.2	16.1	2.0	2.7	7.9	32.9	4.2	3.7
AGS 208 (EGSy208)	.8 abc	3.1 a	29	31	73	89	12.2	21.1	2.0	2.9	10.9	34.4	4.7	3.0
AGS 129 (EGSy129)	.5 ef	2.5 a-d	28	30	76	92	10.0	16.2	2.0	2.6	6.0	27.6	4.2	4.0
IPB Sy 178-30	–	2.1 b-e	–	48	–	100	–	9.3	–	4.0	–	21.3	–	4.0
IPB Sy 178-42	–	1.8 c-e	–	46	–	100	–	9.4	–	3.9	–	17.3	–	4.0
IPB Sy 182-13	–	1.5 e	–	50	–	101	–	8.5	–	4.2	–	15.0	–	3.5
GC 81076-47	–	2.6 a-c	–	39	–	101	–	16.3	–	3.4	–	25.9	–	4.0
Grand Mean (10 entries DS) (12 entries WS)	.6	2.2	33.3	37	81	94	9.8	14.2	2.1	3.3	7.6	23.6	3.8	3.8
C.V.	15.99	16.40	1.6	1.19	.98	.93	7.85	12.08						

[z]Means within a column followed by the same letter are not significantly different at the 5% level by DMRT. [y]Rating of 1 to 5 with 1 = highly resistant and 5 = highly susceptible.

AGS 133 with 2.9 t/ha, second; and AGS 129 with 2.5 t/ha, fourth in the trial. All entries were rated from moderately susceptible to susceptible to rust infection.

Mungbean Evaluation and Selection of Breeding Lines

Summary

One hundred thirty-five stable mungbean lines previously purified and selected at POP were evaluated in nonreplicated trials during the wet and dry seasons of 1987-88. The most promising lines selected from the wet season trial were from the crosses VC 4195-B, VC 4180-B, VC 4169-B, VC 4146-B and VC 4310-B. Bean yields ranged from 102 to 247% over the check BPI-Mg5.

Introduction

Segregating and stable AVRDC mungbean breeding lines are continuously purified and evaluated at POP to identify lines with promising bean yield potential, desirable agronomic characters, tolerance/resistance to major pests and diseases, and acceptable eating and processing qualities.

Through years of purification and selection 135 promising lines that have attained genetic uniformity were evaluated during the crop year 1987-88.

Materials and Methods

The 135 uniform lines were divided into two groups with 79 lines for Group I and 58 for Group II. Each group was provided with a check (BPI-Mg5) and the entries planted in non-replicated 5-m long 2-row plots. Both groups were evaluated during the wet and dry seasons using the AVRDC guide for mungbean trials.

Results and Discussion

The dry season trial was affected by typhoon, resulting to unreliable data.

For Group I, 10 promising stable lines produced bean yields ranging from 1.6 to 2.3 t/ha or 165 to 247% more than the check BPI-Mg5 (0.9 t/ha). For Group II, four lines were promising with bean yields ranging from 1.3 to 1.8 t/ha or 102 to 143% over the check BPI-Mg5 (1.3 t/ha). Three lines were rated relatively resistant to CLS which was comparable to the check. The promising lines which will be elevated to the PYT were selected from the crosses VC 4180-B, VC 4195-B, VC 4146-B, VC 4169-B and VC 4310-B.

Preliminary Yield Trial on Mungbean

Summary

This study was conducted to identify mungbean lines with high bean yield potential, desirable agronomic characters and disease resistance.

Two sets of entries were evaluated for the wet season. The average bean yields were 1.0 t/ha and 1.1 t/ha for Set I and Set II, respectively. For Set I, no test entry outyielded the highest yielding entry Pag-asa 5 with 1.1 t/ha while for Set II six AVRDC breeding lines with yields ranging from 1.4 to 1.6 t/ha outyielded the check cultivar BPI Mg5 with 1.3 t/ha. However, the mean differences were not statistically significant.

Introduction

Selected materials from the observation nurseries were evaluated in the PYT to identify mungbean lines with high bean yield potentials, desirable agronomic characteristics and disease resistance particularly CLS and PM. Selections from this trial were elevated to the GYT.

Materials and Methods

Thirty-eight most promising lines selected from the observational nurseries during the dry season were evaluated in two sets of PYT trials during the wet season. Eighteen entries (Set I) were planted on 30 May 1988 and 20 entries (Set II) on 29 June 1988. Seeds in each entry were sown in a 5-m long four-row plot, set 0.5 m apart and distributed in a randomized complete block design with three replications.

The cultural management and data collection were based on the standard procedure suggested by the AVRDC International Cooperators Guide for Mungbean evaluation trial.

Results and Discussion

Set I. The grand mean of 18 entries was 1.0 t/ha. Only AVRDC lines, VC 3995-B-5 with 1.1 t/ha and VC 3890-B-3-1 with 1.1 t/ha gave comparable yields as the check cultivar Pag-asa 5 with 1.3 t/ha (Table 9). VC 3560-B-4-4 produced the largest seed. Virus infection was observed during the early stage of the crop. However, the crop recovered during the reproductive stage.

Set II. The grand mean yield of the 20 entries was 1.1 t/ha. Six lines with bean yields of 1.2 to 1.6 t/ha outperformed the check BPI-Mg5 (1.3 t/ha). However, the differences were not statistically significant. A selected yellow-seeded line from BPI-Mg5 (VC 2764) showed a high yield potential and moderate level of resistance to CLS and virus infection. Line VC 3560 B-4-4 had the largest seed weight (6.1 g/100 seeds).

Table 9. High yielding mungbean lines selected from the PYT I evaluated during the wet season, 1988.[z]

Entry	Yield (t/ha)	Days to at maturity	Plant Height maturity (cm)	100-seed weight (g)	Disease CLS[y]	Rating virus[x]
VC 3995-B-5	1.1	57.3 b	82.0 ab	6.0 a	3.3 a	1.3 bc
VC 3890-B-3-1	1.1	57.0 b	70.7 d	6.0 a	3.0 ab	1.3 bc
VC 3995-B-6-1	1.0	56.7 b	74.7 b-d	5.9 a	3.0 ab	1.0 c
Pag-asa 5 (ck)	1.2	51.7 ab	81.2 ab	5.0 cd	2.7 a-c	1.3 bc
BPI-Mg5 (ck)	1.1	57.0 b	85.3 a	5.2 bc	3.0 ab	1.7 bc
Grand Mean (18 entries)	1.0	57.6	74.9	5.2	2.6	1.6
C.V. %	16.39	1.01	6.69	1.03	17.09	31.28

[z]Means in each vertical column followed by the same letter are not statistically different at 5% level (DMRT). [y]CLS = Cercospora Leaf Spot on a scale of 1 to 5 where 1 is highly resistant and 5 is highly susceptible. [x]Reaction to virus rated on a scale of 1 to 3 where 1 is resistant and 3 susceptible.

General Yield Trial on Mungbean

Summary

The study was designed to further screen and select PYT lines for yield potential, adaptability to local agroclimatic conditions and reactions to common pests and diseases.

Fifty-one entries were evaluated in three sets of trials during the CY 1987-88. The highest yielding entries during the wet season were VC 3738 A, VC 3890-B-2-1-1-B and VC 3827-2B-2-1-B with yields ranging from 1.4 to 1.8 t/ha; and during the dry season; VC 3890-2B-B-1-B and VC 3738 A with 0.7 and 0.8 t/ha, respectively.

From the previous GYT, lines VC 3121-2B-1-1-B, VC 3108-2B-1-2B, VC 3061-7-1-1-1-B and VC 3102-B-2-2B were selected for inclusion in the RYT.

Introduction

Selected lines from the PYT were elevated to the GYT to get more precise information on their yield potentials, adaptability under local agroclimatic conditions and reactions to common pests and diseases. Results of the trial served as basis for selecting entries for inclusion in the RYT of the National Cooperative Test.

Materials and Methods

Fifty-one entries were evaluated in three sets of GYT trials during the crop seasons of 1987-88. Eleven entries (Set I) were planted on 21 October 21 1987 (DS) and 30 May 1988 (WS). In Set II, 16 entries were planted on 21 October 1987 (DS) and 29 June 1988 (WS); and, in Set III, 24 entries were selected from the previous PYT trials on 30 May 1988. A randomized complete block design (four row-plot, 5-m long) with three replications was used in all sets of trials. The AVRDC suggested cultural management and data collection procedures were followed.

Results and Discussion

Set I. Of the 11 entries evaluated, only line VC 3738 significantly outyielded the check BPI-Mg5 during the dry and wet seasons (Table 10). Four other entries were comparable to the check during the dry season and six during the wet season but their yield differences were not statistically significant. The low grand mean yield of 0.6 t/ha during the dry season was due to typhoon and heavy CLS infection that occurred during the reproductive stage of the crop.

Set II. Seven entries during the dry season and five during the wet season outyielded the check BPI-Mg5 but the yield differences were not significant in both seasons. So far, line VC 3890-2B-B-1-B was most promising during the wet and VC 3827-2B-2-1-B during the dry season in terms of bean yield and other yield components. Similar to Set I, the grand mean yield during the dry season was low due to adverse weather condition and severe CLS infection during the trial.

Set III. The field performance of the eight top yielding entries during the wet season ranged from 1.2 to 1.4 t/ha which did not significantly differ from the check UPL-Mg5 (Pag-asa 5) which yielded 1.2 t/ha. The other yield parameters measured (e.g. 100-seed weight and disease ratings) did not differ much among entries.

Table 10. Performance of the 10 AVRDC mungbean breeding lines compared with the check cultivar BPI-Mg5 under the GYT during the dry and wet seasons, 1987-88 Set I.[z]

Entry	Yield (t/ha)		Days to maturity		Plt. ht. at maturity (cm)		100-seed wt. (g)	
	DS	WS	DS	WS	DS	WS	DS	WS
VC 3738 A	0.8 a	1.7 a	56.7 b	56.7	53.5 a-c	62.9 c	5.8 b	5.8 cd
VC 3907 A	0.7 b	1.5 a-c	56.7 b	57.3	51.4 a-c	66.6 a-c	6.1 a	5.9 a-c
VC 3890 A	0.7 b	1.4 a-d	56.0 bc	56.3	51.2 b-c	64.9 bc	5.7 b	5.8 b-d
VC 3857	0.6 bc	1.5 ab	57.3 b	57.3	52.7 a-c	74.8 a	5.4 cd	6.0 a
VC 3541 A	0.6 bc	1.5 a-c	56.7 b	56.7	53.5 a-c	63.7 c	6.0 a	5.9 ab
BPI-Mg5 (ck)	0.6 bc	1.1 b-d	56.7 b	57.7	56.2 ab	74.1 ab	5.5 c	5.5 e
VC 3678 A	0.6 bc	1.3 b-d	56.3 bv	56.7	53.1 a-c	62.3 c	4.8 f	4.9 b
VC 3932 A	0.6 b-d	1.2 b-d	60.0 a	57.3	51.3 a-c	68.5 a-c	5.3 d	5.4 f
VC 1973 A	0.6 b-d	1.1 d	56.7 b	56.7	56.9 a	74.1 ab	6.0 a	5.8 d
VC 2991 A	0.5 cd	1.1 cd	55.0 c	57.9	52.3 a-c	75.3 a	5.1 e	5.0 g
VC 3853 A	0.5 d	1.4 a-d	60.3 a	51.0	49.4 c	62.9 c	5.0 e	5.0 g
Grand Mean	0.6	1.4	51.1	51.0	52.9	68.2	5.5	5.5
CV (%)	11.7	13.8	1.31	1.08	5.36	6.98	0.99	1.08

[z]Means in each vertical column followed by the same letter are not statistically different at 5% level (DMRT).

International Mungbean Nursery

Summary

Twenty IMN entries were evaluated during the dry and wet seasons of 1987-88. The dry season data were not valid due to adverse weather conditions during the trial resulting to low grand mean yield (0.4 t/ha) of the 20 entries and high CV of 36%.

During the wet season, five entries with bean yields of 1.5 to 1.9 t/ha outyielded the check V 3476 (Pag-asa 1) which produced 1.7 t/ha. The differences, however, were not significant.

So far, entries VC 3888 A and VC 2768 A showed better CLS resistance and had bigger seeds, compared to the check V 3476 (Pag-asa 1).

Introduction

The IMN is an international cooperative trial on mungbean currently coordinated by AVRDC. The entries are elite cultivars/accessions from different countries of origin collected by AVRDC and sent to different cooperators. The study aimed to provide information on the range of adaptation of the mungbean species and specific cultivars, and characteristics of the mungbean plant influencing adaptation. It also served as a means of disseminating superior cultivars to mungbean research workers.

Materials and Methods

Twenty elite mungbean cultivars/accessions were planted on 18 November 1987 (DS) and 29 June 1988 (WS) in a randomized complete block design with four replications. The entries were from AVRDC (17), India (1), Korea (1) and the Philippines (V 3476 or Pag-asa 1 used as check). The AVRDC guide for mungbean evaluation was followed.

Results and Discussion

During the dry season, entries V 2984 with 0.8 t/ha, VC 3737 A with 0.6 t/ha, significantly outyielded the check V 3476 (Pag-asa 1) which produced 0.3 t/ha. However, the low grand mean yield (0.4 t/ha) of the 20 entries and the high CV of 36% due to adverse climatic conditions invalidated the dry season data (Table 11).

Table 11. Performance of the top yielding mungbean entries in the IMN during the dry and wet seasons of 1987-88.[z]

Entry	Yield (t/ha)	Days to maturity	Plant height at maturity (cm)	100-seed wt. (gm)	Disease rating	
					CLS[y]	virus[x]
Dry Season						
V 2984	0.8 a	58.7 bc	53.1 a	4.0 g	3.0	1.3
VC 3737 A	0.6 ab	59.7 ab	47.4 a-d	5.0 d	2.3	1.3
VC 3888 A	0.6 a-c	59.3 bc	50.7 ab	5.4 b	2.0	2.0
VC 3301 A	0.6 a-d	61.0 a	50.0 ab	4.4 f	2.6	1.7
VC 3012 A	0.6 a-d	59.3 bc	44.0 b-f	4.5 ef	2.3	1.7
V 3476 (ck) (Pag-asa 1)	0.3 c-e	59.0 bc	42.3 d-h	4.5 ef	2.6	1.3
Grand Mean (20 entries)	0.4	59.3	44.4	4.9	2.8	1.6
CV (%)	36.5	1.18	13.43	1.28	17.89	32.27
Wet Season						
VC 3300 A	1.9 a	57.0 d-f	82.7 a-c	5.8 b	3.0 bd	1.7 d
VC 2768 A	1.9 a	56.7 ef	70.0 de	5.9 ab	2.0 e	2.0 cd
V 2984	1.6 ac	56.3 f	81.9 a-c	3.6 h	3.3 a-c	2.0 cd
VC 2917 A	1.6 a-d	57.3 c-e	83.3 ab	4.9 f	2.3 dc	1.7 d
VC 1973 A	1.5 a-e	56.7 ef	80.6 a-d	5.3 de	2.7 b-e	1.7 d
VC 3476 (ck) (Pag-asa 1)	1.7 ab	57.0 d-f	74.4 b-e	5.0 f	2.7 c-e	1.7 d
Grand Mean (20 entries)	1.2	58.5	75.1	5.2	2.9	2.5
CV (%)	20.8	0.9	7.7	1.4	16.8	12.7

[z]Means in each vertical column followed by the same letter are not statistically different at the 5% level (DMRT). [y]Reaction to CLS-Cercospora leaf spot rated on a scale of 1 to 5, where 1 is highly resistant and 5 is highly susceptible. [x]Reaction to virus rated on a scale of 1 to 3, where 1 is resistant and 3 is susceptible.

For the wet season, five entries with bean yields ranging from 1.5 to 1.9 t/ha outperformed the check V 3476 (Pag-asa 1) with 1.7 t/ha. However, the differences were not significant.

So far, entries VC 3888 A and VC 2768 A showed better resistance to CLS (rating of 2) and had bigger seeds compared to the check V 3476 (Pag-asa 1).

Regional Yield Trial on Mungbean

Summary

A component of the National Crop Improvement Program, the RYT aims to determine the seasonal and regional adaptabilities of new strains/varieties of crops. The results from the RYT are used by the Philippine Seedboard in releasing new commercial varieties.

For the mungbean improvement program, of the 10 entries evaluated in 1987-88 four were AVRDC lines. EGM 2307 ranked first in terms of yield across locations during the wet season and EGM 2768 during the dry season.

Due to the outstanding performance of line EGM 1973 in the RYT from 1985-1987, the Philippines Seedboard approved its release for commercial production as variety BPI-Mg7 in June 1988.

Introduction

The RYT is jointly undertaken by the different research organizations engaged in crop improvement. In mungbean varietal improvement program, RYT is conducted simultaneously in 8 to 12 sites to evaluate the performance of promising lines/accessions in the different regions of the country. The results obtained from the RYT serve as the basis for recommendation/approval by the Philippine Seedboard of new varietal releases for commercial production.

Materials and Methods

Promising mungbean lines/accessions from the PYT and GYT of the different national breeding programs were screened by the National Legume Technical Committee of the Philippine Seedboard for inclusion in the RYT. Acceptable entries were evaluated in 8 to 12 locations using the procedures described in the Upland Crops National Cooperative Trial (UCNCT). The committee reviews yearly the results of the RYT. After undergoing four seasons of testing, it is either recommended for approval by the seedboard or is dropped from the RYT.

For 1987-88, 10 mungbean entries (four of which were AVRDC lines) including a national and two regional checks were evaluated in the RYT.

Results and Discussion

The performance of the 10 entries were means of seven stations during the wet season and six stations during the dry season. In terms of bean yield among the test entries, EGM 2307 ranked first during the wet season and EGM 2768 during the dry season. So far, bean yield appeared to be unstable among the entries and was affected by the season. In terms of seed size, lines EGM 2768 and EGM 2778 with over 6 g/100 seeds were most promising for both seasons and surpassed MG50-10A with 5.3 to 5.5 g/100 seeds. Depending on the season, most entries were moderately resistant to moderately susceptible to disease infection, especially to CLS.

Regional Programs

Property of Bentley

AVRDC-Thailand Outreach and Regional Training Program

In 1988, the following project activities were established at the TOP experimental field:

- Yield trials for Chinese cabbage, sweet potato, tomato, mungbean, soybean and pepper.
- Crop protection trials
- Cultural management trials
- Seed multiplication and quality evaluation trials
- Home garden programs including nutritional assessment studies
- Disease and insect resistance screening
- Experimental research for the trainees and visiting scholars
- Demonstration plots on AVRDC-improved crops released in Thailand

On crop improvement, TOP conducted out-of-station research and on-farm trials in cooperation with the Thai government, academic research institutions and farmers. These trials determined the performance and stability of AVRDC developed lines/varieties in different agroclimates, methods of cultivation as well as the adoption of the AVRDC developed technologies. In 1988, a total of 65 research trials and 10 on-farm trials were conducted, the results of which are highlighted in this report.

Chinese Cabbage On-farm Trials

Results of on-farm trials showed that the commercial cultivars grown in the Central lowland area of Thailand from March to August when the average maximum temperature was over 32°C did not form heads and gave a very low yield of 4-10 t/ha. On the other hand, the AVRDC-developed heat-tolerant Hybrid 62, grown during the off season yielded 25-30 t/ha. Reduction in the yield of this variety due to excessive heat was not high compared to the commercial varieties.

To promote adoption of Hybrid 62, information dissemination by radio and distribution of seed samples to farmers were done during the early summer of 1988. Favorable feedback was received, such as letters from farmers requesting seeds for large scale planting. F_1 hybrid seeds were produced through the initiative and coordinative efforts of TOP in three different stations: in the highland Doi Ang-Kang of Chiang Mai, Pakchong Research Station in the North East, and in AVRDC-TOP field at Kamphaeng Saen, Nakhon Pathom.

Besides several varietal, cultural management and crop protection trials conducted by the 6th RTP training scholars, a study on the effect of plant density on the yield of Chinese cabbage was completed in February, 1988. A brief description of this study is outlined here.

Effect of Plant Density on Chinese Cabbage Yield

Introduction

Hybrid 62 had been grown several times in preliminary and advance yield trials following the spacing used for bigger commercial and late maturing cultivars. It was observed that much

space was left between plants and also within the row even at maximum growth. To find the most suitable spacing for Hybrid 62 during both warm and cool seasons, two experiments with four levels of spacing were conducted.

Materials and Methods

Chinese cabbage cultivars, Hybrid 62 and Elephant Brand (a commercial cultivar) were grown during the rainy season (July-September, 1987) under five levels of spacing; 40 × 40, 40 × 30, 40 × 35, 30 × 30 and 30 × 25 cm^2. During the cool season (December, 1987 - January, 1988) the same varieties were tested using four spacings: 30 × 50, 30 × 40, 30 × 30, and 30 × 27 cm^2. The experimental design used was split-plot with four replications and with cultivars as the main plot and spacing as the subplot.

Results and Discussion

In the rainy season, the temperature was rather high during head formation. More than 50% of the commercial cultivar Elephant Brand did not form head and 30% was infected with soft rot compared to Hybrid 62 with only 16-17% that did not form head and 2-3% of the plants that had soft rot infection.

Consequently, the commercial cultivar gave a low yield of only 4-11 t/ha, while Hybrid 62 gave a high yield of 26 t/ha.

There were no significant differences in terms of head yield among various spacings tested. However, during the cool season, Hybrid 62 grown under spacing of 30 × 27 cm^2 gave a maximum yield of 51.6 t/ha. This significantly differed from the yield obtained from plants spaced at 30 × 50 cm^2. Yields from 30 × 30 cm^2 and 30 × 40 cm^2 were not much different from those planted with the closest spacing. No significant differences were obtained among spacings using Elephant Brand Commercial Variety (Tables 1 and 2).

Closer spacing affected many aspects in Hybrid 62 but seemed to affect only the mean head weight of the commercial cultivar. The HSI value of Hybrid 62 increased as the space between plants lessened.

These results suggest that 40 × 40 cm^2 and 30 × 30 are the optimum spacings for Hybrid 62 during the warm season and 30 × 40 cm^2 during the cool period. Elephant Brand, which is a larger plant and late maturing should be planted at the closest spacing of not less than 40 × 40 cm^2.

Tomato Variety Released

Another tomato variety was officially released after Seedathip I. This variety was officially named Seedathip II. It is of determinate type, takes 22 days to flower, with pink and pear-shaped fruit and weighs 30 g. It is tolerant to Cercospora leaf mold. AVRDC's tomato SVRDC 4 is one of its parents.

Table 1. Effect of plant spacing on growth and yield of two Chinese cabbage varieties during rainy season, 1987.

Spacing (cm)	Total stand	Harvest rate	% Soft rot	% Non-heading	Day to maturity (DAT)	HSI[z]	Ave. plant wt. (kg)	Ave. head weight (g)	Yield (t/ha)
Commercial var.									
30 × 25	437	33	24	43	45	1.62	0.91	333	11.0
30 × 30	392	23	21	56	45	1.61	0.95	365	7.5
40 × 25	335	23	25	52	45	1.66	1.00	398	7.0
40 × 30	315	22	34	44	45	1.59	1.01	303	4.8
40 × 40	252	19	20	51	45	1.66	1.21	400	4.3
Hybrid 62									
30 × 25	472	79	2	19	39	1.42	0.85	309	26.6
30 × 30	410	72	3	25	39	1.45	0.86	351	23.8
40 × 25	369	83	2	15	39	1.35	0.97	391	27.9
40 × 30	322	81	3	16	36	1.29	1.08	438	26.5
40 × 40	251	91	2	7	36	1.27	1.29	487	26.0
								LSD (05) =	4.227

[z]HSI = Head Shape Index = $\frac{\text{Mean head length}}{\text{Mean head width}}$

Table 2. Effect of plant spacing on growth and yield of two Chinese cabbage varieties during cool season, 1988.

Treatment spacing	Total stand	Harvest rate	% Soft rot	% Non-heading	Tip-burn	Day to maturity (DAT)	HSI[z]	Ave. plant wt. (kg)	Ave. head weight (kg)	Yield (t/ha)
Commercial var.										
30 × 27	351	77	4.0	19.0	0	46	1.81	1.02	379.5	35.7
30 × 30	319	80	3.5	16.5	0	45	2.00	1.07	397.0	35.5
30 × 40	240	93	2.0	5.0	0	44	1.91	1.28	467.4	36.0
30 × 50	192	92	4.0	4.0	0	41	1.97	1.43	541.5	33.1
									(NS)	
Hybrid 62										
30 × 27	352	89	3.0	1.0	7	33	1.49	0.87	475.3	51.6[a]
30 × 30	320	91	3.0	1.0	5	33	1.44	0.89	503.5	50.7[a]
30 × 40	240	92	1.0	0.0	7	31	1.41	1.06	604.7	46.7[b]
30 × 50	129	99	0.5	0.0	0.5	32	1.32	1.11	611.0	40.3[b]

CV for subplot = 12.2498 LSD (05) = 4.506
CV for mainplot = 30.7109

[z]HSI = Head Shape Index = Mean head length / Mean head width

Evaluation of Heat-tolerant Tomato Combinations

Introduction

Since the introduction of cherry tomato in the country more than 20 years ago, variety Seeda, with small, pink fruits has been the preferred common fresh market table tomato in Thailand. Seeda is still widely grown. However, it poses great problems to farmers because it carries only a moderately heat-tolerant gene and is also susceptible to many diseases. Thus, during off season (rainy warm season) very low yield is obtained resulting to a rise in market price of tomato. To help the farmers, AVRDC-TOP established a tomato breeding program with the aim of developing improved varieties which are heat-tolerant, resistant to diseases, high yielding and acceptable to both producer and consumer.

Materials and Methods

AVRDC-TOP has improved cultivars by transferring the heat-tolerant character from AVRDC's materials into the Seeda variety and selecting plants with pink ovate fruits from segregated populations under high temperature at night in summer and rainy seasons. Breeding trials were carried up to F_7 generation.

Evaluation tests showed that the newly developed cultivars Seedathip I and II had an average yield twice as high as the material Seeda. The two improved cultivars were released in 1987 and 1988. However, since Seedathip I and II are open-pollinated varieties they still possess some variations and do not produce as much fruits as the hybrid.

Combination attempts started in 1987 resulted in the development of seven F_1 hybrids in 1988. With heat-tolerant parents and excellent to KPS conditions, these F_1 hybrids were produced and tested in three different seasons: cool (October-February), hot (March-July) and rainy (July-October).

Results and Discussion

The yield and other fruit characteristics of the different combinations obtained from these trials are presented in Table 3.

The local cultivar, Seeda gave the lowest yield in all trials especially during summer and rainy seasons with fruit yields of 3.8 and 0.3 t/ha, respectively. Seedathip I and II produced fruits at least

3-4 times of these amounts. Although these two heat tolerant varieties had higher yield than Seeda, they were outyielded by all hybrids. All F_1 hybrids with Seedathip I or Seedathip II as one of their parents set better fruits than those with Seeda as one of their parents. Seedathip I had less attractive fruit color and was shunned by consumers when there was an over supply of tomato in the market. Although Hybrid 110 was the highest yielder among the cultivars tested, Hybrid 111 and 115 were more acceptable because of their pinkish and rather large fruits.

Table 3. Yield and fruit characteristics of tomato F_1 hybrids during three cropping seasons, 1988.

Combination and variety	Yield (t/ha)			Ave	Fruit	
	Cool (Oct-Feb)	Summer (Mar-Jul)	Rainy (Jul-Oct)		Size (g)	Color
#110 (B1 x Seedathip I)	58.2	33.8	6.0	32.7	22.0	Pink-orange
#111 (B1 x Seedthip II)	48.3	22.8	5.5	25.5	24.6	Pink-red
#112 (B1 x 26-44B4)	54.5	33.5	2.5	30.2	25.4	Pink-red
#113 (B1 x Seeda)	38.7	15.7	1.6	18.7	23.5	Pink
#114 (B2 x Seedathip I)	47.6	30.2	6.1	28.0	22.6	Pink-orange
#115 (B2 x Seedathip II)	52.4	20.3	4.9	25.9	23.3	Pink-red
#116 (B2 x 26-4484)	47.5	27.7	3.9	26.4	24.5	Pink-red
Seedathip I (HTck)	32.7	17.4	5.9	18.7	19.7	Pink-orange
Seedathip II (HTck)	39.4	10.9	2.4	17.6	23.5	Pink
Seeda (Local ck)	30.1	3.8	0.3	11.4	18.8	Pink

Improvement of Seedathip I

Seedathip has gained acceptability among farmers since its release in 1987. However, the pink-orange fruits command a lower market price than the popular Thai cultivar Seeda. AVRDC-TOP's breeding program aimed to improve the fruit color by backcrossing with a variety that has true pink fruits. The present improvement program has just completed the F_4 generation.

Evaluation of Heat-tolerant Tomato Hybrids

Forty-five F_1 hybrids which combined heat tolerance and heat sensitivity characteristics were evaluated together with open-pollinated commercial cultivars from April to August 1988. The heat sensitive cultivars were chosen for their large, pink fruit and thick fruit wall. Some of these cultivars are: Chiang Feng, Early Pink, Mishou Mom Sze from China; Hoc Mon from Vietnam; and Floradale from USA. The heat tolerant materials used were the improved lines from AVRDC such as: CL 5915-206D_5-2-5-0, CL 5919-223D_4-2-10-0, CL 93D_4-1-0-1-2 and CL 95-280D_5-1-7-0. AVRDC selected lines, 3-12B_4-1-12, 3-12B_4-1-21 and 3-12B_4-2-13 which had some degree of pink fruit were also used.

All hybrids gave high fruit yield ranging from 12.8 to 41.2 t/ha compared to 5.6 and 0.9 t/ha obtained from Seeda and VF 134-1-2, respectively. High yielding combinations were those of the HT line from AVRDC, HS line Hoc Mon from Vietnam and Floradale from USA. These high yielding hybrids, however, had orange fruit and thin fruit wall. The combinations of HS Chiang Feng and a selected line from AVRDC-TOP produced pink fruits with thick fruit wall. Unfortunately the yield of this material was low, less than 20 t/ha.

In view of the aim to produce an F_1 hybrid table tomato which is both heat-tolerant and with pink fruit, the AVRDC-TOP program needs to use more cultivars with pink fruit for both male and female parental lines.

Pepper

Since this is a new crop for AVRDC-TOP, initial activities were mainly concentrated on germplasm collection. To date, 12 varieties are pooled in the AVRDC-TOP germplasm collection.

Sweet Potato

Sweet potato trials were carried out by the 6th RTP training scholars. Aside from these trials, activities were centered mainly on germplasm collection. To date, 66 varieties/cultivars are being maintained in the field for distribution to cooperators and for future experiments.

The 7th RTP training scholars from Sri Lanka, Vietnam and China brought in new cultivars for propagation and testing, in addition to those presently maintained.

Acceptance of Released Mungbean Varieties

AVRDC mungbean varieties KPS 1 and KPS 2 have gained popularity among mungbean growers and became the most sought after cultivars in Thailand. Last rainy season, these cultivars reached a price of 25 Baht per kilo, 9 baht higher than the price of other cultivars.

In the previous rainy season, the farmers of Petchabun province grew KPS 2 in an area of over 2,000 ha and KPS 1 in around 500 ha. Since the province was the largest mungbean producer, it was expected that the area planted to KPS 1 alone could easily be over 5,000 ha in the late rainy season of 1989. If there will be no other cultivars to replace these two in the future, then the planted area all over the country can have a share of as much as 10% of the total mungbean area.

AVRDC-TOP produces seeds suitable for breeding which are supplied to government and private sectors. Though TOP's annual production is not much, slightly at one ton per cultivar, the genetic quality has been kept at the highest standard.

New Mungbean Variety for Southern Thailand

Introduction

Mungbean is an important food and cash crop in Southern Thailand. Evaluations of the different cultivars/lines collected from different sources were conducted to determine the most suitable varieties for cultivation in the area.

Materials and Methods

Twenty-eight yield trials of 5-12 lines or cultivars of mungbean were conducted at different locations on the east coast of Southern Thailand. The experimental sites included research stations, paddy fields before rice and between rows of young rubber trees.

Results and Discussion

VC 2768A from AVRDC was found to be the best yielder (1.6 t/ha) in all locations. It outyielded the established Thai cultivar U-thong 1, the check variety, by 22% and KPS 1 by 10%. It has the same seed size as U-thong 1 and was found highly resistant to lodging and Cercospora leaf spot. The variety was named PSU 1 after the Prince of Songkla University which spearheaded the evaluation and screening tests of this new mungbean variety. PSU 1 was officially released in Southern Thailand during the third National Mungbean Seminar held last 21-23 November at Kanchanaburi.

Effect of Leaflet Shape and Number on Mungbean Yield

Introduction

To further improve physiological characters of mungbean lines at AVRDC-TOP, several crossings were made using lines with characters correlated to high yield.

Materials and Methods

In 1987, a cross was made between V 5926 (entire multiple leaflet mungbean) and V 2273-5 (lobed trifoliate leaflet mungbean). The F_4 families derived from the same F_3 plants were grown and tested to determine the effect of leaflet type on yield and yield components per plant.

Results and Discussion

The lobed-multiple leaflet mungbean gave the lowest yield among the four leaflet types. Plants with three to five lobed leaflets yielded similarly to those of the normal mungbean, but with lower 1,000 seed weight. This observation was based on a small number of plants. However, the results obtained show promise for a similar experiment worth conducting using isolines extracted from the population.

Effect of Flower and Pod Removal on Yield and other Agronomic Characters of Kamphaeng Saen 1 and 2

When flowers and pods of mungbean varieties KPS 1 (VC 1983A) and KPS 2 (VC 2778A) were removed at 5, 10 and 15 days after flowering, KPS 1 gave a significantly higher average yield than KPS 2. A significant reduction in yield was obtained from KPS 1 with the removal of pods (Table 4). This was mainly due to the flowering habits of the cultivars since KPS 1 flowered continuously until harvest while KPS 2 flowered at intervals. The second flush of flowers in KPS 2 began 7-10 days after flowering (DAF); thus, new pods emerged at 10 DAF. The number of pods dropped sharply at 15 DAF treatment.

Table 4. Yield (t/ha) and number of pods per plant of KPS 1 and KPS 2 mungbean in response to pod and flower removal at various dates after flowering, rainy season, 1988.

Characters	Cultivars	Date of removal				
		0 DAF	5 DAF	10 DAF	15 DAF	Ave
Yield (t/ha)	KPS 1	2.3	1.9	1.9	1.7	2.0
	KPS 2	1.8	1.6	1.7	1.4	1.7
# Pods/plant	KPS 1	15.2	15.6	14.3	13.4	14.6
	KPS 2	13.9	12.6	15.2	11.5	13.4

Downy Mildew Resistance in Soybean

Nakhon Sawan 1 (NW1) soybean, officially released by the Department of Agriculture in early 1987, was highly susceptible to downy mildew disease caused by *Peronospora manshurica*. To solve this dilemma, AVRDC-TOP transferred the downy mildew resistant gene from AGS 129 to NW1. A total of four backcrossings were accomplished; the BC_4 progenies carried up to 96.9% of the

recurrent parent NW1 but was resistant to the disease. If these backcross progenies are agronomically the same as NW1, they will be used as breeder seeds for distribution in late 1989.

Vegetable Soybean Evaluation Trial

Introduction

Fifteen vegetable soybean cultivars introduced from AVRDC were evaluated against Nakhon Sawan 1 (NW1) at TOP field in Kamphaeng Saen during the rainy season of 1987 and dry season of 1988.

Materials and Methods

Sixteen lines were evaluated at KPS field in a randomized complete block design, replicated four times. Spacing was 50 × 12.5 cm^2 with one plant per hill and maintained at 3 × 5 m^2 plot per replicate.

Results and Discussion

Line 7061 and cultivar NW1 gave the highest pod yield in both seasons. However, these lines had too small seeds and low palatability ratings. The Thai domestic market had accepted NW1 as vegetable soybean cultivar but not the international market. The large-seeded Tzurunoko and Ryokkoh produced some large pods of international standard but their yields were among the lowest. With these results, more tests need to be conducted to identify the soybean cultivar that meets the requirements of both local and international markets.

Home Garden

About 23 kinds of vegetables were grown in each home garden set. From the three home gardens set up in AVRDC-TOP field, a total 663.24 kg of vegetables were obtained from January to mid-November, 1988.

To serve more farmers, bigger plots for seed production of vegetable crops commonly grown in the area were also established. The seeds produced from these crops will be given to DOAE for further multiplication and distribution to different agricultural extension offices for their home gardening projects especially in Northeast Thailand. A training scholar from DOAE now implements a seed production project of several vegetable crops.

Home garden trials were also set up in Chiang Mai University where they try to compare the adaptability and profitability of the various cropping patterns and crop combinations of introduced and indigenous vegetables. Most of these indigenous vegetables are species with peculiar flavor and taste of the Northeast cuisine. The produce from the home garden at KPS is shown in Table 5.

1987-1988 Regional Training Program (RTP)

Twenty training scholars graduated from the 6th AVRDC-TOP Regional Training Course in Vegetable Production and Research conducted from 1 October 1987 to 29 February 1988. These scholars were from China (6), the Philippines (1), Sri Lanka (3), Thailand (2) and Vietnam (8). Apart from attending 375-hour lectures on different aspects of vegetable production and research, the scholars also conducted actual field and laboratory work on important crops. Data from their experiments are also used in various crop improvement programs of AVRDC.

Funding support for the above training scholars came from different international agencies such as FAO, IDRC, USAID, GTZ and the Thai-Australia Tung Kula Ronghai Project. The financial support given by ADB and AVRDC covered the operational costs of the program.

Table 5. Vegetable production at KPS home garden, 1988.

Crop	Total yield (kg)
Chinese kale	49.63
Chinese radish	32.38
Green onion	21.96
Kangkong	111.73
Yardlong bean	37.60
Green kwang futsoi	33.81
Cucumber	52.02
Chinese cabbage	15.48
Bitter gourd	37.41
Amaranth	10.60
Eggplant (Brinjal)	76.58
Snake eggplant	18.18
Leucaena (Ipil-ipil)	3.04
Sacred basil	29.66
Hoary basil	13.28
Mint	21.54
Lemon grass	20.78
Galangal	6.57
Chinese chive	13.62
Hot pepper	4.79
Dry gourd	29.18
Angled loofah	12.85
Sweet basil	10.54
Grand total	663.24

The 7th Regional Training Course commenced 15 October 1988. The training scholars consisted of 8 Chinese, 1 Filipino, 3 Nepali, 4 Sri Lankan, 4 Thais and 7 Vietnamese. So far, the 7th RTP is the biggest training group which the outreach program ever had.

Workshops and Conferences

The first in a series of in-country workshops was conducted with the main objective of enhancing adaptation and extension of the results from the training program as well as facilitating the transfer of technology. Recognizing the advances Taiwan has made in this aspect of vegetable production a resource person from AVRDC was invited to come to Thailand to assess the field and technical problems of asparagus production as well as vegetable growing under nets in Thailand. The participants were extension workers and subject matter specialists from the different extension offices of DOAE and representatives from private agencies concerned in vegetable production.

An International Sweet Potato Planning Workshop was held last 7 November 1988 at the National Extension and Training Center of Kasetsart University at Kamphaeng Saen Campus. This workshop was held to discuss the establishment of the Sweet Potato International Nursery Trial.

Participants were training scholars from various countries in the region such as China, the Philippines, Sri Lanka and Vietnam. These scholars will carry out the Sweet Potato International Nursery Trail (SWINT) in their respective countries.

During the year, the Director/Resident Scientist and/or staff of AVRDC-TOP attended various seminars/conferences and workshops organized by other international/scientific institutes.

Publications

To maintain linkages with the RTP alumni, a directory covering the period 1982-1988 was published. Each alumnus was given a copy.

Technoguide and Books

AVRDC-TOP published Home Garden technoguide, a technical bulletin on mungbean diseases, a program brochure and the RTP brochure. Another bulletin which features major diseases of crucifers is in press.

Infrastructure

The construction of the ADB-funded laboratory/storage building started 10 December and was projected to be completed in May 1989. This one-storey complex will be composed of two laboratories, one office, one lecture hall and four small cold rooms for germplasm storage.

Germplasm Collection and Distribution

A total of 111.674 kg seeds were received and distributed to 23 entities in 1988. AVRDC-TOP also started sending tissue culture sweet potato materials from AVRDC to other countries in the region.

Africa Vitamin A Gardening Project

Summary

From 1 October 1987 – 30 September 1988, the project accomplished the following:

Assessment. A preliminary assessment was initiated focused on the project activities during its first year. The project staff assessed the existing vitamin A garden crop production in Sahelian West Africa during both dry and rainy seasons; identified locations in Niger and Burkina Faso where vitamin A deficiency is most severe; and planned the best approaches for initiating appropriate vitamin A gardening research, and conducting workshops and training.

Research. Based on information gathered during the preliminary assessment, observation and variety trials were initiated at the project's facility in Niger. Seasonal research was conducted on culturally acceptable vitamin A garden crops, and on cultural practices that will increase their yields and lengthen their growing seasons.

Workshops. In July 1988, the project held its first international vitamin A gardening workshop in Niamey, Niger attended by 50 participants from four Sahelian nations.

Collaboration/Networking. To meet the networking requirement of the project grant, during this first year of activities in Sahelian West Africa, the project began to collaborate with governments in the Sahel, private voluntary organizations, nongovernment organizations, USAID Missions, international agricultural research centers, and other organizations involved in vitamin A activities.

As the project progresses it will collaborate with these entities in research, workshops, training and information exchange.

Training. The project staff planned its first training program to be held at the Niger facility in early 1989. Approximately 20 Africans will attend each 50-day training program. After graduation, the project staff will give follow-up assistance in the graduates' home countries as they initiate their own vitamin A gardening activities.

Preliminary Assessment

The assessment began in the host country, Niger. During this initial period, the project gathered and analyzed preliminary data that will help to focus project activities. The initial assessment in Niger and a small amount of the work in Burkina Faso helped the project staff identify vitamin A problems and related information to vitamin A crop gardening.

Where vitamin A problems are prevalent. Most populations in Niger live in the southern fertile belt. Studies conducted in this region by Helen Keller International showed that vitamin A deficiency among children is a chronic problem. The World Health Organization (WHO) conducted similar studies in the north central dry region of Niger, among the nomadic herders who have managed to remain

there despite the 20-year drought. The results indicated no vitamin A deficiency, probably because the nomads consume meat and milk, sources of vitamin A, as their daily fare.

Such data will help the project decide where to focus its activities in Niger. Vitamin A deficiency is most prevalent in the southern half of the nation where there is enough rainfall to grow gardens.

General Information on Gardening and Vitamin A Crops

Regions. Most garden crop production is in the southern part of Niger, where rainfall is 250-350 mm every year. This is where settled farmers live and where irrigated agriculture is practiced.

Seasonality. Gardening generally takes place during the *contra saison* (the cool dry period after the rainy season), from October to March. Thereafter, there is a very hot period (April-May) when vegetables are not grown because the daytime temperatures reach 45-50°C. The rainy season starts in June and continues until August or September. During this season, farm families are busy planting staples such as millet. However, some rainy season vitamin A sources such as sorrel, jute and amaranth are grown. Also, wild greens such as *Portulaca oleracea*, *Talinum triangulare*, *Cassia tora*, and *Adansonia* species are picked at this time.

During *contra saison*, many temperate vitamin A crops such as tomato, lettuce, cabbage, yellow squash, hot and sweet pepper, sweet potato and carrots are grown. Some legumes (e.g., cowpea and pigeon pea) are grown for their vitamin A rich leaves.

Water. Success in gardening during *contra saison* appears to depend on whether there is a water source, such as a well or pond nearby. Gardening also takes place along riverbanks, around pools of receding water, and in areas where the water table is high enough to dig shallow wells.

Location. Garden locations, unlike in Asia, are generally not around the household because gardens are located around a water source, which is often far from a household; garden-crop eating animals are kept in household compounds at night; gardens are seen to attract malarial mosquitos, rodents and reptiles; and it is more convenient for the family to have gardens in the field.

Soil. Soils in Niger are sandy, acidic, deficient in phosphorus, nitrogen and other nutrients. Rock phosphate as well as manure are available in Niger, but knowledge on their effective and efficient use is limited.

Postharvest. There is little or no cold storage available to the average Nigerien gardener. Crops are sold in nearby markets for fresh consumption, and they are sun-dried for later sale for use in traditional sauces. There is year-round availability of sun-dried tomatoes, onions, green leafy vegetables (GLVs), okra, peppers and various squashes. There is also some pickling of GLVs, often sold at local markets along with a small amount of peanut butter. The combination is called 'copto' and is very popular as a type of salad.

Among the constraints to production and marketing of perishables by small farmers are: little knowledge of market demand, market distances, road conditions, modes of transportation and poor or non-existing extension services.

Desire for Gardening. The Government of Niger (GON) has started its effort to 'green Niger with edibles', and is attempting to get people to consume more vegetables. However, farm families (especially women gardeners) want to grow vegetables as a source of income rather than as food.

Though gardening has potential, there are still a number of constraints: unavailability of enough water; excessively high temperatures; destruction of garden crops by wind and blowing sand; sandy, acidic soils, low in phosphorus and natural fertility and unable to retain nutrients or water, and are susceptible to wind erosion; and pests, especially nematodes and grasshoppers.

Niger advisory and extension services are minimal in terms of vegetable production. These services are yet to be developed.

As the project expands beyond Niger, so will the assessment. The project plans to include four countries in its activities: Burkina Faso, Mali, Mauritania and Niger.

Research

Dry season

During the dry season (November 1987 - May 1988), observation trials were conducted in both heavy 'cuvette' soils representative of riverbank areas, and in sandy soils representative of most of the gardening soils in Niger.

Trials were conducted on vitamin A crops that are culturally acceptable in the region, such as various GLVs (*Amaranthus*, *Corchorus*, *Celosia*, *Sesamus*, *Basella* and *Hibiscus*), hot and sweet pepper, tomato, carrot, common cabbage, lettuce, sweet potato, squash and legumes, the leaves of which are consumed (cowpea and pigeon pea), as sources of vitamin A.

The dry season research results were inconclusive due to lack of statistical experimental design because of poor availability of planting material, and high seedling mortality rates; plant loss during growing season due to virus and fungal diseases; unreliable recording of yields by local staff; unavailability of water for irrigation; and additional crop loss due to theft and animal damage.

Nevertheless, the project staff learned a great deal during this planting season. New information was gathered on (1) the problems and constraints in dry season vegetable production, (2) the techniques needed to overcome the constraints, and (3) where the focus should be during the next dry season's gardening research.

The following is a summary of lessons learned from this dry season's research:

A. Obtaining healthy seedlings for transplant

1. Poor or no emergence from possible seed rot and inability of seed to penetrate hard soil surfaces. **Solution:** treat seed with available fungicide/insecticide and/or cover seed bed with mulch.
2. Insect damage (especially from crickets) in young seedlings. **Solution:** try available mosquito netting over beds. Niger's Protection Vegetaux recommends treating plants regularly with commercial compounds, some of which are toxic and perhaps too expensive for poor farm families.
3. Lizard damage. Lizards eat seedlings as they emerge. **Solution:** netting, and locating nurseries away from trees and walls.
4. Weed competition. Sterile potting soil is not easy to obtain. **Solution:** work and water soil before planting seedlings, and weed out whatever emerges; then carefully weed after planting seedlings.

B. Transplanting

There was a high mortality rate in all transplanted crops. The project's Resident Scientist suspected heavy cuvette soils at the research site, heat stress and poor seed handling to be the causes. **Solution:** better seed handling, shading of transplants and trying different soils.

C. From transplanting/seedling to harvest

The major problems observed were from insects and disease, especially in tomato, pepper and some GLVs. **Solution:** wider spacing of plants, removal of infested leaves, manual removal of insects and treatment with Decis.

D. Other

1. Sunscald in peppers and tomatoes. This problem occurs early in season in peppers and later in tomatoes. **Solution:** selection of less susceptible varieties, use of shade structures and making sure fruits are not splashed during watering.
2. Heat stress. This is a problem in tomato, pepper and in GLVs, especially during the latter part of the dry season (March to May). **Solution:** construction of simple hangars for shading material, selection of more resistant varieties, avoiding the planting of heat susceptible crops (cabbage, lettuce, carrot), and concentrating more on local varieties that have shown heat tolerance.

One of the main points learned from the dry season research is that preparing vegetable beds on sandy soils, with the addition of composted manure and straw, appears to be a promising method. As such, along with the above possible solutions to inherent gardening problems, it will give the project a good start in this first year of operation in the Sahel.

Rainy Season Trial

After the end of the 1987-88 dry season trial, another research site was selected at the project's host institution in Niger. The new site has better soil and it is more representative of the soils in the Sahel. The site has a more reliable water source and is completely fenced and guarded.

In the rainy season (June October 1988) six research activities were planned based on experiences gained during the dry season trials:

(1) Variety trials of tomato, peppers (sweet and hot), *Amaranthus* and *Celosia* species, *Cochorus clitorius*, *Basella alba* and *B. rubra*, and *Sesamus* species.
(2) Observation trials on *Hibiscus sabdariffa*, *Solanum aethiopicum*, and *Tricosanthes cucumerina*.
(3) Intercrop demonstration plots of: (1) millet, plus a) *H. sabdariffa*, b) cowpea (local variety), c) *H. sabdariffa* and *cowpea* and d) *Corchorus* (local variety) and sesame, and (2) squash (local variety) and *Morinqa olifera*.
(4) Propagation of orange-fleshed sweet potatoes from botanical seed.
(5) Cultivation of groundnuts as 'trap plants' for nematodes, and to have a supply of leguminous material for making compost.
(6) Establishment of pigeon pea as a windbreak along the research site's protective fence.

Workshops

The first workshop was held on 16-21 July 1988 in Niamey. It was attended by about 50 participants from private voluntary and non-government organizations (PVOs and NGOs), the Peace Corps, and government agricultural, health and nutrition workers from Burkina Faso, Mali, Mauritania and Niger.

The purpose of the workshop was to exchange information on gardening activities in the region, and to establish collaboration among representatives of PVOs, NGOs and governmental agencies of these four countries engaged in vitamin A crop production, capsule distribution and nutrition education and evaluation. Specifically, this collaboration consists of an information exchange geared towards better production and healthful consumption of vitamin A crops in countries of Sahelian West Africa.

Workshop presentations were made by participants including project staff. Visitors described successful techniques and failures in gardening activities in their respective countries. At the end of each presentation the floor was opened to discussion and recommendations from other participants.

One afternoon was devoted to field visits to the project's research facilities at its host institution in Kollo, Institut Pratique de Developpement Rural (IPDR), and to a local maternal/child health clinic. At the project's research facility, the participants were shown the progress made by the project in its adaptive research efforts. Of special interest to participants was the use of local materials for shading,

mulching and fencing, and incorporating organic farm waste into the soil to improve soil fertility. Additional interest was raised by preliminary results of the project's use of planting material from Asia, including AVRDC's open pollinated tomato lines, some of which initially performed well in rainy season trials and showed promise to perform well when the weather gets too warm for local lines.

After the visit to the research site, the participants were taken to the Kollo maternal/child health clinic to attend nutrition education talks and cooking demonstrations that taught mothers how to incorporate gardening vitamin A sources into traditional weaning foods. Some of these sources were provided to the clinic from outputs of the project's research gardens (e.g., GLVs, tomato, squash, carrot).

The associations made among individuals at the workshop will help to establish an information network that the project can utilize as a pathway to send out research results and receive in turn results of vitamin A gardening activities from the field.

Participants expressed interest in publishing a newsletter to better disseminate this exchange of information throughout the Sahel.

Collaboration and Networking

The project's sponsor, the Agency for International Development (AID), Washington, requested collaboration and networking with various government and non-government organizations in the Sahel to increase production and consumption of vitamin A crops in the project's regional focus (Burkina Faso, Mali, Mauritania and Niger). During this year, the project collaborated and established a network with the following organizations:

AVRDC. Scientists at AVRDC responded to requests by project staff in Niger for planting material and for information on crop management, pest and disease control. AVRDC also sent copies of its publications for use by the project and for limited distribution in the region. Some of AVRDC's mandate crops were also tested under Sahelian conditions. This should provide AVRDC with some advance information if it carries through with plans to directly establish a network in Africa.

Ministry of Agriculture, Niger. Project staff members contacted Protection Vegetaux where research is being conducted on the use of neem seed extract to control insect pests in vegetables. The extract renders the plants distasteful to insects and halts larva in the pupa stage. Insects controlled by neem seed extract are those in the Coleoptera and Lepidoptera families (e.g., Hellula, Hymenia, Heliotis), and also crickets. Neem extract is not toxic to humans, and plants can be harvested and consumed after being treated.

USAID/Niamey. The Mission recently started a five-year agricultural development project with Niger, the Niger Applied Agronomic Research Project (NAAR). NAAR conducts basic agronomic research and also builds up the capabilities of the extension system so it can translate research findings into useful information that can be extended to Niger farmers. One NAAR component deals with horticultural research. USAID/Niamey recommends that this project collaborate with NAAR by providing them with AVRDC's horticultural research findings.

Peace Corps. The project has collaborated with Peace Corps/Niger by providing planting materials and instructions for use of volunteers working on dry season gardens. The project also hosted visits to the project's research site for new volunteers. In addition, the project staff members served as resource persons for volunteers enrolled in the Peace Corps training program in Niger. A number of Peace Corps volunteers who are working in the Africa Food System Initiative (AFSI) participated in the project's first gardening workshop.

ICRISAT-Sahelian Center. ICRISAT invited the project staff to meet the scientists in the Center. The result was fruitful with the project staff given the chance to interact with the scientists who are experienced in horticulture in the semi-arid tropics. ICRISAT scientists have also visited the project's

site as part of problem solving activities, and its Center has provided the project with planting material such as vegetable cowpea, the leaves of which are eaten in Niger.

IBPGR. IBPGR has a regional office at ICRISAT-Sahelian Center. The Institute staff provided the project with planting materials and gathered samples of wild greens for the project when they went on collecting trips in the Sahel. They also participated in the project's first workshop.

Institut Senegalais de Recherches Agricoles Centre pour le Developpement de l'Horticulture (ISRA-CDH). This is the foremost horticulture center in Sahelian West Africa engaged in ongoing vegetable research in Senegal. It is also involved in seed production, varietal development of vitamin A crops, insect and disease problems, and regional training. ISRA-CDH collaborated with project staff by providing technical materials for workshops and trainings. They hosted visits by project staff and provided resource persons for the project's first training conducted in early 1989. ISRA-CDH is familiar with AVRDC and has developed their best performing tomato line (XIN A) from AVRDC's CL143-0-10-3UG. They also have one Irish potato clone developed from early AVRDC material. A close working relationship with the project is anticipated. If AVRDC is to establish a network in Africa it should make early contact with ISRA-CDH.

Office de Recherches sur l'Alimentation et la Nutrition Africaine (ORANA). ORANA is a regional organization based in Dakar, Senegal. It conducts studies on food intake and on vitamin A analysis using HPLC methodology. It also offers training in general nutrition and in conducting surveys. ORANA collaborated with the project by providing resource persons and visual aids for the project's training program. It offered to do HPLC beta carotene analyses of the project's crops. Project staff visited ORANA and obtained useful information on training in nutrition at the village level in the Sahel.

Training

The training programs are to be of the train-the-trainor type. Training will take place at the project's host institution, IPDR, near Niamey, Niger. The goal is to have 40-50 Africans in place in their home countries, working on training others to increase production and consumption of vitamin A crops in their regions. Because agricultural extension systems in Sahelian West African countries are, in some cases, not yet mature, the project will concentrate mainly on training Africans from PVOs and NGOs.

Originally, each training program would last 100 days. However, during the project's initial assessment regarding how the training will be conducted, it was found that 100 days is too long for African trainees to be away from home and family, and without full salary. Therefore, the training was shortened to 50 days, with appropriate in-country follow-up by project staff as the graduates start new projects in their respective regions or modify old methods with new techniques learned from their training. The follow-up will also attempt to assist graduates in identifying points of entry in extension systems where there is a possibility to assist them and promote production and consumption of vitamin A crops.

Genetic Resources and Information Services

Genetic Resources and Seed Unit

Introduction

In 1988, the GRSU acquired a total of 792 accessions of 16 species. The breakdown of introductions for the six AVRDC principal crops and their related species is shown in Table 1. For *Capsicum*, the Center acquired 65 accessions but the collection is reported only in 1988 with the materials that are still under accessioning (Table 2).

Germplasm Conservation

The germplasm maintained at AVRDC totalled 31,484 accessions (Table 3). There were 7,784 accessions in base storage.

The sweet potato field genebank was badly hit by a flood on 13 August 1988. About 636 accessions had to be transplanted to pots to save them. Forty-seven accessions did not survive. The duplicate collection at TARI, Chiayi can provide only 40 of the 47 accessions. As a result, seven accessions (i.e. I 111, I 448, I 456, I 483, I 488, I 503 and I 586) were lost after this flood.

Germplasm Characterization

The status of germplasm characterization is summarized in Table 4.

Germplasm Documentation

The status of documentation is given in Table 5.

Seed Distribution

In 1988, 14,293 seed samples of both germplasm and breeding lines were distributed to 91 countries and territories. The 303 germplasm recipients are listed separately. About 3,621 germplasm materials were distributed for screening and further evaluation.

Information Management System

The GRSU with the assistance of the Computer Service is building up an information management system. The system covers both data bases on the seed samples, i.e. germplasm (e.g. passport, characterization, evaluation) and handling of seeds (e.g. gene banking and seed distribution). The latter provides the genebank management with the facility to monitor the inventory of seeds stored, viability of seeds in storage, regeneration requirement and distribution. The resulting more efficient management system allows more time for the maintenance of the genetic integrity of each individual accession and for characterization and evaluation.

Table 1. New introductions in 1988.

Source	No. of entries	Remarks
***Brassica* species and radish**		
China	13	11 *campestris*, 2 *oleracea*
Japan	75	8 *juncea*, 19 *oleracea*, 8 *chinensis*, 11 *rapa*, 19 *pekinensis*, 4 *campestris*, 1 *alboglabra*, 5 *japonica*
Korea	4	1 radish, 1 hybrid Chinese cabbage, 2 unknown
Germany, Democratic Republic	6	*B. rapa* L. emend Metzg spp. *pekinensis*
Taiwan	5	Local types
Thailand	1	Native radish
Total	104	
***Glycine* species**		
Japan	22	18 vegetable soybean, 4 *G. max*
Mali	6	*G. max*
Nigeria/IITA	5	*G. max*
U. S. A./USDA	5	*G. max*
Total	38	
***Ipomoea* species**		
China	1	Most popular variety in China
Thailand	1	Important cultivar in Thailand
Tonga	7	–
Solomon Islands	102	Only 48 survived meristem culture
Total	111	
***Lycopersicon* species**		
Syria	6	–
Taiwan	1	–
Oman	2	Traditional variety in the Le bel
China	11	5 processing and 6 fresh market types
Total	20	
***Vigna* species**		
Australia	1	*V. trilobata*
Australia/CSIRO	3	1 *V. luteola*, 1 *V. parkeri*, 1 *V. radiata*
Belize	1	*V. luteola*
Ethiopia/ILCA	9	4 *V.* sp., 1 *V. trilobata*, 4 *radiata*
India	2	–
Japan	1	*V. angularis* var. *nipponensis*
Mali	33	31 *V. radiata*, 2 unknown
Niger	1	*Vigna* species
Oman	10	–
Philippines	1	–
Taiwan	30	*V. angularis* var. *nipponensis*
U.S.A.	1	*Vigna caracalla*
Total	93	

Table 2. *Capsicum* species germplasm introduced until 1988.

Country	No. of[z] entries	Country	No. of[z] entries
1. Afghanistan	19	9. Brazil	208
2. Algeria	1	10. British Indian Ocean Territory	1
3. Angola	1	11. British Virgin Islands	2
4. Argentina	50	12. Bulgaria	107
5. Austria	22	13. Canada	25
6. Belgium	3	14. Chile	12
7. Belize	7	15. China	115
8. Bolivia	75	16. Colombia	89

Table 2. Continued.

Country	No. of[z] entries	Country	No. of[z] entries
17. Costa Rica	235	50. Nepal	8
18. Cuba	15	51. Netherlands	104
19. Czechoslovakia	32	52. Nicaragua	9
20. Denmark	5	53. Nigeria	13
21. Ecuador	55	54. Pakistan	10
22. Egypt	10	55. Panama	13
23. El Salvador	88	56. Paraguay	2
24. England	35	57. Peru	290
25. Ethiopia	66	58. Philippines	60
26. Fiji Islands	3	59. Portugal	10
27. France	43	60. Puerto Rico	20
28. Germany, Democratic Rep.	28 (7)	61. Romania	38
29. Germany, Federal Rep.	23	62. Singapore	1
30. Greece	5	63. Solomon Islands	1
31. Guatemala	143	64. South Africa	1
32. Guinea (French)	1	65. Spain	58
33. Guyana	7	66. Sri Lanka	1
34. Honduras	87	67. Sudan	2
35. Hungary	245	68. Surinam	10
36. India	217	69. Switzerland	9
37. Indonesia	9 (16)	70. Syrian Arab Republic	7
38. Iran	52	71. Taiwan	33
39. Israel	8	72. Thailand	70
40. Italy	116 (9)	73. Trinidad	5
41. Jamaica	1	74. Tunisia	10
42. Japan	30	75. Turkey	395
43. Kenya	4	76. Uruguay	4
44. Korea	147 (1)	77. U.S.A.	320
45. Lebanon	3	78. U.S.S.R.	56
46. Libya	10	79. Venezuela	27
47. Malaysia	186 (3)	80. Yugoslavia	493
48. Mariana	1	81. Zambia	6
49. Mexico	270	Unkown	174
Total			5,177

Table 3. Germplasm maintained at AVRDC, 1988.

Crop	Accessions	Available	Temporarily numbered accessions	Suspected duplicates[z]
AVRDC principal crops				
Soybean	12,504	11,584	137	2,111 (9,034)
Mungbean	5,274	5,072	465[y]	985 (5,112)
Tomato	5,814	5,676	305	40 (4,734)
Sweet potato	1,372	1,334	190	9 (1,363)
Chinese cabbage	856	814	369	–
Pepper	4,973	4,863	61	–
Subtotal	30,793	29,343	1,527	3,145 (20,243)
Other crops				
Adzuki bean	125	125	25	–
Amaranth	86	86	–	–
Black gram	408	408	339	–
Rice bean	72	72	73	–
Subtotal	691	691	437	–
Total	31,484	30,034	1,964	3,145 (20,243)

[z]Figures in parentheses indicate the total number of accessions from which the suspected duplicates were counted. [y]Including 357 accessions (lines) of wild black gram purified from four populations.

Table 4. Status of AVRDC germplasm characterization in 1988.

Crop	Morphological and physiological characters		Chemical characters	
	Accessions characterized	% of total	Accessions characterized	% of total
Mungbean	4,945	96.8	4,945	96.8
Soybean	2,672[z]	22.9	2,622	22.5
Chinese cabbage	315[y]	39.2	–	–
Pepper	1,808[x]	36.4	–	–
Sweet potato	1,168	85.1	734[w]	53.5
Tomato	1,750[x]	22.8	–	–

[z]Non-USDA accessions. [y]Open-pollinated cultivars. [x]Ongoing in fall 1988. [w]Accessions flowering at AVRDC.

Table 5. Status of documentation at GRSU, 1988.

	Soybean (%)	Mungbean (%)	Tomato (%)	Chinese cabbage (%)	Sweet potato (%)	Pepper (%)
Passport data entry	100	100	100	100	100	100
Characterization data entry	25	97	0	37	85	26
Germplasm catalog	Spring 1989	1988	–	1986 (for OP[z])	Summer 1989	–
Seed inventory data input	0	0	0	100	0	0

[z]OP = Open pollinated.

Structure of the Data Base

Presently, AVRDC's research and development mandate covers soybean, mungbean, tomato, Chinese cabbage, sweet potato and pepper. The total number of accessions maintained is over 30,000. The data base structure is, therefore, designed to accommodate this unique feature within the working environment of the software package (MINISIS) used. Passport, inventory and distribution data are common in all species and placed in individual files. However, characterization and evaluation data are crop specific. Files for individual crops are set up independently.

MINISIS - the Data Base Software Package

Developed by the International Development Research Centre (IDRC), MINISIS is an integrated data base software package run on the HP 3000 series of minicomputers. It allows data bases to be defined as selected parts of larger data bases or records and combinations of data bases and records. Common information can, therefore, be shared.

An Appraisal of Seed Production Technology Workshop

Seed production training is important to solve the seed problem in the overall development of vegetable production in these countries. Cognizant of the importance of collating information and producing guidelines on seed technologies and to try out the various production steps appropriate for technology transfer, a workshop, the third to be organized by the GRSU and Training Office, aimed to provide basic knowledge of seed production technology was organized.

Results

A questionnaire was used to gather data to evaluate the workshop; the following conclusions were drawn from the responses of 26 training respondents:

Training the trainor. The effectiveness of the speakers and their knowledge of the subject matter were rated good and competent, respectively.

Majority expressed that time allocation for the entire workshop and for individual topics was sufficient.

Alternative teaching method and new knowledge gained. Most of the participants (73%) indicated that they learned more in a workshop than in a classroom type (lecture) session.

The evaluation showed that reference materials and informal discussions with the resource person during the workshop were effective in enabling participants to acquire new knowledge.

The depth of treatment for the different topics was regarded adequate. About 50% claimed that knowledge gained in the workshop is useful for their work in their countries, and the other 50% felt that it will be needed occasionally. Participants suggested that assignments be compiled and printed so that they can bring them back home as reference materials in their work. The group also suggested to put more emphasis on seed production, seed quality and seed health.

Other topics covered using teaching method. The workshop method appeared to be a more effective method of imparting information to training participants. However, it could mean a lot of extra work for them especially when English is often a second language. The resource person also has to spend more time with participants than when giving formal lectures. The training staff, therefore, tried to find out how many of these workshops they could handle in a 5-month course. It seemed that the most ideal is two workshops per course. However, 54% indicated that one is sufficient. Most participants suggested postharvest technology as a topic for the workshops. Other topics included pest control, crop management, production technology of specific vegetables, varietal improvement, nutrition, technology transfer, etc.

Demonstration and field trip. Demonstrations were felt to be valuable/very valuable by 65% of the participants; 31% felt that they were just average. Various demonstration topics were listed by the trainees for further strengthening of the course. The field trip was considered a valuable/very valuable exercise as indicated by 85%; 81% felt it to be compatible with lectures and demonstrations.

Personal development. The workshop was viewed as an opportunity for the trainees to develop their spoken (77%) and written English (58%). All concurred that it provided them an environment for working as a group and it helped them know their fellow participants better. The initial search for reading materials had provided them (89%) with a valuable experience in using the library.

Future Improvement

Workshops seemed to be a better alternative to formal lectures. The participants appeared to learn more in the process. However, there are two main areas that could improve this teaching method.

First, more guidance should be given the participants, especially during visual aid preparation and presentation. A fortnightly meeting between the participants and the resource persons to check on their progress is recommended. The assignments should be finalized before the workshop so that they could be distributed as handouts. More resource persons from other institutions should be invited to comment on the presentation and to stimulate discussion.

Second, field trips and demonstrations were seen as important sources of information. The participants should be briefed prior to the trip and divided into smaller groups to have closer contact with resource persons. A field visit to farmer's seed production fields should be given priority. After two weeks of lectures, demonstrations and visits, a formal post-workshop session should be held.

Sweet Potato Germplasm Introduction and Distribution

The introduction, virus indexing and conservation of the Asian and Pacific sweet potato germplasm and the international distribution of the virus-indexed AVRDC elite clones and other popular sweet potato germplasm are ongoing.

Germplasm introduction. To date, AVRDC has in its genebank 1,372 accessions for the Asian and Pacific sweet potato germplasm. An estimated 3,258 accessions from the Asia and Pacific regions will be introduced in the near future.

Virus indexing. The report is reflected under virology of sweet potato.

Conservation. The field genebank is the principal conservation method presently used. Each accession is maintained in an 8-cutting plot. Establishment is done from shoot cuttings from the old field. The maintenance system requires large field space and intensive labor. The germplasm is exposed to biotic and abiotic hazards. Thus, an *in vitro* genebank was initiated using the meristem culture method.

Meristem culture has been adopted because of its genetic stability. Bud culture may be a good alternative system but buds are more difficult to sterilize especially if the cuttings for meristem extraction are taken directly from the field. GRSU has limited screenhouse space to prepare clean vigorous cuttings for this purpose.

In 1988, a total of 6,710 meristems were extracted from 1,116 accessions. A total of 456 accessions were successfully cultured *in vitro*. The monthly success rate in meristem culture was around 42% (Fig. 1). The callus forming meristems were discarded to avoid propagation of mutant plantlets derived from embryogenesis. The rate of callus formation in the meristem culture was around 32% (Fig. 2), and the contamination rate during meristem culture about 26%.

Germplasm distribution. A total of 33 clones consisting of 30 breeding lines and three accessions were released from the virus-indexing program for international distribution (Table 6). The first batch of pathogen-tested clones was sent to Japan in October 1987. To date, 805 tubes have been distributed to 22 countries.

An experiment was carried out to find a more reliable system to distribute *in vitro* sweet potato cultures. A three replicate 3 × 2 × 2 factorial experiment arranged in RCBD was used. Each replicate consisted of five tubes per treatment, thus, a total of 60 tubes per replicate. The factors studied were:

(1) Concentration of agar in the media:
   (a) 0.75%
   (b) 0.85%
   (c) 0.95%

(2) Types of tubes used:
   (a) Normal test tube
   (b) Tube with an indented groove around the circumference at 2.5 cm from the base

(3) Flaming of test tube neck before packaging:
   (a) Flaming
   (b) Non-flaming

Each replicate of 60 tubes without any plantlet inside was packed with a rubber sponge in a paper carton box. After packing, the three boxes (i.e. 3 replicates) were dropped 15 times each from a height of two meters to a concrete floor. The boxes were then kept in the store for a month before they were opened for inspection.

Only one tube broke at the neck. This indicated that the packaging method could withstand shock well. All rubber stoppers and aluminum foils covering the stoppers of the tubes were intact. There were only three fungal contaminated tubes, one of which was because the tube had been broken. The other two were contaminated because of the flame treatment from two different replicates. It can, therefore, be concluded that flaming of the tube's neck before packaging is unnecessary.

Table 6. Pathogen-tested clones available for distribution.

AVRDC accession or cross no.	Plant type	Skin color	Flesh color	Dry matter (%)	Texture[z] after cooking	Yield[x] (t/ha)		Remarks
						hot-wet season	cool-dry season	
I 57 (Tainung 57)	Semi-prostrate	Yellow	Yellow tinged w/ pale orange	25	Dry	13 (14)	16 (10)	Dessert & staple type
I 981 (Tainung 66)	Semi-erect	Reddish brown	Light orange	27	Slightly dry	18 (7)	18 (2)	Dessert type; early maturing[y]
I 423 (Tainan 17)	Prostrate	Pink	Pale yellow	26	Dry	11 (7)	28 (2)	Starch-type
CN 942-47								
CN 1028-15	Semi-prostrate	Red	Orange w/yellow	24	Slightly dry	30 (7)	30 (6)	Early maturing
CN 1038-16	Semi-erect	Pink	Yellow	27	Dry	16 (18)	35 (12)	Feed-type early maturing
CN 1058-10	Semi-erect	Red	Deep orange	22	Slightly dry	20 (11)	18 (6)	Dessert-type
CN 1058-84								
CN 1108-13	Semi-erect	Light reddish orange	Light orange	25	Slightly dry	18 (12)	27 (11)	Early maturing
CN 1216-10	Semi-erect	Yellow	Yellow	28	Dry	14 (7)	20 (6)	
CN 1219-1	Prostrate	Yellow	Yellow	27	Dry	22 (6)	21 (6)	
CN 1232-9	Semi-erect	Yellow	Pale yellow	26	Slightly dry	20 (10)	24 (7)	Early maturing
CN 1280-3	Erect	Light brown	Yellow	27	Dry	14 (7)	23 (6)	
CN 1345-8	Semi-erect	Yellow	Yellow	33	Moist	14 (4)	34 (2)	
CN 1367-2	Prostrate	–	–	–	–	–	–	Tips usable as green vegetable; yellow green leaf Tender texture; suitable for wet & dry seasons

Table 6. Continued.

AVRDC accession or cross no.	Plant type	Skin color	Flesh color	Dry matter (%)	Texture[z] after cooking	Yield[x] (t/ha)		Remarks
						hot-wet season	cool-dry season	
CN 1421-56	Bushy	Reddish orange	Light orange w/ yellow	31	Slightly dry	X (3)	29 (2)	Dessert-type early maturing
CN 1421-68	Semi-erect	Orange	Light orange	32	Slightly dry	X (3)	24 (2)	Dessert type early maturing
CN 1424-9								
CN 1424-36								
CN 1448-49	Semi-prostrate	Red	Yellow w/ orange	32	Moderately dry	19 (3)	28 (2)	
CN 1448-59	Semi-erect	Pink	Pale yellow	30	Moderately dry	17 (3)	20 (2)	
CN 1489-43	Semi-prostrate	Yellow tinged w/ light red	Pale yellow	36	Moderately dry	15 (3)	17 (2)	Early maturing
CN 1489-89	Prostrate	Yellow	Yellow	32	Dry	22 (5)	28 (3)	
CN 1510-25	Semi-erect	Pale red	Yellow	29	Moderately dry	26 (9)	26 (2)	Early maturing
CN 1517-139	Semi-prostrate	Pale red	Yellow w/ pale orange	32	Moderately dry	24 (3)	25 (2)	Early maturing
CN 1517-142	Prostrate	Pale orange	Orange	31	Dry	19 (7)	23 (2)	
CN 1525-11	Semi-prostrate	Yellow	Yellow	29	Slightly dry	20 (9)	28 (2)	Early maturing
CN 1618-461								
CN 1656-37	Prostrate	Dark red	Yellow	32	Dry	21 (3)	23 (2)	
CN 1656-89								
CN 1656-97	Prostrate	Pale red	Pale yellow	31	Dry	24 (3)	23 (1)	
CN 1656-101								
CN 1683-18								

Note: The information given here is based on results of trials conducted under AVRDC conditions. [z]Texture after cooking: Based on the panel tests at AVRDC. [y]Early maturing: acceptable yield at 120 days after planting. [x]Yield: Average yield at AVRDC, Figure with parenthesis shows number of trials, X = very poor yield.

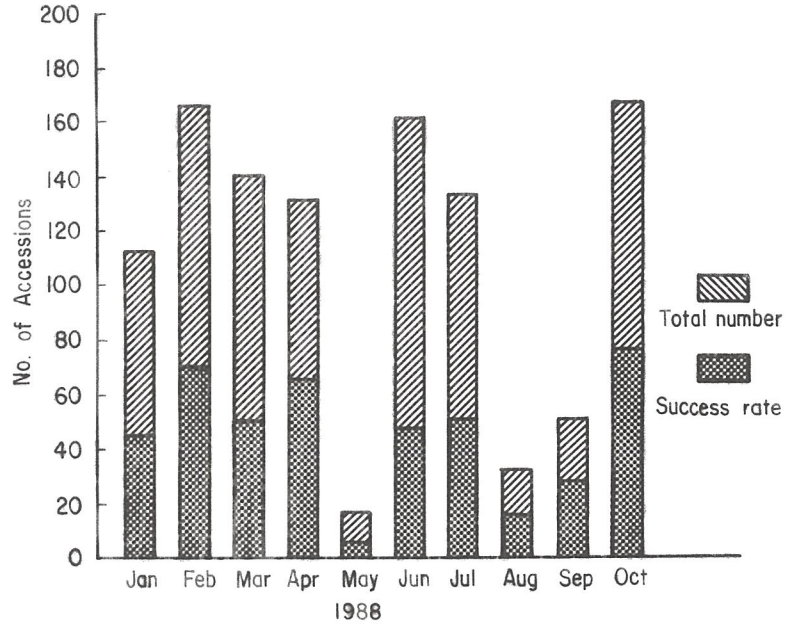

Fig. 1. Monthly success rate in sweet potato accession meristem culture.

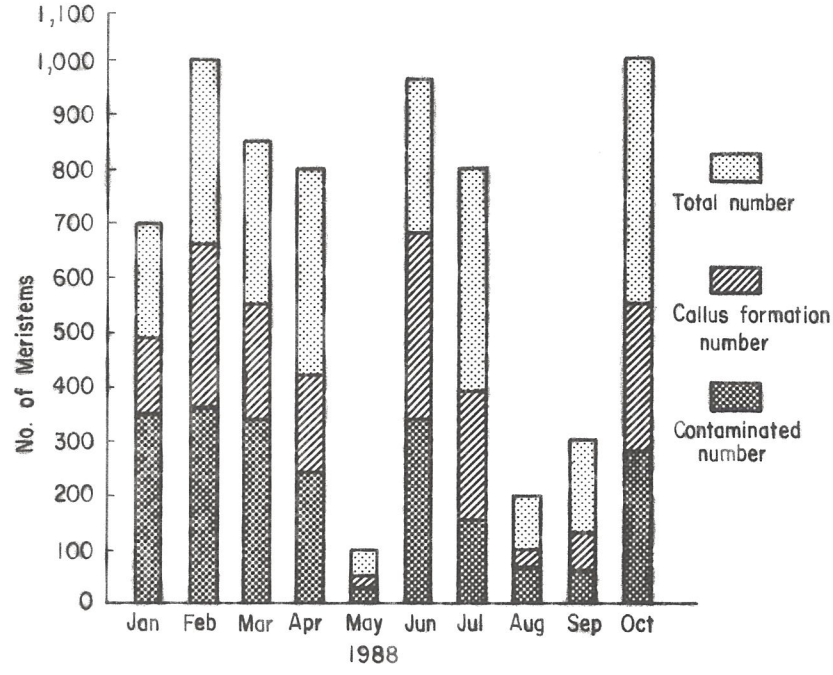

Fig. 2. Monthly rate of contaminated and callus formation in sweet potato accession meristem culture.

The more important factors that should be considered are the agar concentration and the type of tube used. The media with an agar concentration of 0.95% in grooved tubes conserved the media in the tubes best because the groove stopped the harder media from spilling off. In another experiment, plantlets grew well in 0.95% agar and, therefore, probably became hardier for planting.

Soybean Seed Quality and Storage

Introduction

Seed storage technology for soybean is an important consideration in soybean production.

An experiment was conducted to study the seed quality of different AVRDC improved soybean lines produced in summer and autumn corresponding to seed ripening in wet and dry seasons, respectively. It also aimed to come up with a method to predict soybean seed quality and viability at different storage conditions.

Materials and Methods

AVRDC improved soybean lines used in this study were divided into two sets:

Set I -	Date of maturity
AGS 66 SU	17 October 1985
AGS 66 AU	28 November 1985
AGS 129 SU	14 October 1985
AGS 129 AU	27 November 1985
G 2120 M8 SU	06 October 1985
G 2120 M8 AU	12 November 1985
Set II -	
AGS 65	02 December 1985
AGS 124	04 December 1985
AGS 160	03 December 1985
AGS 162	02 December 1985
AGS 208	20 December 1985
AGS 217	21 December 1985
AGS 270	01 January 1986
AGS 299	26 December 1985

The four storage treatment regimes used were:

(1) open storage at GRSU seed conditioning room (25 $\pm$ 5°C and 85 $\pm$ 10% RH)
(2) sealed in aluminum-polyethylene bags with 8% seed moisture content fresh weight basis and kept at 30°C
(3) open storage in breeder store (25°C and 50% RH)
(4) open storage in GRSU short-term store (15°C and 40% RH)

The treatments were started on 25 March 1986. The germination test was carried out on 200 seeds (divided into 50 seeds of four replicates) in sand in the seed laboratory. Seed counts were done on the fifth and eighth days according to ISTA rules (1985). The seed samples for the germination test were maintained in equilibrium with ambient environment for 24 hr before testing to reduce seed injury due to quick rehydration.

Results and Discussion

Seed quality produced from different seasons. Results showed that the quality of soybean seed lots produced in summer was poorer than those produced in autumn although there were only 42, 44 and 37 days, differences in crop maturity between two seasons for the three lines, respectively (Fig. 3). The weather data at ripening stage is shown in Figure 4. The differences in seed quality between the lines were more obvious in summer than in autumn. The original germination rate of AGS 66 SU (summer crop) was 89% which was much lower than that of the other five seed lots.

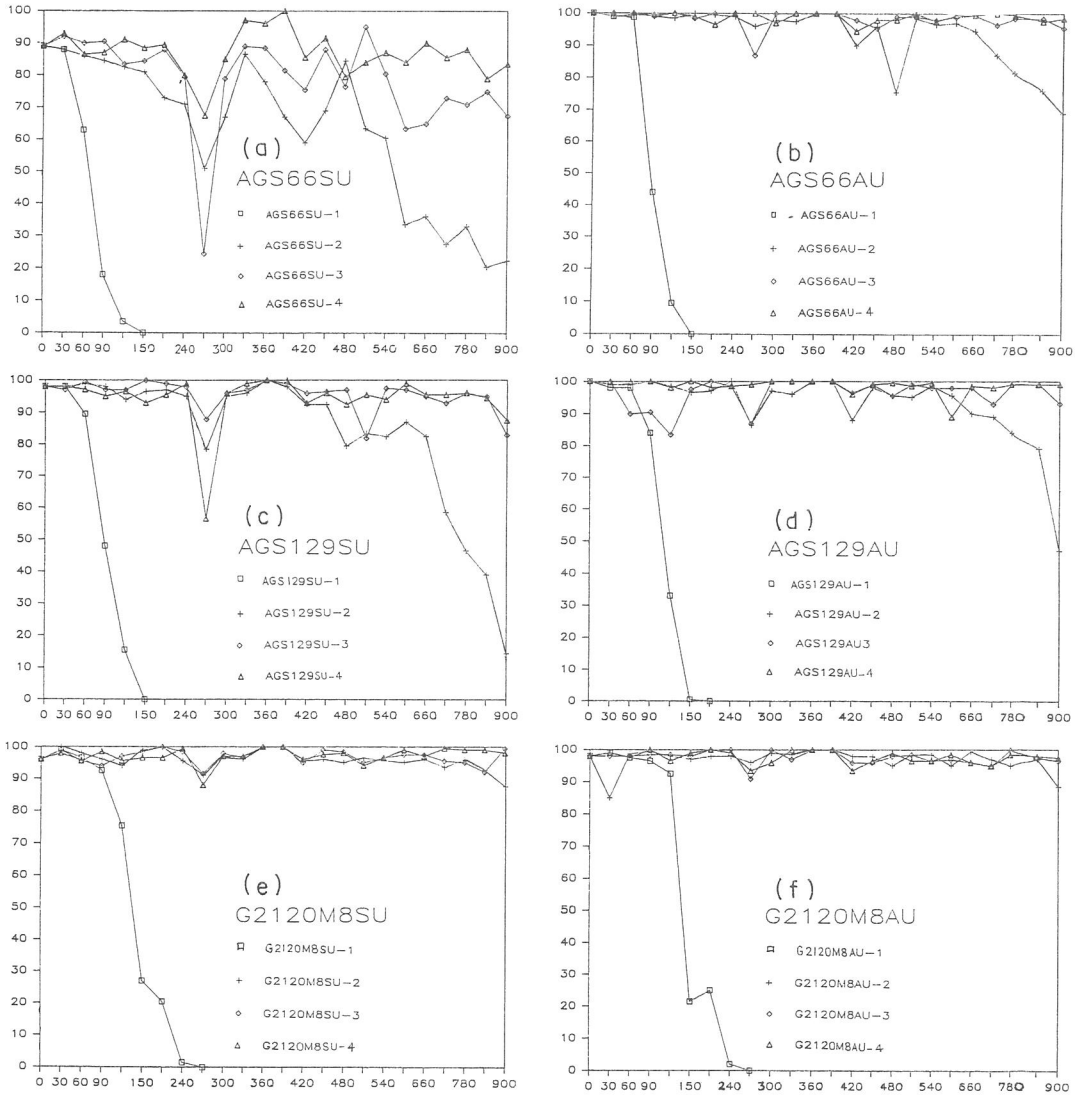

Fig. 3. Viability curves of AGS 66, AGS 129 and G 2120 M8 from summer (SU) and autumn (AU) crops under four storage regimes — (□) unprotected storage (25-30°C, 85% RH), (+) 30°C, 8% seed moisture content fresh weight basis, (◇) open storage at 25°C, 50% RH and (△) open storage at 15°C, 40-45% RH.

Its viability in four different storage regimes was low compared with the other five seed lots. These results confirm the empirical field observation of the poor seed quality of AGS 66. The small-seeded G2120 M8 behaved differently from the bigger-seeded, AGS 66 and AGS 129 in having good quality seeds even from the summer crop. However, there seemed to be no relationship between seed quality and seed size in each line.

Responses to different storage regimes. Open storage without any temperature and moisture protection in hot-wet tropical condition, i.e. simulated by storage regime (1) from the start of the experiment on 25 March 1985 to 25 September 1985 at AVRDC, was detrimental to soybean seed viability. Even G2120 M8, the best seed quality line, could retain high germination for only four months and there was then a sharp drop in viability on the fifth month (Fig. 3 e and f). The other standard grain-type soybean lines, AGS 65, AGS 124, AGS 129, AGS 160, AGS 162,

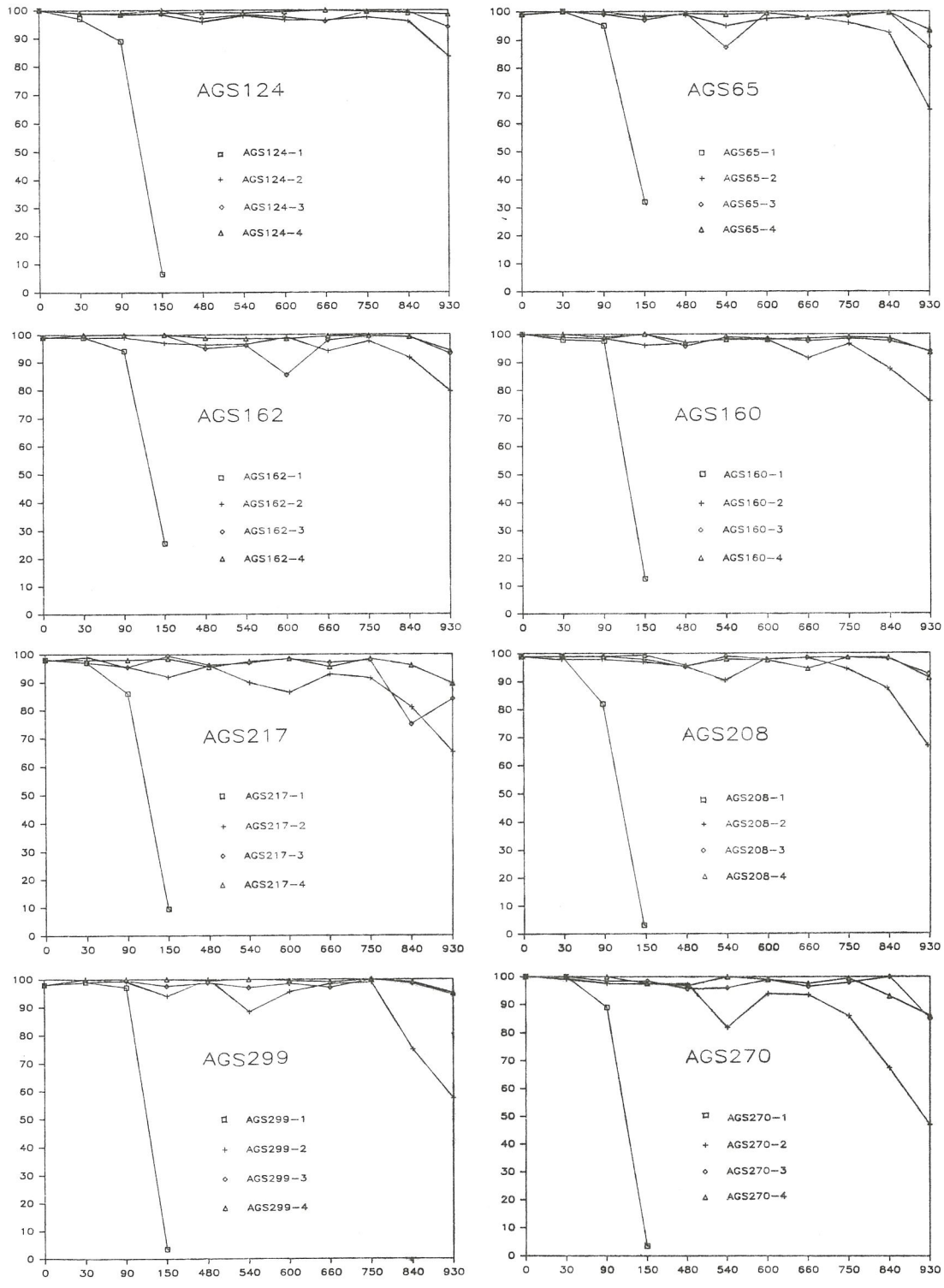

Fig. 4. Viability curves of AGS 65, AGS 124, AGS 160, AGS 162, AGS 208, AGS 217, AGS 270 and AGS 299 from the autumn crop (The storage regimes are similar to those in Fig. 1).

AGS 208, AGS 217, AGS 270 and AGS 299, from the fall season crop could maintain high viability of at least more than 82% for three months (Fig. 4). AGS 66 was the only line with a significant drop in viability to only 44% from the autumn crop (Fig. 3b). Poorer quality seed lots produced in summer deteriorated after only two months of storage as in AGS 66 SU (Fig. 3a).

A practical storage regime in tropical countries should provide protection against excessive moisture after the seed lot is dried down to 8% MC fresh weight basis. Storage treatment (2) simulated this storage regime. Seed lots with good quality seed, i.e. all samples produced in autumn and G2120 M8 summer lot, could be stored for at least 720 days and maintain more than 85% germination rate using this regime (Table 7). Poorer quality seed lots like AGS 66 and AGS 129 from the summer crop could be kept for about a year using this storage regime (Fig. 3a and c).

Storage treatment regimes (3) and (4) continued to maintain the initial high quality of seed lots for up to 930 days (31 months). Both storage regimes could be used as alternative storage methods to keep soybean seeds in bulk. Storage regime (3) can be achieved by using ordinary household type airconditioning equipment set at 25°C. Storage regime (4) can be achieved with a specialized cooler/airconditioning machinery. Ordinary household airconditioning normally maintains a relative humidity (RH) of about 55-60%. The low RH of 40% to 50% can only be achieved using either a chemical or refrigerate-reheat type of dehumidifier. The lower temperature and RH (i.e. 15°C, 40% RH) in storage treatment (4) prevents insect problems. A regular fumigation program required under storage treatment (3) is, therefore, not necessary.

Table 7. Viability of soybean seed lots stored at 30°C and 8% moisture content storage regime (Treatment 2).

Seed lot	Viability (%) after storage			
	720[z]	750	780	840
AGS 65 AU	–	96.0[y]	–	92.5
AGS 66 SU	27.5	–	33.0	20.5
AGS 66 AU	87.0	–	81.5	76.0
AGS 124 AU	–	97.5	–	96.0
AGS 129 SU	58.5	–	46.5	39.0
AGS 129 AU	89.0	–	84.0	79.0
AGS 160 AU	–	96.5	–	87.5
AGS 162 AU	–	97.5	–	91.5
AGS 208 AU	–	94.5	–	87.5
AGS 217 AU	–	91.5	–	81.0
AGS 270 AU	–	86.0	–	67.5
AGS 299 AU	–	99.0	–	75.0
G 2120 M8 SU	93.5	–	96.0	92.5
G 2120 M8 AU	97.0	–	95.0	97.0

[z]Days in storage. [y]% germination.

Predicting the Storage Life of Soybean Seed Lots. The seed viability equation developed by Ellis and Roberts (1980) for predicting seed longevity at certain storage temperature and seed moisture content is:

$$V = Ki - P/10^{ke} - Cwlogm - Ch - Cq$$

where V = probit percentage viability after a storage period p (days), ki = probit percentage viability at the beginning of storage, m = seed moisture content (percent on fresh weight basis) and t = temperature (°C) during storage, and Ke, Cw, Ch and Cq are constants for the species concerned. The species constants for soybean are as follows: Ke = 7.748, Cw = 3.979, Ch = 0.053 and Cq = 0.000228 (Ellis, Osei-Bonsu and Roberts 1982). The Ki value of a seed lot, i.e. initial viability, can be estimated by probit analysis using a series of viability monitoring. In a past experiment, using high temperature and high humidity aging, (i) 40°C and 100% RH (T1), (ii) 30°C in 84% RH for 14 days followed by 40°C and 100% RH (T2), gave consistent Ki values between the two methods used for each seed lot (t paired = -0.877, p = 0.3 - 0.4).

However, the Ki values estimated using different experimental techniques should be interpreted with caution because the longevity of a seed lot also depends on other intrinsic seed inherited physiological and physical properties of a variety. For example, G2120 M8 AU seed lot with 2.877208 Ki value had half viability period, p(50) i.e. the time taken (147.9 days) for viability to be reduced to 50%, longer than AGS 66 AU and AGS 129 AU seed lots with only 92.6 and 100.4 days, respectively. The Ki values of AGS 66 AU and AGS 129 AU were 3.898882 and 3.846585, respectively, which were larger than that of G2120 M8. In general, the better quality seed lots from harvests in autumn seemed to have higher Ki values than the poorer seed lots of a variety in summer. Indeed, the Ki value might be less accurately estimated from the result of a single germination test before storage (Ellis and Roberts 1981).

The predicted storage periods of the seed lots of AGS 66 are given in Table 8. They indicated the poor seed quality of the seed lot of AGS 66 in summer.

Table 8. Predicted storage period (days) for AGS 66 summer and autumn seed lots to lose viability to 70, 75, 80 and 85% using average Ki values of 99.9% and 92.3% estimated from storage treatment regimes (1) and (2), respectively.

Seed lot	Storage temp. (°C)	Storage seed MC (%)	Viability after storage			
			85%	80%	75%	70%
AGS 66 SU	30	12	18	26	34	41
	30	10	36	55	70	85
	30	8	88	133	171	205
	30	5	572	862	1110	1333
	20	12	77	117	150	180
	20	10	160	241	310	372
	20	8	389	585	754	905
	20	5	2522	3797	4891	5873
	5	12	588	885	1140	1369
	5	10	1215	1829	2356	2829
	5	8	2951	4444	5724	6874
	5	5	19153	28837	37146	44606
AGS 66 AU	30	12	100	109	117	124
	30	10	207	226	241	255
	30	8	503	548	586	621
	30	5	3266	3555	3804	4027
	20	12	442	481	514	545
	20	10	912	993	1063	1125
	20	8	2217	2414	2582	2734
	20	5	14388	15663	16757	17739
	5	12	3355	3652	3907	4136
	5	10	6929	7544	8070	8544
	5	8	16838	18331	19611	20761
	5	5	109268	118952	127261	134721

Implication of formulating a soybean seed program in tropical countries. The initial quality in seed lots is a function of genotypic differences, i.e. varieties, and pre-storage environmental differences both during seed production and processing before storage. High seed viability in storage can be achieved by improving the initial seed quality (i.e. with high Ki value) and by reducing the storage temperature and/or seed moisture content. Results showed that most AVRDC improved soybean lines gave high quality seed lots if ripened in a cool dry season with Ki values up to 5.475255, i.e. approximately 100%, and that their viability declined steeply within 2 to 5 months under ambient storage conditions in hot humid conditions (Fig. 3 and 4).

Under these circumstances, basic or foundation seeds should be produced in the best available site during a cool dry season for ripening and drying the seed crops. Artificial drying and processing

facilities should be installed to support the seed program in case the weather changes unpredictably during the harvesting season. Certain stock should be carried over between seasons as reserve for unpredicted demand caused by crop disasters. This calls for controlled environment storage. The ordinary household type of airconditioner can be used with a chemical dehumidifier to lower the humidity to about 40-50% RH, i.e. storage regime (3). Alternatively, a specialized airconditioner-cum-dehumidifier can be very cost effective in operating at this temperature and RH condition. The storage should be airtight to prevent leakage of moisture. It should be tidy to reduce the outbreak of insect pests and thus cut down on the number of fumigation cycles. The latter can be avoided by lowering temperature to about 15°C, i.e. storage regime (4).

The seed multiplication ratio in soybean is especially low for the bigger seeded varieties. Most newly developed areas for soybean in developing countries could not maintain **one generation-flow system** in their seed distribution. Instead of the normal three regenerations from foundation seed to certified seed up to nine regenerations may be required to multiply enough seeds for the farmers. The farmers may yet have to follow their traditional field-to-field seed supply system wherever harvesting time in one district coincides with the planting time in the neighboring districts. In this system, the newly harvested good quality seed can be traded immediately. Production systems and technology should be provided to guide the farmers to improve the quality of the seed saved. Seeds should be temporarily stored after drying to about 8-10% MC in air-tight tin containers or thick high density plastic bags and hermetically sealed. This could maintain high seed viability for up to two years at 30°C if the seed lot has high seed quality initially, i.e. storage regime (2).

Germplasm Recipients 1988

Argentina

Agrotecnica Trebol Sur S.R.L.

Australia

CSIRO Division of Tropical Crops and Pastures
DPI, Gatton
Department of Primary Industries
Pacific Seeds
Redlands Horticultural Research Station
South Australian Seed Growers Co-operative Limited

Bahamas

Department of Agriculture

Bangladesh

BARD, c/o AID
BARI

Barbados

CARDI

Belgium

Koninklijk Museum voor Midden-Afrika

Bhutan

IFAD Project, Dept. of Agriculture

Botswana

Botswana Development Corporation Ltd.

Brazil

EMBRAPA-Centro Nacional de Pesquisa de Hortalicas
Estacao Experimental de Anapolis
UFRRJ — Inst. Biologia-Fitopa-tologia
Universidade Estadual Paulista
Universidade Federal de Viçosa

Brunei

Agriculture Department
Ministry of Development
Sinaut Agricultural Training Centre

Burma

Agricultural Research Institute

Burundi

Institut des sciences agronomiques du Burundi (ISABU)

Canada

King Agro Inc.
Stokes Seeds Ltd.

Cape Verde Islands

Instituto nacional de investigacao agraria (INIA)

China

Chinese Academy of Agricultural Sciences (CAAS)

Colombia

CIAT
Instituto Colombiano Agropecuario
Instituto Linguistico de Verano

Congo

University Marien Ngouabi

Cook Island

Ministry of Agriculture

Costa Rica

ANAI
CINDE
Universidad de Costa Rica

Dominican Republic

Industrias Asociadas, C. por A.

Ecuador

Estación Experimental "Boliche", INIAP
Estación Experimental "P"

Egypt

Ministry of Agriculture

Ethiopia

Agricultural Development Department
Agricultural Research Centre
Institute of Agricultural Research, Bako Research Center
Nazreth Research Center

Fiji Islands

H.E. the President of the Republic of Fiji
Sigatoka Research Station
South Pacific Commission
Teidamu Central Nursery
Vuda Garden Ltd.

France

Andre Blondeau, Slectionneur-Obtenteur
INRA
IRAT
le Maulin Berra, le Landreau

Gambia

C.R.S. II Marina Patade
Department of Agriculture
Gambia Freedom From Hunger Campaign

Germany, Federal Rep. of

Biologische Bundesanstalt für Land und Forstwirtschaft
Institut für Biochemie
Institut für Viruskrankheiten der Pflanzen
Max Plank Institute

Ghana

Ministry of Agriculture
Nkawkaw Agriculture and Vegetable Centre

Guatemala

Instituto de Nutrición de Centro America, Panamá

Hong Kong

P.H.K. Trading Limited
Pillsbury Company
University of Hong Kong

Hungary

Hortus Botanicaus Universitatis

India

Allahabad Agricultural Institute
Central Agricultural Research Institute
Coonor Tea Estate
Hexamar Agricultural Research and Development Foundation
Himachal Pradesh Agriculture University
ICAR
ICAR Research Complex for N.E.H. Region, Shillong
Indian Agricultural Research Institute (IARI)
Kerala Agricultural University
Krishi Vigyan Kendra
Main Pulse Research Centre
Nath Seeds, Pvt. Ltd.
National Bureau of Plant Genetic Resources
Navalakha Group
New Hope, Rural Leprosy Trust
Osmania University
PAK-College of Agriculture
Pioneer Overseas Corporation
Punjab Agricultural University
Shri A.M.M. Murugappa Chettiar Research Centre
Shri Girivanavasi Pragati Mandal
Tamil Nadu Agricultural University
University of Delhi
Vijay Seeds Co., Pvt. Ltd.
YSP University of Horticulture and Forestry

Indonesia

Bogor Agricultural University
Bogor Research Institute for Food Crops (BORIF)
Chinese Agricultural Technical Mission
Central Research Institute for Food Crops (CRIFC)
Lembang Horticultural Research Institute (LEHRI)
MARIF, Kendalpayak
Organization for Rural Development
Winrock International, Balittan Sukarami

Iran

Agrosoy International
Seed and Plant Improvement Institute

Iraq

Agriculture and Water Resources Research Centre

Israel

Israel Gene Bank for Agricultural Crops
Levi Eshkol School of Agriculture
Volcani Centre

Jamaica

Biochemical Equipment and Services Ltd.

Japan

Agricultural Research Center
Kagome Co., Ltd.
Kagoshima Agr. Exp. Station
Kaneko Seeds Co., Ltd.
Kyoto University
Kyushu University
Mikado Seed Growers Co., Ltd.
Nagano Chushin Agriculture Experiment Station
National Institute of Agrobiological Resources (NIAR)
Sakata Seed
Takii Seed Co., Ltd.
Tokita Seed Co., Ltd.
University of the Ryukyus
University of Tokyo
Watanabe Seed Co., Ltd.
Yonoza Farmers Association

Korea, Republic of

Choong-Ang Seed Co., Ltd.
Dan Kook University
Hung Nung Seed Company
Kyungpook National University
Rural Development Administration (RDA)
Seoul National University

Lesotho

AID

Liberia

AVSPP/NCRDP
Catholic Mission
Southeastern Liberia Rural Development Programme

Madagascar

Département de recherches agronomiques, FO.FI.FA.
Opération de développement agricole intégré
S/C FAO/PUND MAG 82/016

Malawi

Bvumbwe Research Station

Malaysia

Agricultural Chemicals (M) Sdn. Bhd.
Agricultural Research Centre
Department of Agriculture
Divisional Agriculture Office
MARDI
Perunding Bersatu Sdn. Bhd.

Maldives

Ministry of Atolls

Marshall Islands

Chinese Agricultural Technical Mission
Peace Corps

Mauritius

Mauritius Sugar Industry Research Institute
Ministry of Agriculture, Fisheries and Natural Resources

Mexico

CSAEG
Instituto Nacional de Investigaciones Sobre Recursos Bióticos
Sede (CIAPAN) Campo Agrícola Experimental del Valle de Culiacań

Nepal

Department of Agriculture, Ministry of Agriculture

Netherlands

Deruiter Seeds B.V.

Niger

Projet horticole vitamine A en Afrique

Nigeria

Ahmadu Bello University
Bamol Nigeria Limited
Hensmor Agro Allied Industry Limited
Ministry of Agriculture and Cooperatives
Oipuala Cooperatives
Vegifarms Limited

Oman

Ministry of Agriculture and Fisheries

Pakistan

Agricultural Research Station
Conimplex Hatchery and Breeding Farms

Nuclear Institute for Agriculture and Biology
Pakistan Agricultural Research Council (PARC)

Panama

IDIAP
Chinese Agricultural Technical Mission
Nestlé Panamá, S.A.

Papua New Guinea

Division of Primary Industry, Food Crops

Peru

Autoridad Autónoma de Majes
Bayer Perú, S.A.
Fundación Contra el Hambre
Programa de Investigación Amaranthus
Programa Nacional de Kiwicha
Universidad Nacional Agraria

Philippines

Central Mindanao University
Department of Agriculture
Hortanova Vegetable Farm
Institute of Plant Breeding (IPB)
Intenseed Agriculture
International Rice Research Institute (IRRI)
Isabela State University
Litton Agro-Marine Co., Inc.
Mariano Marcos State University
Palawan National Agricultural College
Panay State Polytechnic College
Pangasinan State University
Philippine Coconut Producers Federation
POP/AVRDC
Quirino State College
Second Laguna de Bay Irrigation Project — Vegetable Component
University of the Philippines at Los Baños (UPLB)

Reunion (France)

IRAT

Saipan

Northern Mariana College

Samoa, Western

Office for Tokelau Affairs

Saudi Arabia

Ministry of Agriculture and Water
Tabuk Agricultural Development Co. (TADCO)

Senegal

Institut sengalais de recherches agricoles (ISRA)

Sierra Leone

Egyptian Embassy, Agric. Div.
Functional Adult Literacy Program, CUSO
Rice Research Station, Rokupr

Singapore

Eastreco (Pte.) Ltd.
National University of Singapore

Solomon Islands

Chinese Agricultural Technical Mission

South Africa

Mayford Seeds (Pty.) Ltd.

Spain

Centro de Investigación y Desarrollo Agrario
Universidad Politécnica

Sri Lanka

Agricultural Research Station
Canadian High Commission
Department of Agriculture
Development Alternatives, Inc.
Gnanammah Integrated Research Farm
Israel Interests Section
Plant Genetic Resources Centre
Tropic Green Isle Seeds
University of Peradeniya
University of Ruhuna

Sudan

Agricultural Research Corporation
University of Khartum
University of Gezira

Suriname

Ministry of Agriculture, Animal Husbandry and Fishery

Swaziland

Agricultural Research Division
Malkerns Research Station
Ministry of Agriculture and Cooperatives

Switzerland

Station fedrale de recherches agronomiques de Changine

Taiwan, China

Academia Sinica
Evergrow Seed Company
Fengshan Tropical Horticultural Experiment Station
First Seed Company
Fu Jen University
Known You Seed Company
National Chiayi Institute of Agriculture
National Chung Hsing University
National Pingtung Institute of Agriculture
National Taiwan University
Taiwan Agricultural Research Institute (TARI)
Taiwan Seed Improvement and Propagation Station

Thailand

Agricultural Development Research Center in Northeast Thailand (ADRC)
APTA Phaya Thai Court
Biological Nitrogen Fixation Research Center
Chainat Field Crops Research Center
Chia Tai Co., Ltd.
Chiang Mai Field Crop Research Center
Department of Agriculture
Hsin Seed Co., Ltd.
IBSRAM
Kasetsart University
Maejo Institute of Agricultural Technology
Pacific Seeds (Thai), Limited
Thai Potato Seed Co., Ltd.
TOP/AVRDC

Tonga

Department of Agriculture
M.A.F.F.

Trinidad and Tobago

University of the West Indies

United Kingdom

University of Birmingham
University of London
University of Reading

USA

Asgrow Seed Company
Campbell Inst. for Research and Technology
Dairyland Seed Co., Inc.
Funk Seeds International
Harris Moran Seed Company
Honolulu Community Gardens
Land O'Lakes, Inc.
Mississippi Agricultural and Forestry Experiment Station
Northrup King Company
Northwest Area, Grain Legume Genetics and Physiology Research
Peto Seed Co., Inc.
Seedcraft, Inc.
Sundance Farms, Inc.
Sungene Technologies Corporation
Texas A & M University
The Land EPCOT Center
University of Arizona
University of California
University of Hawaii at Manoa
University of Idaho
University of Illinois
University of Minnesota
University of Nevada-Reno
University of New Hampshire
USDA Plant Germplasm Quarantine Center
USDA Regional Plant Introduction Station
Virginia State University
Winrock International
Yuma Mesa Agricultural Center

Uruguay

Estación Experimental Granjera "Las Brujas"

Vanuatu

Torqil Centre

Vietnam

University of Cantho

Virgin Islands

University of the Virgin Islands
Water Isle Botanical Garden

Western Caroline Islands

Division of Agriculture and Forestry

Yemen Arab Rep.

Agricultural Research and Extension Project
Rural Development Project, al Mahwit Province
Seyun Research Center

Yugoslavia

University of Zagreb

Zaire

Institut national pour l'étude et la recherche agronomiques (INERA)

Zambia

University of Zambia

Zimbabwe

University of Zimbabwe

Information Services

Publications

During 1988, AVRDC through the Office of Information Services (OIS) published 15 publications (Table 1). By year-end an additional 750-page publication was prepared to camera-ready stage. There was an increase of approximately 15% over 1987 output. One issue of *Centerpoint* and the *1987 Progress Report Summaries* were printed.

Table 1. AVRDC publications released in 1988.

Author/Editor	Publication	No. of copies	TVIS[z]
Green/Opeña/Llemit	Tomato & Pepper Symposium Abstracts	335	
Llemit/Lastimosa	Gardening Nutritious Vegetables	1,250	
Talekar	Int. Coop. Guidesheet — IPM of Sweetpotato Weevil	1,750	
Sundar	Catalog of Mungbean Cultivars	1,000	x
Talekar/Sun	Int. Coop. Guidesheet — IPM of Sweetpotato Weevil (Chinese ed.)	750	
	Mungbean/Black Gram Bibliography	1,000	x
Opeña, Yoon, Kuo	TB 17 — Breeding and Seed Production of Chinese Cabbage	1,250	x
Yoon	Directory of Chinese Cabbage Researchers	1,000	x
McLean/Soderlund	1987 Progress Report Summaries	2,500	
McLean	Vegetable Research in Southeast Asia	1,500	
Llemit/Lastimosa	1986 Progress Report	600	
Sundar/McLean	2nd Int. Mungbean Symposium	–	x
	Subtotal	12,935	
	Periodicals		
McLean/Soderlund	TVIS News, Vol. 3, No. 1	1,000	x
McLean/Soderlund	TVIS News, Vol. 3, No. 2	1,000	x
McLean/Llemit	AVRDC Newsletter (weekly)	–	
	Subtotal	2,000	
	Brochures/Announcements		
McLean	Publication Lists	1,250	
	Total	16,185	

[z]An x indicates that publication is part of Tropical Vegetable Information Services (TVIS) project.

Journal Publication and Symposium Presentations

During the year, 14 journal papers written by AVRDC scientists were published and another five articles were prepared for publication (Tables 2 and 3). Thirty symposium presentations were made by AVRDC scientists (Table 4); many of these will be published in proceedings. Other articles published in 1988 are listed in Table 5.

Table 2. Journal papers published in 1988.

Author(s)	Title	Journal
S.H. Choi, S.K. Green, D.R. Lee, J.Y. Yoon	Incompletely dominant single resistance gene for peanut stripe virus in soybean line AGS 129	Euphytica 40:193-197
S.H. Choi, S.K. Green, D.R. Lee	Linkage relationship between two genes conferring resistance to peanut stripe virus and soybean mosaic	Euphytica 44:163-166
G.C.J. Fernandez, H.K. Chen	Effects of temperature and photoperiod on reproductive development of reduced photoperiod-sensitive mungbean genotypes: a quantitative model	J. Amer. Soc. Hort. Sci. 114(2):204-209
S.K. Green, Y.Sulyo, D.E. Lesemann	Leaf curl virus on tomato in Taiwan	FAO Plant Protection Bul. 35(2):62
S.K. Green, C.Y. Luo, D.R. Lee	Elimination of mycoplasma-like organisms from witches' broom infected sweet potato	J. Phytopathology 126:204-212
S.K. Green, D.R. Lee, N.M. Horne	Survey for viruses of soybean, mungbean and peanut in Java, Indonesia	Plant Disease 72(11):994
M. Kobayashi, I. Yamaguchi, N. Murofushi, Y. Ota, N. Takahashi	Fluctuation and localization of endogenous gibberellins in rice	Agric. Biol. Chem. 50(2): 1189-1184. 1988
C.G. Kuo, B.J. Shen, H.M. Chen, H.C. Chen, R.T. Opeña	Associations between heat tolerance, water consumption, and morphological characters in Chinese cabbage	Euphytica 39:65-73
A. Sajjapongse, M.H. Wu, Y.C. Roan	Effect of planting date on growth and yield of sweet potato	HortScience 23(4):698-699
N.S. Talekar, H.R. Lee, Suharsono	Resistance of soybean to four defoliator species in Taiwan	J. Econ. Ent. 81:1469-1473
N.S. Talekar, H.C. Yang, Y.H. Lee	Morphological and physiological traits associated with agromyzid (Diptera: Agromyzidae) resistance in mungbean	J. Econ. Ent. 81:1352-1358
N.S. Talekar, H.R. Lee	Response of soybean to foliage loss in Taiwan	J. Econ. Ent. 81:1363-1368
N.S. Talekar, Y.H. Lee	Biology of *Ophiomyia centrosematis* (Diptera: Agromyzidae), a pest of soybean	Ann. Ent. Soc. Amer. 81:938-942
N.S. Talekar, Y.H. Lee	Procedure for mass-rearing of beanfly (Diptera:Agromyzidae)	J. Econ. Ent. 81:316-318
N.S. Talekar	Characteristics of *Melanagromyza sojae* (Diptera:Agromyzidae) damage in soybean	J. Econ. Ent. 89:584-588

Table 3. Journal papers prepared in 1988.

Author(s)	Title	Publication
G.C.J. Fernandez H.K. Chen	Implications of genotype x environmental interactions in mungbean yield trials	J. Amer. Soc. Hort. Sci.
S.K. Green, C.Y. Luo, D.R. Lee	Elimination of sweet potato latent virus from *Nicotiana benthamiana* with ribavirin	J. Phytopathology ROC Plant Prot. Bul.
S.K. Green, C.Y. Lo	Elimination of sweet potato yellow dwarf virus (SPYDV) by meristem tip culture and by heat	J. Plant Disease and Protection
C.G. Kuo, H.M. Chen, B.J. Shen, H.C. Chen	Relationship between hormonal levels in pistils and tomato set in hot and wet seasons	J. Plant Growth Regulation
J.E. Yuen	Partial resistance to *Pernospora parasitica* in Chinese cabbage	Plant Disease

Table 4. Symposium/workshop presentations in 1988.

Author(s)	Title	Symposium/workshop
L.C. Chang	Seed production techniques of self-incompatible crops	Symposium on Seed and Seedling Production and Marketing Techniques of Horticulture Crops, PDAF, Taichung, Taiwan
L.C.Chang	Varietal improvement of peppers	Symposium on Vegetable Breeding, DAIS, Taitung, Taiwan, 25-27 February
J.T. Chen	Genetic improvement of fresh market tomatoes	Symposium on Vegetable Breeding, DAIS, Taitung, Taiwan, 25-27 February
J.T. Chen, R.T.Opeña	Breeding for disease resistance and adaptability of processing tomatoes	Report of Vegetable Crops Improvement Series V-VI, PDAF, Taichung, Taiwan
S.K. Green	Sweet potato virus elimination and virus indexing at AVRDC	Germplasm Health of Yam, Cocoyam and Sweet Potato, FAO, IBPGR, DGIS, Wageningen, 14-18 November
C.G. Kuo, H.M. Chen, H.C. Chen	Response of tomato to high temperatures: problems and prospects of adaptation research	Int. Symp. on Tomato and Pepper Production in the Tropics, Tainan, Taiwan, AVRDC, 22-25 March
S.H. Lai	Seed production techniques of solanaceous vegetables	Symposium on Seed and Seedling Production and Marketing Techniques of Horticultural Crops, PDAF, Taichung
S.H. Lai, H.L.Hwang	Tendency of Taiwan processing tomato	Symposium on Vegetable Breeding, DAIS, Taitung, 25-27 February
S.H. Lai, J.T.S. Tsai, S.C.S. Tsou, H. Imai	The contribution of AVRDC tomatoes in Taiwan	Int. Symp. on Tomato and Pepper Production in the Tropics, AVRDC, Tainan, Taiwan, 22-25 March
G.A. Marlowe	Vegetable research at AVRDC: Achievements and future thrusts	Vegetable Research in Southeast Asia Workshop, ADB-AVRDC, Tainan, Taiwan, 1-6 August
G.A. Marlowe	The potential role of AVRDC for collaborative vegetable research in Southeast Asia	Vegetable Research in Southeast Asia Workshop, ADB-AVRDC, Tainan, Taiwan, 1-6 August
R.T.Opeña	Conceptual framework of the workshop	Vegetable Research in Southeast Asia Workshop, ADB-AVRDC, Tainan, Taiwan, 1-6 August
R.T. Opeña	Boosting the vegetable industry of Southeast Asia: areas for further research and development	Symposium on Vegetable Production and Marketing; Asian Productivity Organization, Tokyo, Japan, 18-25 October
R.T. Opeña, S. K. Green, N.S. Talekar, J.T.S. Tsou, A.T. Tschanz, J.T. Chen	Genetic improvement of tomato adaptability to the tropics: Progress and future prospects	Int. Symp. on Tomato and Pepper Production in the Tropics, AVRDC, Tainan, Taiwan, 22-25 March
Y.Ota	Organic farming in Japan	Symposium on Organic Farming, DAIS, Taichung, Taiwan, 27-29 October
Y. Ota	Role of the hull in the ripening of the rice plant	Symposium on Rice Quality, DAIS, Taichung, Taiwan, 7-9 April
Y. Ota, A. Sajjapongse	Effect of choline on yield of sweet potatoes (*Ipomoea batatas* (L.) Lam.)	Eighth Symp. of the Int. Society of Tropical Root Crops, Bangkok, Thailand, 30 Oct.-5 November
A. Sajjapongse, M.H. Wu	Investigation on the effect of some climatic factors on sweet potato yield	Eighth Symp. of the Int. Society of Tropical Root Crops, Bangkok, Thailand, 30 Oct.-5 November
A. Sajjapongse, Y.Ota, Y.C. Roan, C.L. Wu	Some aspects of cultural management of tomato at AVRDC	Int. Symp. on Tomato and Pepper Production in the Tropics, AVRDC, Tainan, Taiwan, 22-25 March

Table 4. Continued.

Author(s)	Title	Symposium/workshop
D.C.S. Tay	Genetic resources of tomato and pepper at AVRDC	Int. Symp. on Tomato and Pepper Production in the Tropics, AVRDC, Tainan, Taiwan, 22-25 March
S.C.S. Tsou	Digestibility of sweet potato starch	Sweet Potato Improvement in Asia, Trivandrum, India, 24-28 October
S.C.S. Tsou, J.T.S. Tsay	Vegetable research in Southeast Asia	Vegetable Research in Southeast Asia Workshop, ADB-AVRDC, Tainan, Taiwan, 1-6 August
S. Shanmugasundaram	AVRDC grain legume program	Food Legume Coordinating Meeting, IDRC-ACIAR, Bangkok, Thailand, 30 April-1 May
S. Shanmugasundaram, H. Imai, S.C.S. Tsou	AVRDC experiences with maximum yield research on soybean	Asian Maximum Yield Symposium, New, Delhi, India, October
N.S.Talekar	Integrated control of sweetpotato weevil	Eighth Symp. of the Int. Society of Tropical Root Crops, Bangkok, Thailand, 30 Oct.-5 November
N.S. Talekar, J.C. Yang	Prospects of diamondback moth control in Southeast Asia	Workshop on Vegetable Pest Control, Honduras, June
N.S. Talekar	Development and testing of an integrated pest management technique to control sweetpotato weevil	Sweet Potato Improvement in Asia, Trivandrum, India, 24-28 October
C.Y. Yang	Cultivation and production of tomato and pepper in China	Int. Symp. on Tomato and Pepper Production in the Tropics, AVRDC, Tainan, Taiwan, 22-25 March
J.Y. Yoon	Country report summaries	Vegetable Research in Southeast Asia Workshop, ADB-AVRDC, Tainan, Taiwan, 1-6 August
J.Y. Yoon, S.K. Green, A.T. Tschanz, S.C.S. Tsou, L.C. Chang	Pepper improvement for the tropics:	Int. Symp. on Tomato and Pepper Production in the Tropics, AVRDC, Tainan, Taiwan, 22-25 March

Table 5. Other articles published in 1988.

Author	Title	Publication
J.Y. Yoon, R.T. Opeña, L.C. Chang	Evaluation of radish-derived cytoplasmic male sterility for use in tropical heading Chinese cabbage	Cruciferae Newsletter
D.C.S. Tay	Utilization of the mungbean collection at AVRDC	IBPGR/FAO Plant Genetic Resources Newsletter
D.C.S.Tay	Flood tolerant amaranth	Amaranth Newsletter
D.C.S.Tay, Y.K. Huang	Mungbean genetic resources at AVRDC	IBPGR/FAO Plant Genetic Resources Newsletter
D.C.S. Tay	Improvement on germplasm distribution at AVRDC	IBPGR/FAO Plant Genetic Resources Newsletter
D.C.S.Tay, Y.K. Huang	The importance of plant genetic resources	Know-You Seed Company 20th Anniversary Special Issue
S. Shanmugasundaram	*Glycine max* (L.) Merrill	Section in Pulses of PROSEA, Wageningen
S. Sakamoto, H. Takagi, C.G. Kuo	*Ipomoea batatas* (L.) Lam.	Section of PROSEA, Wageningen

Copublication Activities

The French edition of AVRDC's Sweet Potato Proceedings was copublished with the Technical Center for Agricultural and Rural Action (CTA) and the Agence de cooperation culturelle et technique (ACCT), through a special project funded by CTA and ACCT. A total of 300 copies were provided at no cost to AVRDC. Half of these copies were sent by CTA to addresses provided by AVRDC.

An agreement was realized between AVRDC and Wiley Eastern, Ltd., of New Delhi to copublish N.S. Talekar's monograph entitled *Agromyzid Flies of Food Legumes in the Tropics*.

Public Awareness

AVRDC issued two press releases: one announcing the upcoming International Symposium on Integrated Management Practices for Tomato and Pepper Production in the Tropics and the other announcing the release of several new cultivars by China, Thailand and Western Samoa which utilized AVRDC-improved materials.

The press release on the Pepper/Tomato Symposium in 1988 subsequently appeared in the March issue (number 15) of *Diversity*, a news journal for the plant genetic resources community. The one on newly released AVRDC-improved vegetables appeared in an article in the *Seed World*, a commercial seed industry magazine in the USA.

OIS met with journalists from Bahrain, India, Indonesia, the Federal Republic of Germany and Taiwan during 1988.

OIS prepared hundreds of briefing kits and ran the slide show in the auditorium for 96 groups of visitors to the Center.

Public Awareness Association

AVRDC, represented by OIS, attended the first meeting of the Public Awareness Association for International Agricultural Research held at CIMMYT from 22-24 June.

In the meeting, a German journalist was provided with information which could be of interest to her target audience: the German public. As a result of this press tour, a series of articles, mostly AVRDC-related vegetable production technologies, appeared in the major German press around the time of the CGIAR's midyear session in Berlin.

Data Bases

Mailing List

The mailing list data base contains the current address, telephone and telex numbers, and commodity interest for each entry and forms the basis for AVRDC's external institutional contacts. The mailing list presently contains about 5,157 subscribers, 415 of which are libraries and 427 are VIPs.

The coding of the addressees into general, director, library and VIPs permits wide categories to be identified. The VIP list is further broken down into 14 subgroups, which allows specific identification of information.

The mailing list is also used to identify and communicate with target groups whose opinions are sought for planning purposes. It is also used to help develop specialized data bases such as the Vegetable International Professional Service (VIPS) or published data bases such as the *Directory of Chinese Cabbage Researchers*.

During the year, the library addresses were updated and an auxiliary library data base was constructed.It contains specific information on library information requirements which now permits selective dissemination of publications (SDP). As a result of this updating, 158 library addresses were deleted.

Photo Services

About 19,300 photographic records of the scientific work in progress during the year were taken in over 1,125 separate photo sessions in the fields, laboratories and studio. A total of 7,197 of these black and white prints and blue slides were developed in the OIS darkroom.

Art Services

About 127 requests for art work which involved the preparation of 496 figures, tables, posters, book covers, etc. were met. Of these were the final drawing of draft illustrations for the *Vegetable Research in Southeast Asia*, the *1986 Progress Report and the Second International Mungbean Symposium*.

Distribution

Considering that all libraries receive complimentary copies of AVRDC publications, a questionnaire was sent to all libraries which participated in the depository scheme in the third quarter of 1987. The questionnaire was designed to determine the libraries' perceived value on the different types of publications; the availability and use by readers of previously-deposited AVRDC publications, the publication(s) AVRDC receives in exchange, and the libraries' willingness and ability to purchase AVRDC publications in the future.

Follow-up questionnaires were sent twice to solicit responses from delinquent libraries after which they were informed that no further complimentary distribution would be carried out unless they responded. Of the 571 libraries, 415 (73%) responded. It was assumed that any library which was unable/unwilling to respond to the survey, despite three queries, was not interested to receive AVRDC publications. A savings in postal charges of US$1,263 was made in 1988 by not distributing any material to these delinquent libraries.

Full Utilization of Postal Tariffs

The utilization of consolidated mailings is a postage-saving technique. Because of the prevailing tariff structure, it costs the same amount to send to the Philippines a single copy of the 40-page Technical Bulletin No. 16, which weighs 110 g, as the 106-page *1987 Progress Report Summaries*, which weighs 240 g. OIS continued to implement measures in 1988 to design individual AVRDC publications to remain within the upper limit of the tariff utilized and utilize consolidated mailings to substantially reduce postage costs over the former practice of distributing each publication individually.

Custom designing AVRDC publications. The slight reduction in paper weight from 100 lb to 80 lb and space-saving typesetting and layout practices kept the overall weight of publications within the upper limits of a lower-weight tariff category. This practice permitted a substantial savings of from 29% to 45% in postage charges for individual mailings.

Consolidated mailings. OIS consolidated its entire automatic complimentary distribution in 1988 in three mailings. Consolidated mailings in combination with the selective dissemination of publications (SDP) provides AVRDC with the maximum cost efficiency which the existing tariff structure permits.

Increased Sales

Total sales of AVRDC publications in 1988 were over 25% more than the total sales in 1987 (Table 6).

Table 6. Sales of publications, 1988.

Source	Sales (US$)
Headquarters	5,274
– Pepper/Tomato Sym. Display	1,056
– Promotional campaigns	1,694
Subtotal	8,024
Distributors	
– Germany (Europe)	70
– Indonesia	495
– Japan	180
– Malaysia	97
– Taiwan	487
– Thailand	13
– USA (North America)	1,073
Subtotal	2,415
Grand total	10,439

Distributor network. During the year distributors in the Philippines and Singapore were enlisted and expected to generate sales in 1989. The new Indonesian distributor, the ESCAP-CGPRT Centre, proved to be an extremely good outlet for AVRDC publications. It undertook many promotional activities such as advertising AVRDC's publications in its newsletter and publication catalog.

Promotional activities. Behind the many sales of AVRDC publications were the solid promotional campaigns. OIS systematically prepared announcements of forthcoming major publications for the appropriate journals/publications and offered complimentary review copies for eventual book reviews.

OIS systematically conducted two direct promotional campaigns which have led to US$ 1,694 sales in 1988. The *Progress Report Summaries* was offered at a discounted price to readers in developed countries to whom AVRDC was unable to provide complimentary copies. In 1988, a total of 319 copies of the 1985, 1986 and 1987 Summaries were sold.

Publications Available

How to Order

All publications herein listed can be ordered from the Office of Information Services (OIS), AVRDC, P.O. Box 205, Taipei 10099. The following list of distributors in the highly developed countries (HDC) and less developed countries (LDC) have many of these publications available for sale in local currency.

The prices quoted below include surface postage. If airmail delivery is required the additional postal charges will be added to the invoice. All charges should be paid with a US dollar check (**payable by a bank in the USA**) made out to AVRDC, or with Unesco coupons.

HDC Distributors

Select Books Pte, Ltd.
19 Tanglin Rd.
Singapore 1024
Republic of Singapore

Publishers International Corp.
2nd Floor, Newfield Building
42-3 Ontsuka 3-chome
Bunkyo-ku, Tokyo 112
Japan

TRIOPS. Tropical Scientific Books
Toeche-Mittler Distribution
6100 Darmstadt
Hindenburgstr, 33
Fed. Rep of Germany (Orders for Europe)

INFO-LINE
GPO Box 506
Sydney, N.S.W. 2001
Australia
(Orders for Oceania)

Agribookstore
1611 N. Kent Street, Suite 600
Arlington, VA 22209
USA (Orders for North America)

LDC Distributors

World Universities Press
B-5/132, Safdarjung Enclave
New Delhi - 110 029, India

University of Malaya Co-Operative Bookshop, Ltd.
P.O. Box 1127
Jalan Pantai Baru, 59.700
Kuala Lumpur, Malaysia

Africa Book Services, Ltd.
Quran House
Mfangano Street
P.O. Box. 45245
Nairobi, Kenya

INDEX, Book Promotion & Service, Ltd.
Ploenchit Road, Pathumwan
Bangkok 10500, Thailand

Publications Section
CGPRT Centre
Jalan Merdeka 99
Bogor 16111, Indonesia

Annual Progress Reports

1983 Progress Report. 444 p.
1984 Progress Report. 480 p.
1985 Progress Report. 471 p.
1986 Progress Report. 541 p.
1987 Progress Report. 482 p.
(All issues of Progress Reports cost HDC $20.00; LDC $15.00)

Progress Report Summaries

1985 Progress Report Summaries. 96 p.
1986 Progress Report Summaries. 94 p.
1987 Progress Report Summaries. 98 p.
1988 Progress Report Summaries. 100 p.
(All issues of Progress Report Summaries cost HDC $7.50; LDC $4.00)

Symposium Proceedings

AVRDC. 1977. Vegetable Technology in Asia. Proceedings of the Workshop on Pre- and Post-harvest. 156 p. (HDC $12.00; LDC $8.00)

Cowell, R. (ed.). 1978. Tropical tomato: Proceedings of the First International Symposium. 290 p. (HDC $18.00; LDC $10.00)

Talekar, N. S. and T. D. Griggs (eds.). 1981. Chinese cabbage: Proceedings of the First International Symposium. 489 p. (HDC $25.00; LDC $15.00)

Villareal, R. L. and T. D. Griggs (eds.). 1982. Sweet potato: Proceedings of the First International Symposium. 481 p. (HDC $28.00; LDC $15.00)

Shanmugasundaram, S., E. Sulzberger and B.T. McLean (eds.). 1986. Soybean in Tropical and Subtropical Cropping Systems, Revised ed. 485 p. (HDC $25.00; LDC $18.00)

Talekar, N. S. and T. D. Griggs (eds.). 1986. Diamondback Moth Management: Proceedings. 483 p. (HDC $25.00; LDC $18.00)

Shanmugasundaram, S., P. Lastimosa and N. Llemit (eds.). 1987. Soybean Varietal Improvement: Proceedings of the International Workshop. 93 p. (HDC $7.50; LDC $4.00)

Lastimosa, Pura J. and N.V. Llemit (eds.). 1987. Gardening Nutritious Vegetables; Proceedings of the Vegetable Improvement Gardening Workshop. 136 p. (HDC $10.00; LDC $6.00).

Sapin and Grange (trans.). 1988. La Patate Douce: Actes du premier symposium international. CTA, ACCT and AVRDC, Belgium. p. 483. (From the original Sweet Potato: Proceedings of the First International Symposium. R.L. Villareal and T.D. Griggs (eds.) AVRDC, 451 p. (HDC $28.00; LDC $15.00).

B.T. McLean (ed.). 1988. Vegetable Research in Southeast Asia. 242 p. (HDC $17.50; LDC $10.00)

S. Shanmugasundaram and B.T. McLean (eds.). 1988. Mungbean: Proceedings of the Second International Symposium. 750 p. (HDC $40.00; LDC $25.00)

Technical Bulletins

TB 1 Menegay, M. R. 1975. Taiwan's specialized vegetable production areas: An integrated approach. 17 p. (HDC $4.00; LDC $3.00)

TB 2 Menegay, M. R. 1976. Farm management research on cropping systems. 19 p. (HDC $4.00; LDC $3.00)

TB 3 Calkins, P. H. 1976. Four approaches to risk and uncertainty for use in farm management extension. 18 p. (HDC $4.00; LDC $3.00)

TB 4 Calkins, P. H. 1977. Farmers' viewpoint of sweet potato production in Taiwan. 44 p. (HDC $5.00; LDC $3.50)

TB 5 Calkins, P. H. 1978. Vegetable consumption in five cities of Taiwan. 24 p. (HDC $4.00; LDC $3.00)

TB 6 Huang, S. Y. and P. H. Calkins. 1978. Summer tomato production in Taiwan. 29 p. (HDC $5.00; LDC $3.50)

TB 7 Huang, K. R. and P. H. Calkins. 1978. Vegetable production in Taiwan; A survey of 300 farmers. 36 p. (HDC $5.00; LDC $3.50)

TB 8 Calkins, P. H. 1978. Why farmers plant what they do: A study of vegetable production technology in Taiwan. 92 p. (HDC $7.50; LDC $4.00)

TB 9 Calkins, P. H. and H. M. Wang. 1978. Improving the marketing of perishable commodities: A case study of selected vegetables in Taiwan. 65 p. (HDC $6.00; LDC $3.50)

TB 10 Calkins, P. H. and S. H. Tu. 1978. White potato production in Taiwan: A farm survey. 29 p. (HDC $4.00; LDC $3.00)

TB 11 Calkins, P. H. 1978. Soybean production in Taiwan: A farm survey. 28 p. (HDC $4.00; LDC $3.00)

TB 12 Riley, J.J. 1978. Evaluation of environmental parameters in the humid tropics for crop scheduling purposes. 31 p. (HDC $4.00, LDC $3.00)

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Sen-hsiung Lai, B.S., Associate Development Officer

Soil Science

Yasuo Ota, Ph.D., Principal Soil Scientist
Chin-hua Ma, B.S., Assistant Specialist*

Ching-liu Wu, B.S., Research Assistant
Chuen-how Ng, B.S., Research Assistant†

Development Program

Program Director: Arnold T. Tschanz‡
George A. Marlowe, Jr.***‡

Cooperative Programs

Indonesia/AVRDC Bilateral Project

Subijanto, Ph.D., Director, Central Research Institute for Horticulture, Jalan Ragunan 29, Pasar Minggu, Jakarta, Indonesia

Malaysia MARDI/AVRDC Vegetable Research Program

Mohammed Yusof bin Hashim, Ph.D., Deputy Director General, Malaysian Agricultural Research and Development Institute, P.O. Box 12301, 50774 Kuala Lumpur, Malaysia

The Korean Sub-Center Affiliated with AVRDC

Jung-Ho Kim, Ph.D., Director, Horticultural Experiment Station, Rural Development Administration, No. 475 Imok Dong, Suweon 170, Rep. of Korea

AVRDC Philippine Outreach Program

Benjamin M. Legaspi, B.S., Project Director, Bureau of Plant Industry, Ministry of Agriculture, Economic Garden, Los Baños, Laguna, Philippines

Thailand Outreach Program/AVRDC

Charles Y. Yang, Ph.D., Director and Resident Scientist, P.O. Box 9-1010, Kasetsart, Bangkok 10903, Thailand

Training

Diosdado V. Castro, M.S., Training Specialist
James Sedlacek, Ph.D., Training Associate†
Sy-ming Wang, B.S., Senior Training Assistant‡
Yi-ming Chen, M.S., Principal Training Assistant†
Eduardo I. Castro, M.S., Research Fellow†

Regional Programs

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Anne Daniel Turner, M.S., Resident Scientist
Douglas L. Robertson, M.S., Horticulturist†
Elhadj Amadou Amadou Cisse, Assistant Scientist†

Research Support Services

Chemistry

Samson C.S. Tsou, Ph.D., Biochemist
Kuang-kung Kan, M.S., Assistant Specialist‡
Tuan-liang Hong, M.S., Principal Research Assistant‡‡**

Computer and Statistical Services

Hsien-yang Tien, B.S., Principal Computer Assistant
Yuh-ling Chen, B.S., Computer Assistant

Experimental Farm

Teng-sheng Tu, B.S., Farm Superintendent

Genetic Resources and Seed Unit (GRSU)

Chong-seng Tay, Ph.D., Associate Seed Technologist
Yung-kuang Huang, M.S., Principal Research Assistant‡‡**
Chew-ann Chen, B.S., Research Assistant‡
Huei-lung Chiou, B.S., Research Assistant‡
Liang-miin Jean, B.S., Research Assistant†

Information Services

Bruce T. McLean, B.A., Associate Information Specialist
Norma V. Llemit, M.A., Assistant Information Specialist
John W. Soderlund, B.S., Editorial Assistant‡

Library

Teng-hui Hwang, B.A., Senior Librarian
Ying-jen Wong, M.S., Documentalist‡

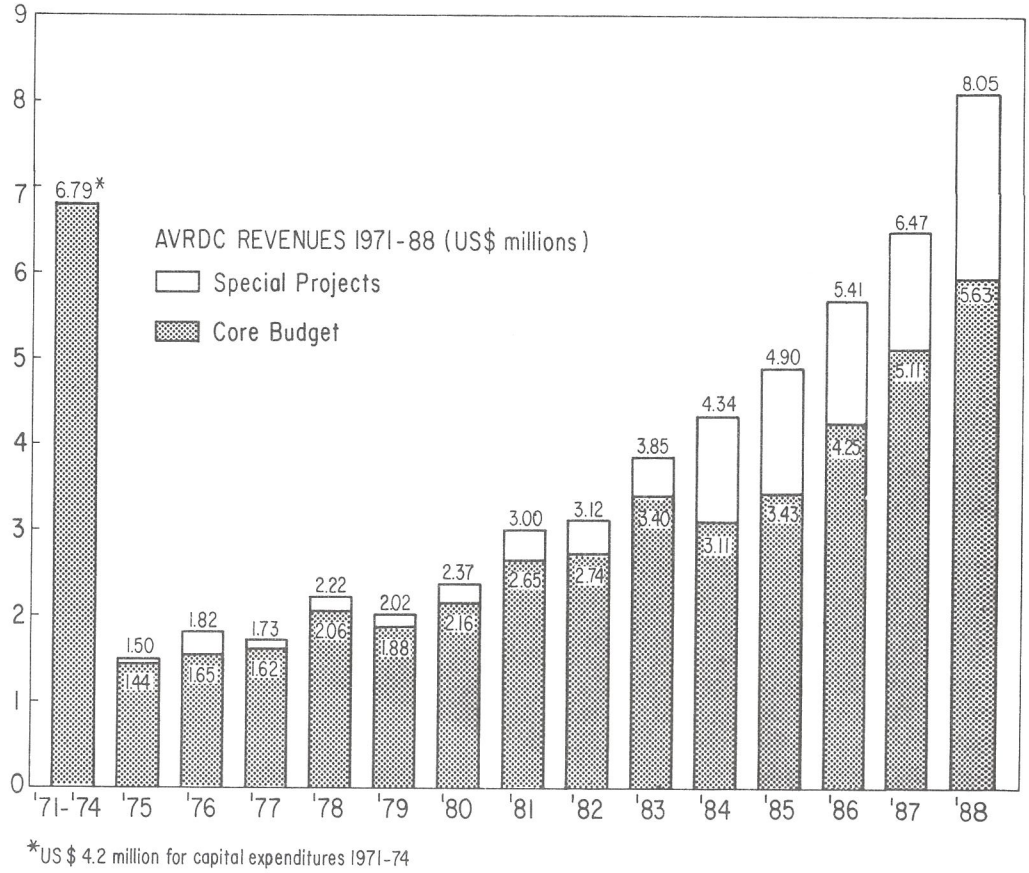
† Arrived during 1988.
†† Transferred in 1988.
‡ Left during 1988.
‡‡ Reinstated after advanced study leave.
* Advanced study leave.
** Promoted in 1988.
*** Acting personnel

Finances

AVRDC's projected budget for 1988 was US$6,700,000 compared with an actual income of US$8,047,373 and total expenditures of US$7,371,887. In 1988 AVRDC received support from the following governments:

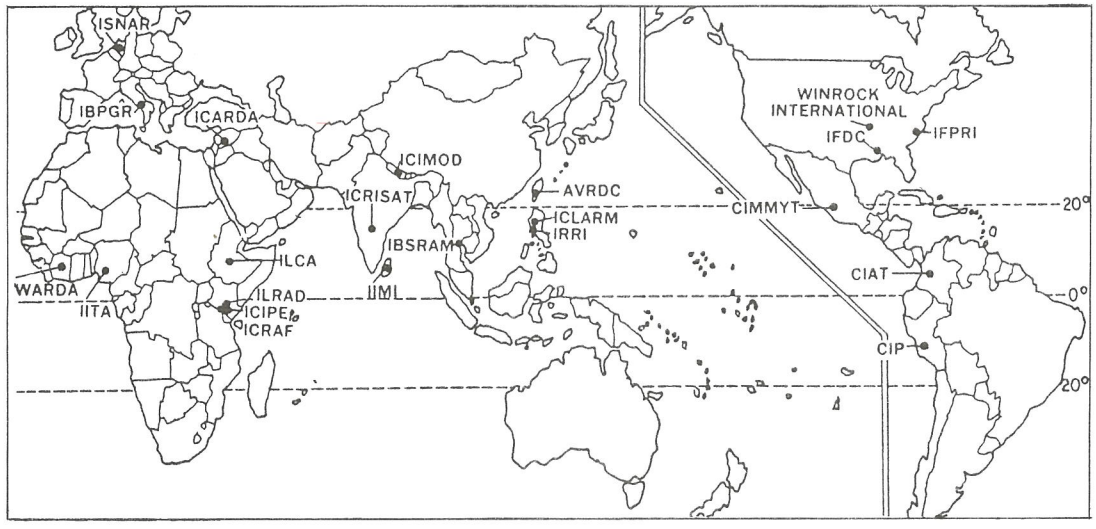
- the Republic of China
- the United States of America
- Japan
- the Federal Republic of Germany
- the Kingdom of Thailand
- the Republic of Korea
- the French Republic
- the Commonwealth of Australia

Grants and other forms of assistance were also received from: the Japan Shipbuilding Industry Foundation (JSIF), the ROC Council of Agriculture (COA), the United States Agency for International Development (USAID), the Asian Development Bank (ADB), the International Development Research Centre (IDRC) of Canada, the United States Department of Agriculture (USDA), the German Ministry for Economic Cooperation (BMZ), the German Agency for Technical Cooperation (GTZ) and the Technical Centre for Agricultural and Rural Co-operation (CTA).



*US $ 4.2 million for capital expenditures 1971-74

International Agricultural Research Centers



- Asian Vegetable Research and Development Center (AVRDC)
- Centro Internacional de Agricultura Tropical (CIAT)
- Centro Internacional de la Papa (CIP)
- Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT)
- International Board for Plant Genetic Resources (IBPGR)
- International Board for Soil Research and Management (IBSRAM)
- International Center for Agricultural Research in the Dry Areas (ICARDA)
- International Centre of Insect Physiology and Ecology (ICIPE)
- International Centre for Integrated Mountain Development (ICIMOD)
- International Center for Living Aquatic Resources Management (ICLARM)
- International Council for Research in Agroforestry (ICRAF)
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
- International Fertilizer Development Center (IFDC)
- International Food Policy Research Institute (IFPRI)
- International Institute of Tropical Agriculture (IITA)
- International Irrigation Management Institute (IIMI)
- International Laboratory for Research on Animal Diseases (ILRAD)
- International Livestock Centre for Africa (ILCA)
- International Rice Research Institute (IRRI)
- International Service for National Agricultural Research (ISNAR)
- West Africa Rice Development Association (WARDA)
- Winrock International Institute for Agricultural Development (WINROCK INTERNATIONAL)