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Abbreviations and Acronyms

-ACIAR -Australian Centre for International Agricultural Research
-ACP-EC -African, Caribbean and Pacific-European Community
-ADB -Asian Development Bank
-ADRC -Agricultural Development Research Center (Northeast Thailand)
-a.i. -active ingredient
-AID -Agency for International Development (USA)
-AIT -American Institute in Taiwan
-AMV -alfalfa mosaic virus
-ANOVA -analysis of variance
-ARTT -advanced soybean rust tolerance trials
-ASET -AVRDC Soybean Evaluation Trials
-ATI -Agricultural Training Institute (Philippines)
-AVNET -Collaborative Vegetable Research Program for Southeast Asia
-AVRDC -Asian Vegetable Research and Development Center
-AYT -advanced yield trial

-BARI -Bangladesh Agricultural Research Institute
-BAW -beet armyworm
-BePMV -bell pepper mottle virus
-BER -blossom end rot
-BINA -Bangladesh Institute of Nuclear Agriculture
-BMZ -German Ministry for Economic Cooperation
-BP -bacterial pustule
-BSU -Benguet State University (Philippines)
-BW -bacterial wilt

-CARDI -Caribbean Agricultural Research and Development Institute
-CATIE -Centro Agronómico Tropical de Investigación y Enseñanza
-cfu -colony-forming units
-CGIAR -Consultative Group on International Agricultural Research
-CGN -Centre for Genetic Resources (the Netherlands)
-CGR -crop growth rate
-CHT -cherry tomato
-CIAPAN -Centro de Investigaciones Agricolas del Pacifico Norte (Mexico)
-CIAT -Centro Internacional de Agricultura Tropical (CGIAR)
-CIDSE -Cooperation internationale pour le developpement socioeconomique
-CIMMYT -Centro Internacional de Mejoramiento de Maiz y Trigo (CGIAR)
-CINDE -Coalicion Costarricense de Iniciativas de Desarrollo (Costa Rica)
-CIP -Centro Internacional de la Papa (CGIAR)
-CLS -Cercospora leaf spot
-CMS -cytoplasmic male sterility
-CMV -cucumber mosaic virus
-COA -Council of Agriculture (Taiwan)
-CPA -para-chlorophenoxy acetic acid
-CSIRO -Commonwealth Scientific Industrial Research Organization (Australia)
-CTA -Technical Center for Agricultural and Rural Cooperation (EC)
-cv. -cultivar
-CVMV -chili veinal mottle virus

-DAE -days after emergence
-DAIS -District Agricultural Improvement Station (Taiwan)
-DAS -days after sowing
-DAS ELISA -double antibody sandwich
-DBM -diamondback moth
-DM -downy mildew
-DMRT -Duncan's multiple range test
-DNA -deoxyribonucleic acid
-DOAE -Dept. of Agricultural Extension (Thailand)
-DWB -dry weight basis

-EC -European Community
-EDTA -ethylenediaminetetraacetic acid
-ELISA -enzyme-linked immuno-sorbent assay
-ENEA -Comitato Nazionale per la Ricerca per lo Sviluppo dell'Energia Nucleare e delle Energie Alternative (Italy)

-FAO -Food and Agriculture Organization of the United Nations
-FIRDI -Food Industry Research and Development Institute (Taiwan)
-FMTT -fresh market tropical tomato
-FMV -feathery mottle virus

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

-HPLC -high performance liquid chromatography
-HS -heat sensitive
-HT -heat tolerant

-IARC -international agricultural research center
-IARI -Indian Agricultural Research Institute
-IBPGR -International Board for Plant Genetic Resources (CGIAR)
-IBSRAM -International Board for Soil Research and Management (IARC)
-ICARDA -International Center for Agricultural Research in the Dry Areas (CGIAR)
-ICIMOD -International Centre for Integrated Mountain Development (IARC)
-ICIPE -International Centre of Insect Physiology and Ecology (IARC)
-ICLARM -International Center for Living Aquatic Resources Management (IARC)
-ICRAF -International Council for Research in Agroforestry (IARC)
-ICRISAT -International Crops Research Institute for the Semi-Arid Tropics (CGIAR)
-ICW -imported cabbageworm
-IDIAP -Instituto de Investigación Agropecuaria de Panamá
-IDRC -International Development Research Centre (Canada)
-IFDC -International Fertilizer Development Center (IARC)
-IFPRI -International Food Policy Research Institute (CGIAR)
-IIMI -International Irrigation Management Institute (IARC)
-IITA -International Institute for Tropical Agriculture (CGIAR)
-ILCA -International Livestock Center for Africa (CGIAR)
-ILRAD -International Laboratory for Research on Animal Diseases (CGIAR)
-IMN -International Mungbean Nursery (AVRDC)
-INA -Instituto Nacional Agrario (Honduras)
-INIREB -Instituto Nacional de Investigaciones Sobre Recursos Bioticos (Mexico)
-INRA -Institut national de la recherche agronomique (France)
-INTHOPE -International Hot Pepper Trial Network
-IPB -Institute of Plant Breeding (UPLB)
-IPDR -Institut pratique de developpement rural (Niger)
-IPM -Integrated pest management
-IRRI -International Rice Research Institute (CGIAR)
-ISNAR -International Service for National Agricultural Research (CGIAR)
-IYT -intermediate yield trial

-LAD -leaf area duration
-LAI -leaf area index
-LAR -leaf area ratio
-LEHRI -Lembang Horticulture Research Institute (Indonesia)

-MAFF -Ministry of Agriculture, Forestry and Fisheries (Japan)
-MARDI -Malaysian Agriculture Research and Development Institute
-MARIF -Malang Research Institute for Food Crops (Indonesia)
-MYMV -mungbean yellow mosaic virus

-NAR -net assimilation rate
-NARS -national agricultural research systems
-NBPGR -National Board for Plant Genetic Resources (India)
-NIRS -near infrared reflectance spectroscopy

-OIS -Office of Information Services (AVRDC)

-PCARRD -Philippine Council for Agriculture, Forestry and Natural Resources Research and Development
-PDA -potato dextrose agar
-PE -polyethylene
-PeMV -pepper mottle virus
-PM -powdery mildew
-PMMV -pepper mild mottle virus
-POP -Philippines Outreach Program (AVRDC)
-ppm -parts per million
-PVMV -pepper veinal mottle virus

-PVX -potato virus X
-PVY -potato virus Y
-PYT -preliminary yield trial

-RDA -Rural Development Administration (Rep. of Korea)
-RGR -relative growth rate
-ROI -return of investment
-RYT -regional yield trial
-SDP -selective dissemination of publications
-SEP -standard error of prediction
-SPLCV -sweet potato leaf curl virus
-SPLV -sweet potato latent virus
-SPV II -sweet potato virus II
-SPYDV -sweet potato yellow dwarf virus

-TA -technology adaptation
-TARC -Tropical Agricultural Research Center
-TARI -Taiwan Agricultural Research Institute
-TEV -tobacco etch virus
-TFW -tomato fruitworm
-TLCV -tobacco leaf curl virus
-TMGMV -tobacco mild green mosaic virus
-TMV -tobacco mosaic virus
-ToMV -tomato mosaic virus
-TOP -Thailand Outreach Program (AVRDC)
-TSWV -tomato spotted wilt virus
-TuMV -turnip mosaic virus
-TVDF -Tropical Vegetable Data File (AVRDC)
-TVMV -tobacco vein mosaic virus

-UCNCT -upland crop national cooperation trial
-UNDP -United Nations Development Program
-UPLB -University of the Philippines at Los Baños
-USDA -United States Department of Agriculture

-WARDA -West Africa Rice Development Association (CGIAR)
-WAT -weeks after transplanting

-YDV -yellow dwarf virus

Crop Improvement Program

Chinese Cabbage Breeding

Improvement of Open-pollinated Cultivars for Uniform Maturity

Summary

Maternal lines of the MLS_4 generations of two AVRDC-bred Chinese cabbage open-pollinated cultivars, 77M(3)-27 and 77M(3)-35 were evaluated in the late summer of 1989. General observations on each population indicated clear variations within maternal lines for maturity and other characters. The ML population of 77M(3)-35 was later maturing with longer head shape and exhibited more variations than 77M(3)-27. Lines and individual plants were selected from the 77M(3)-27 population to develop the next cycle.

Introduction

Two AVRDC-bred open-pollinated cultivars, 77M(3)-27 and 77M(3)-35 were previously found to possess good heat tolerance and resistance to downy mildew. However, the cultivars varied widely in maturity. To obtain uniform maturity, maternal line selection (MLS) was applied on both populations. Four cycles were completed by the 1988-89 cool season. Based on the performance in the late summer of 1989, lines and individual plants were selected to constitute the population of the next cycle.

Materials and Methods

Twenty-eight and 15 maternal lines of MLS_4 generation were produced in 77M(3)-27 and 77M(3)-35, respectively in 1988-89 cool season. These were sown on 9 August and transplanted 5 September 1989. A randomized complete block design was employed for each cultivar group with three replications. Each plot consisted of 8-m-long double-row beds. Spacing was 150 cm between adjacent beds from center to center, 50 cm between rows on beds, and 40 cm between plants within rows. Standard AVRDC cultural practices were followed in the nursery and in the field.

Selections were made in 77M(3)-27 population during the last week of October. Degree of uniform maturity, mean days to maturity, acceptability and uniformity of head shape, head size and disease incidence were considered during line selection. Individual plants of desired maturity, head shape and size were chosen regardless of the maternal line to which they belong. The superior lines were selected from these plants.

Results and Discussion

In spite of typhoon and heavy rain one week after transplanting, the experiment was completed although growth was delayed. General observations of each population indicated clear variations within maternal lines for maturity and other characters. MLS population of 77M(3)-35 was later maturing with longer head shape and exhibited more variations than 77M(3)-27. Table 1 summarizes the selections made in cultivar group 77M(3)-27. Selected plants will contribute to the creation of the MLS_5 generation. Selection in 77M(3)-35 is in progress.

Table 1. Summary of selections made from MLS_4 generation of two open-pollinated Chinese cabbage cultivars to constitute the next cycle.

Cultivar	Planted		Selected		
	Lines	Plants	Lines	Paternal parents	Maternal parents[z]
77M(3)-27	28	6720	7	115 (1.7%)	48 (0.7%)
77M(3)-35	15	3600		(in progress)	

[z]Used as both maternal and paternal parents.

Breeding for Heat-tolerance and Cylindrical-head Shape

Summary

A total of 46 BC_3F_2 and BC_2F_3 families and 43 F_2s and F_1s derived from intercrosses were evaluated in the late summer of 1989. Higher heat tolerance was clearly observed in BC_3F_2 generation compared to BC_2F_3 in both combinations, B61 × E-9 and B61 × R1-3. Intercrossed families appeared more vigorous than other families.

Introduction

Most heat-tolerant Chinese cabbage cultivars have round head shape. This has been one of the major hindrances in promoting tropical Chinese cabbage in some countries where consumers are familiar with elongated-head shape cultivars. Thus, a backcross breeding project had been initiated to combine heat tolerance and cylindrical or elongated-head shape to meet this preference in some countries.

Materials and Methods

The plants of BC_2F_2 and BC_1F_3 families selected from an evaluation in the late summer of 1988 were advanced to BC_3F_2 and BC_2F_3 by artificial pollination during the 1988-89 cool season. Selected plants from intercrosses among selected BC_1F_2 families were also selfed to F_2 and further intercrossed with elite heat-tolerant inbreds to search for superior genotypes from segregating populations. These advanced generations were planted during late summer in 1989 and evaluated for heat tolerance, head shape and other desirable horticultural traits. Promising families and plants were selected therefrom for further generation advancement.

A total of 46 BC_3F_2 and BC_2F_3 families and 43 F_2s and F_1s derived from intercrosses were sown on 17 August and transplanted on 8 and 11 September 1989. A randomized complete block design with three replications was employed. A plot consisted of two 4-m-long double-row beds. Two adjacent beds were 150 cm apart from center to center. Spacing between rows on beds 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 experiment for reference in evaluation and selection. The parents and check were laid out in a randomized complete block design. However, each plot consisted only of one double-row bed.

Results and Discussion

These experiments were severely damaged by a typhoon with continuous heavy rain just after transplanting. Growth was seriously retarded and maturity was delayed. Although great variations were observed among plants within families and among families within a given generation in a given combination, higher heat-tolerance of short-head materials was clearly observed in BC_3F_2 generation compared to BC_2F_3 in both combinations (Table 2). Intercrossed families, especially F_1, families appeared more vigorous than other families. In families belonging to B61 × R1-3 combination, tipburn and internal rot were observed. Bolting before head formation was unusual in all combinations.

Development of Heat-tolerant Composites

Summary

A total of 70 AVRDC-bred inbreds and open-pollinated families were grown in the field in late summer of 1988 for grouping into distinct types. During 1988-89 cool season, the composite was produced by hand intercrossing from components as follows: 27 of Chang Puh, 16 of ASVEG 1 and 19 of semitropical type. These were grown in the late summer of 1989. Selections from these populations will be used for further intercrosses to create the new base population of the composite.

Introduction

As the main goal of Chinese cabbage tropicalization has already been attained, the Center decided to scale down its research activity on this crop to a maintenance level. Thus, the development of a few, diverse heat-tolerant composites was adopted as a general strategy to secure maximum utilization of the previously developed genetic materials by growers as well as by breeding institutes in client countries, and to preserve the opportunity for further improvement of any additional major constraints when the situation in the future permits. This project is now at the stage of selecting lines to create the base population of the composite.

Materials and Methods

A total of 70 inbreds and open-pollinated Chinese cabbage families developed by AVRDC were grown in the field in the late summer of 1988. Seeds of 25 elite inbreds, 24 open-pollinated cultivars and 21 new inbreds were sown on 11 August and transplanted on 9 September 1988. A randomized complete block design with three replications was employed for the experiment. Each plot consisted of one 2.4 m long, double-row beds. Spacing was 150 cm from center to center between two adjacent beds, 50 cm between rows on beds, and 40 cm between plants within rows. Characteristics such as maturity, head shape, vigor, hairiness, etc. were considered as the criteria for grouping the materials into three main groups (i.e. Chang Puh, ASVEG 1 and semitropical types).

During the 1988-89 cool season, synchronization of flowering among the selected components was carried out for the three groups. The components were intercrossed by hand-mass pollination using an equal amount of mixed pollen within the group. Components of the composite produced in this manner were sown on 28 August and transplanted on 2 October, 1989. A randomized complete block design with three replications was employed for each group. A plot consisted of 2.4 m long, double-row bed. Spacing was 150 cm from center to center between two adjacent beds, 50 cm between rows on beds, and 40 cm between plants within rows.

Results and Discussion

Table 3 shows the characteristics used as the criteria for grouping the AVRDC-bred genetic materials into three types. Chang Puh type group included 34 lines/cultivars that were early maturing, with round head, of small plant stature with reduced vigor, and with most cultivars possessing smooth and hairless leaves. Semitropical type consisting of 20 components were later maturing with longer-head shape, large plant size with high vigor, and with a greater proportion of lines with dense hairy leaves. Most components of the ASVEG 1 type group fell between the two groups.

Depending upon flowering synchronization, the composite was produced by hand pollination using 27 of Chang Puh, 16 of ASVEG 1 and 19 of semitropical type. These were grown in late summer 1989. Unfortunately, the seedlings were damaged by typhoon and continuous heavy rain and badly infected by Sclerotinia rot resulting in delayed transplanting. Selection from these populations will be used for further intercrosses to create the new base population of the composite.

Table 2. Heat tolerance and other characteristics of BC_3F_2's and intercrosses of heat tolerance x cylindrical-head combinations in late warm season, 1989.

Combination[z]	Generation	HT level	Head shape	Head top posture	Tipburn/ internal rot	Bolting	Remarks
B61 × E-9	BC_3F_2	high	short elongated	mostly much overlapping	rare	–	wavy, dark green leaves
	BC_2F_3	moderate	short cylindrical	mostly overlapping	rare	rare	wavy, dark green leaves
B61 × R1-3	BC_3F_2	high	elongated	overlapping	often	–	erect-type
	BC_2F_3	moderate	elongated-short cylindrical	overlapping-michihili type	often	–	erect-type
Intercross	F_2	low-high	elongated-short cylindrical	overlapping-michihili type	rare	rare	much variation
	F_1	moderate-high	round-short cylindrical	much overlapping-michihili type	rare	rare	generally very high vigor

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

Table 3. Criteria for grouping AVRDC lines into three types for development of composites in late summer, 1988.

Type	Maturity	Head shape	Vigor	Hairiness			No. of lines	Final component[z]
				Hairless	Variable	Hairy		
Chang Puh	early-medium	round-nearly round	low-medium	21	2	11	34	27
ASVEG 1	early-medium late	round-elongated	medium low-medium high	9	5	2	16	16
Semitropical	medium-late	elongated-cylindrical	medium-high	11	7	2	20	19

[z]Number of lines which contributed to the subsequent composite populations.

Cytoplasmic Male-sterility Program

Summary

To develop a simple and stable system of hybrid seed production, two different sources of cytoplasmic male sterility (CMS) found in radish, *Raphanus sativus* and mustard, *Brassica juncea* had been repeatedly backcrossed to tropical Chinese cabbage. More variations were noted among individual plants within a family than among families. Almost every family yielded only a few variant chlorotic plants. Twenty-six selected lines in the radish-derived CMS backcross program, and 29 from the mustard-originated CMS backcross families were grown in the field, and will be allowed to flower under natural conditions to produce more seeds for selection in the next generation.

Introduction

The commercial F_1 hybrid seed production of Chinese cabbage has exclusively employed the self-incompatibility mechanism. The system is complicated for many tropical countries to adopt where the crucifer seed industry is not well-developed. Moreover, self-incompatibility is weakened in many Chinese cabbage inbred lines when grown under hot and humid conditions. AVRDC attempted to transfer the cytoplasmic male sterility found in radish, *Raphanus sativus* and mustard, *Brassica juncea* to tropical Chinese cabbage lines through repeated backcrossing.

Materials and Methods

In the radish-derived CMS backcross program, open-pollinated seeds of 26 selected lines from six backcross families were sown on 6 October and transplanted on 1 November 1989. Each family comprised of 60 plants. The materials were planted in a design which insures that each CMS progeny is surrounded by four plants of the recurrent male fertile parent, CT1-27, thereby equalizing the pollen source for all male-sterile plants in the field.

A total of 2,485 hand-pollinated seeds in 10 mustard-originated CMS backcross families were also sown on 6 October 1989. After discarding the undesirable seedlings (poor vigor and intense chlorosis), 1,813 plants were transplanted on 1 November 1989 using the same field design as the radish-derived CMS families.

Open-pollinated seeds from 19 mustard-originated CMS backcross families were also sown on 6 October 1989 and transplanted on 2 November 1989. Each family consisted of 100 plants each planted in the same design as the CMS families described above.

Results and Discussion

Table 4 shows the horticultural characters of seedlings from various CMS backcross families. In general, more variations were noted among individual plants within a family than among families.

Table 4. Horticultural characters of seedlings and yields of CMS backcross families in previous pollination.

CMS Source	Pollination	Recipient	Uniformity[z]	Vigor[y]	Chlorosis[x]	Seed yield
Radish	OP after BC	CT1-27	2-3	2-5	0-2	fair-good
	OP after intercross	CT1-32/CT1-56	2-3	1-4	0-4	fair-good
Mustard	Continuous BC	CT1-32	1-3	1-2	1-5	poor-fair
		CT1-56	1-2	1-2	0-5	fair
		B-18	3	1-2	0-2	very poor
	OP after BC	CT1-32	1-3	1-4	0-5	poor-good
		CT1-56	2	1-3	0-5	poor-good
		B-18	2	1-3	0-4	poor-good

[z]1 = poor to 5 = excellent. [y]1 = weak; 2 = slightly vigorous; 3 = moderate; 4 = vigorous; 5 = very vigorous. [x]0 = none; 1 = very slight; 2 = slight; 3 = moderate; 4 = severe; 5 = very severe.

Almost every family yielded only a few variant chlorotic plants. The remaining plants were transplanted to the field and will be allowed to flower under natural conditions instead of culturing them in pots to produce more seeds.

International Cooperation

In 1989, 580 Chinese cabbage seed packets were distributed to 81 cooperators in 28 countries. Most seeds consisted of open-pollinated or F_1 hybrid cultivars together with local checks and AVRDC's standard heat-sensitive check for testing. A limited number of shipments to national programs of parental lines of F_1 hybrids for in-country seed production experiments were also made. One hybrid was officially released in Taiwan in 1989. Reports of promising performance of AVRDC breeding materials from various cooperators were received and are briefly reported below.

Cultivars Released

Taiwan. Hybrid 82-156 was officially released in Taiwan as Taoyuan-ASVEG 2 on 21 July, 1989. Desirable characters of this variety are high and stable yield during the hot rainy season; easy recovery after typhoon and heavy rain imbued by its strong root system; and, other preferred horticultural traits which meet the preference of local consumers, such as hairlessness, smooth and dark-green leaves with a 0.6-1.2 kg oval head. Mr. T. L. Chen of the Taoyuan District Agricultural Improvement Station conducted the regional yield trial of six AVRDC hybrids and two local checks at Chu Bei, Hsin Chu. Hybrid 82-156 significantly outyielded other entries, averaging 0.7 kg head weight (Table 5).

Table 5. Yield and other horticultural characters of new hybrids[z] at Chu-Bei, Shin Chu, Taiwan.

Entry	Maturity (DAT)	Head weight (kg)	Bolting rate (%)	Tipburn (%)	Yield[y] (t/ha)
Hybrid #82-156	56	0.7	0	14.2	27.7 a
Hybrid #86187	56	0.5	0	14.6	20.0 b
Hybrid #85216	56	0.4	0	15.4	18.2 bc
Hybrid #86186	56	0.4	0	16.0	17.5 bc
Hybrid #86182	56	0.4	0	15.2	16.8 bc
Hybrid #86181	56	0.4	0	13.8	14.8 c
Combi #2 (ck 1)	56	0.4	1	15.5	17.2 bc
Shin Hailuh (ck 2)	56	0.4	0	15.4	14.6 c

[z]Sown on 12 August, transplanted on 10 September, and harvested on 5 November, 1988. [y]Mean separation within columns by DMRT at 5% probability level.

Japan. Mr. Kunichika Sameshima of the Kumage-branch of the Kagoshima Agricultural Experiment Station conducted two summer trials of 30 AVRDC cultivars, two F_1 hybrids from a private company in Taiwan, and two F_1 hybrids from Japan as local checks. Seeds were sown (11 July) in the greenhouse with mist cooling equipment, and transplanted (8 August 1988) in vinylhouse with screens on both sides, and in the field with screen tunnel to protect plants from insect. Performance of some selected AVRDC cultivars in vinylhouse is listed in Table 6 and in field trial is on Table 7. Early maturity of AVRDC cultivars was more pronounced in vinylhouse than in the field. Head weights of 77M(3)-25, 77M(2/3)-46, Hybrids 58 and 83-3 were higher than the checks, Seikai and Kenryu. Considering the yields and other characteristics in both trials, open-pollinated 77M(3)-25, Hybrids 58 and 83-3 were the most promising entries.

Swaziland. Dr. Sebenzile Matsebula of the Ministry of Agriculture and Cooperatives conducted a trial which included two open-pollinated and six hybrid cultivars from AVRDC, and one heat-sensitive check from Japan at Malkerns Research Station during April-July, 1988. No data could be obtained in the trial due to severe bolting of all plants (including the heat-sensitive check) before head formation. The trial will be repeated in the warm season.

Turkey. Prof. A. Yazgan at the Cumhuriyet University at Tokat conducted a two-season trial with two open-pollinated and six AVRDC hybrid cultivars vs. the standard heat-sensitive check, B40. In spring (sown on April 1 and transplanted on 6 May 1988), all plants bolted before head formation. In fall (sown on August 1 and transplanted on 24 August 1988) most entries gave low yields because of a high bolting rate (Table 8). Only Hybrids 62 and 83-20 were relatively resistant to bolting with a promising high yield in a short growing duration of 63 and 65 days, respectively. Higher yield of B 40 was mainly due to its late maturity and the favorable cool season for its growth and development.

Zimbabwe. Table 9 summarizes the data obtained from three-season trials conducted by Mr. E. Manzungu of Chiredzi Research Station. All hybrids matured in 43 to 46 days from

Table 6. Performance of some selected Chinese cabbage cultivars[z] in vinylhouse at Kumage Branch of Kagoshima Agricultural Experiment Station, Kagoshima, Japan.

Entry	Maturity (DAT)	Head weight (kg)	Solidity	Internal rot (%)	Soft rot (%)	Harvest rate (%)	Yield (t/ha)
77M(3)-25	47	1.4	0.52	0	10	90	41.5
Hybrid 80-37	42	1.2	0.55	0	0	100	39.3
77M(2/3)-46	47	1.3	0.48	45	5	90	38.7
Hybrid 83-3	42	1.3	0.45	10	5	85	36.5
Hybrid 58	42	1.3	0.49	25	0	75	32.3
77M(3)-38	43	1.0	0.47	30	10	55	19.0
Seikai (ck1)	53	1.2	0.42	10	0	50	19.2
Kenryu (ck2)	39	0.9	0.55	25	10	85	25.3

[z]Sown on 11 July and transplanted on 8 August, 1988.

Table 7. Performance of some selected Chinese cabbage cultivars[z] in the field at Kumage Branch of Kagoshima Agricultural Experiment Station, Kagoshima, Japan.

Entry	Maturity (DAT)	Head weight (kg)	Solidity	Internal rot (%)	Soft rot (%)	Harvest rate (%)	Yield (t/ha)
Hybrid 58	48	1.3	0.50	0	2	88	39.3
Hybrid 83-3	50	1.3	0.51	0	4	90	37.8
77M(3)-38	50	1.2	0.57	0	21	90	35.0
77M(2/3)-46	50	1.3	0.57	0	8	73	31.0
77M(3)-25	50	1.2	0.64	0	4	65	25.3
Hybrid 80-37	49	1.2	0.61	0	4	63	24.9
Seikai (ck1)	52	1.3	0.54	0	6	83	35.0
Kenryu (ck2)	49	0.9	0.56	0	8	73	18.7

[z]Sown on 11 July and transplanted on 8 August, 1988.

Table 8. Yield and other characteristics[z] of AVRDC entries in a fall trial at Cumhuriyet University, Tokat, Turkey.

Entry	Maturity (DAT)	Head weight (kg)	Bolting rate (%)	Harvest rate (%)	Yield (t/ha)
Hybrid 62	63	1.4	10	90	87.1
Hybrid 83-20	65	1.2	–	100	77.9
77M(2/3)-46	70	1.2	60	40	29.3
Hybrid 82-157	62	1.0	75	25	16.4
Hybrid 85216	62	1.2	80	20	16.3
Hybrid 85202	62	1.0	80	20	12.3
77M(3)-40	62	1.7	90	10	9.2
Hybrid 82-156	62	0.8	90	10	5.2
B40 (HS check)[y]	78	1.4	–	100	90.2

[z]Sown on 1 August and transplanted on 24 August 1988. [y]HS: heat sensitive.

transplanting while the heads of the heat-sensitive check, B 40, remained loose until harvest 60 days after transplanting. Only two hybrids outperformed the yield of both heat-tolerant and heat-sensitive checks.

Table 9. Performance of AVRDC cultivars in three-season trial[z] at the Chiredzi Research Station, Zimbabwe.

Entry	Days to maturity	Mean head weight (kg)			Yield (t/ha)		
		Sept. 1986	Oct. 1987	Dec. 1978	Sept. 1986	Oct. 1987	Dec. 1987
77M(3)-40	51	0.9	0.7	0.3	18.4	25.7	10.0
77M(2/3)-46	50	0.8	0.5	0.7	12.8	24.0	11.3
Hybrid 82-156	46	1.0	0.7	0.2	19.9	21.0	12.3
Hybrid 82-157	44	0.9	0.6	0.4	21.7	24.7	12.0
Hybrid 83-20	46	1.0	0.8	0.6	25.1	27.0	11.0
Hybrid 85202	43	–	0.7	0.7	–	22.0	11.3
Hybrid 85216	43	–	0.8	0.6	–	23.3	10.7
Hybrid 59	44	1.0	–	–	23.1	–	–
B189 (HT check)[y]	42	0.9	0.8	0.6	22.8	24.3	8.7
B40 (HS check)[y]	60	1.5	1.3	0.6	22.8	39.3	20.7

[z]Transplanted on 30 Sept. 1986, Oct. and Dec. 1987. [y]HT: heat tolerant; HS: heat sensitive.

Chinese Cabbage Entomology

Effects of Temperature on the Biology of *Diadegma eucerophaga*

Summary

Diadegma eucerophaga is an efficient and very effective larval parasite of diamondback moth, *Plutella xylostella* (L). Despite repeated releases, this parasite, however, has not been established in the lowland but a single release has resulted in the establishment and widespread parasitism of DBM in the highlands of Taiwan. To understand this difference, the effect of temperature on various biological parameters of *D. eucerophaga* was evaluated. Within the range of 15 to 35°C, incubation of parasite eggs within DBM larvae decreased gradually from 2.93 days at 15°C to 1.00 day at 35°C. Hatching of the eggs was not affected by temperature between 15 and 30°C but at 35°C, the rate of hatching declined from 100 to 85%. Duration of larval stage declined from 8.65 days at 15°C to 3.52 days at 35°C and rate of pupation from 90% at 15°C to 19.9% at 35°C. The duration of pupal stage declined from 16.13 days at 15°C to 6.44 days at 30°C and rate of adult emergence from 79% at 15°C to 65% at 30°C. At 35°C most pupae died. Higher temperatures accelerated the development of *D. eucerophaga* but also weakened the insect. The drastic effects of temperatures 30°C and above on the pupation and adult emergence seemed to limit the establishment of *D. eucerophaga* in lowland areas.

Introduction

To control insecticide-resistant diamondback moth (DBM), *Plutella xylostella* (L) (Lepidoptera: Yponomeutidae), which is the most destructive pest of all cruciferous vegetables in southeast Asia, AVRDC imported one larval parasite, Diadegma *eucerophaga* Horstmann from Indonesia in 1985. During the past three years, this parasite had been released in all crucifer growing areas in Taiwan, and has established itself in the highlands of central Taiwan. However, despite repeated releases of the insect, *D. eucerophaga* has not yet been established in the lowlands. DBM problem in the lowlands has been worst as ever. Temperature in the lowlands during crucifer season is relatively low but at times it reaches 30°C. Studies at AVRDC revealed that at temperatures above 25°C, DBM parasitism is lower than at 20 or 25°C. Therefore, the effects of temperature on the biology of *D. eucerophaga* were investigated to draw conclusions on the use of this parasite in the lowlands of Taiwan.

Materials and Methods

The study investigated the effects of temperature on the incubation period of eggs; rate of egg hatching; duration of larval stage; rate of pupation; duration of pupal stage; and rate of emergence of adults from pupae at 15, 20, 25, 30, and 35°C.

Egg incubation and hatching. Several pairs of *D. eucerophaga* adults were confined in cages containing about 200 second instar DBM larvae. After 24 hr of oviposition, the adult parasites were removed and four cages each were placed at 15°C, 20°C, 25°C, 30°C or 35°C. Once a day, we cut 20 larvae which were oviposited by *D. eucerophaga* and recorded the status of parasite egg whether it is intact or hatched. The percent of eggs hatched daily was calculated and duration of egg incubation was determined.

Larval stage duration and pupation. The remaining parasitized DBM larvae from the above study were allowed to remain until pupation. The duration of larval period was determined by subtraction. The number of parasitized larvae pupated and the number of larvae which failed to pupate were recorded and computed.

Pupal stage duration and adult emergence. The parasite pupae from each of the above temperature studies were maintained in petri dishes and the number of adults emerged was recorded daily. From this data, the duration of pupal period and rate of adult emergence (% pupae emerged into adults) were computed.

In a separate experiment, *D. eucerophaga* pupae, raised at 25°C were utilized. Twenty fresh pupae were placed in each of four petri dishes, each petri dish representing one replicate. These were placed at 15, 20, 25, 30, or 35°C. Duration of pupal stage and emergence of *D. eucerophaga* adults were monitored in a similar manner as above.

Adult longevity. Twenty pairs of *D. eucerophaga* adults were placed in each of the three small cages in a rearing room (25±2°C). In one cage, a cotton soaked in water was placed. In the second, diluted honey solution was smeared on a thin plastic sheet and the sheet was hung inside the cage to let adults feed on it. In the third, no food source was placed. The number of dead male and female parasites was recorded every day and the longevity of adults was calculated.

Results and Discussion

Table 1 summarizes the results of egg incubation and the rate of eggs successfully hatched into the first instar larvae. As temperature increased gradually from 15 to 35°C the egg incubation period decreased gradually. There was a highly significant negative correlation between temperature and egg incubation period (r = -0.968). All eggs hatched under temperatures ranging from 15 to 30°C. However, hatching of the eggs declined significantly but not drastically at 35°C.

Results of the larval stage duration of *D. eucerophaga* inside DBM larvae maintained at various temperatures are summarized in Table 2. As temperature increased gradually from 15C to 35°C, there was a gradual decrease in the duration of larval stage. A highly significant negative correlation was observed between temperature and duration of larval period (r = -0.988). There was no difference on the rate of pupation of *D. eucerophaga* at temperatures from 15 to 25°C. The pupation decreased moderately by 30% at 30°C but quite drastically, over 80% at 35°C.

Table 1. Duration of incubation and rate of *D. eucerophaga* eggs hatched inside DBM larvae at various temperatures.[z]

Temperature 0°C	Egg incubation period (days)	Egg hatching (%)
15	2.9 a	100 a
20	2.1 b	100 a
25	1.6 c	100 a
30	1.2 d	100 a
35	1.0 d	85 b

[z]Data are means of four replicates. Means within columns are not significantly different by DMRT at 5% probability level. Larvae of all pupae were raised at 25°C(a). All pupae placed at 35°C failed to emerge (b).

Table 2. Duration of larval stage and rate of pupation of *D. eucerophaga* at various temperatures.[z]

Temperature (°C)	Duration of larval stage (days)	Pupation rate (%)
15	8.7 a	90.0 a
20	6.8 b	96.3 a
25	6.1 c	96.3 a
30	5.2 d	70.0 b
35	3.5 e	19.9 c

[z]Data are means of four replicates. Means within columns are not significantly different by DMRT at 5% probability level.

Duration of pupal stage and the rate of adult emergence from the pupae maintained at various temperatures are summarized in Table 3. As temperature increased from 15 to 30°C there was a gradual decrease in the duration of pupal stage from 16.13 days to 6.44 days. There was a significant negative correlation between temperature and duration of pupal stage ($r = -0.945$). There was no significant difference in adult emergence from pupae at temperatures 15, 20, and 25°C. However, the rate of adult emergence declined significantly at 30°C. At 15°C females had significantly longer pupal stage than males. There was no significant difference in this biological parameter at higher temperatures. At 35°C, insects failed to pupate in two out of four replicates. In the remaining two replicates, only one and two pupae were found.

Results of a separate experiment which used pupae collected from insects raised at 25°C and subjected to various temperatures are summarized in Table 4. Results of this test were similar to those obtained from the previous test where eggs, larvae and pupae were raised at different temperatures. In this test, pupae also failed to emerge at 35°C. Pupation period of females was slightly longer than that of males. Emergence of males was greater than that of females.

Results of adult longevity with and without the source of food are presented in Table 5. Insects maintained without food lived only for three days. Providing water barely increased longevity; however, providing honey drastically increased longevity to over 20 days. Average longevity of female was three days longer than that of male. This information is useful in mass rearing of the parasites.

Table 3. Duration of pupal stage and rate of emergence of *D. eucerophaga* adults from pupae at various temperatures.[z]

Temperature (°C)	Duration of pupal stage (days)	Adult emergence (%)
15	16.1 a	79.0 a
20	10.5 b	86.9 a
25	7.1 c	83.2 a
30	6.4 d	65.5 b

[z]Data are means of four replicates. Means within columns are not significantly different by DMRT at 5% probability level. Larvae of all pupae were raised at 25°C (a). All pupae placed at 35°C failed to emerge (b).

Table 4. Duration of pupal stage and rate of emergence of *D. eucerophaga* adults from pupae at various temperatures.[z]

Temperature (°C)	Duration of pupal stage (days)		Adult emergence	Sex ratio
	male	female	(%)	M/F
15	17.0 a	17.2 a	56.3 a	1.3
20	11.8 b	12.1 b	52.2 a	3.1
25	7.7 c	8.4 c	50.0 a	1.2
30	6.2 d	6.2 d	26.3 b	1.6

[z]Data are means of four replicates. Means within columns are not significantly different by DMRT at 5% probability level.

Table 5. Longevity of *D. eucerophaga* adults with and without source of food.[z]

Sex	Longevity (days)		
	No food	Water only	Diluted honey
Male	3.05 ± 0.61	3.55 ± 0.83	20.15 ± 3.73
Female	2.85 ± 0.37	3.00 ± 0.65	23.85 ± 3.27

[z]Data are means of 20 males and females maintained at 25 ± 2°C.

Parasitism of Diamondback Moth in Crucifer Monoculture and Mixed Cropping

Summary

Past studies at AVRDC demonstrated that *Diadegma eucerophaga* and *Apanteles plutellae* can control diamondback moth (DBM), *Plutella xylostella*, on farmers' fields in the highlands of Taiwan. These parasites are specific to DBM. In most areas, crucifers are often grown as mixed crop with noncrucifers and farmers therefore, use chemicals to control the pests of noncrucifers. AVRDC investigated the effects of mixed cropping compared with monoculture on the parasitism of DBM by *D. eucerophaga* and *A. plutellae*. Monoculture cabbage was planted in a 0.9-ha field next to a 0.9-ha area planted to four randomly selected 15 × 19.5 m plots of cabbage and eight similar sized plots, one each of okra, egg plant, pea, soybean, garlic, tomato, sweet potato, and sweet pepper. Noncrucifers were sprayed once a week with mevinphos, methamidophos or permethrin. Cabbage in neither area received any insecticide treatment. *D. eucerophaga* and *A. plutellae* were released periodically and the parasitism of DBM on cabbage by both parasites was monitored at intervals. There was no significant difference in parasitism rate whether cabbage was grown as a monocrop where no insecticide was used or whether it was grown surrounded by noncrucifers all of which were sprayed frequently. Results implied that *D. eucerophaga* and *A. plutellae*, once established can control DBM even if farmers practice mixed cropping.

Introduction

Diamondback moth (DBM), *Plutella xylostella* (L) (Lepidoptera: Yponomeutidae), is a serious pest of cruciferous vegetables in southeast Asia. As a result of intensive and at times indiscriminate insecticide use to combat this pest, DBM has developed resistance to practically all types of chemical insecticides. To combat this pest, AVRDC has utilized two larval parasites, *Diadegma eucerophaga* Horstmann, imported from Indonesia, and *Apanteles plutellae* Kurdjumov, collected locally. Research at AVRDC and on farmers' fields has shown promise in controlling DBM with these parasites. However, research has been confined to a crucifer monoculture situation where use of chemical insecticide was restricted. In the farmers' fields, however, crucifers are grown in mixed culture in same areas as noncrucifers. Since noncrucifer farmers may spray insecticides for protection purposes, the effect of such practice on the control of DBM on crucifers by both larval parasites was investigated. This information is essential in determining the suitability of an area for parasite establishment.

Materials and Methods

A 1.8 ha experimental area was divided into two equal sections separated by 1 m-wide strip of a barrier crop, corn. Each section was divided into 12 plots of 15 × 19.5 m with a distance of 1.5 m between two adjacent plots (Fig. 1). In one section, all plots were planted to cabbage whereas in other section four randomly selected plots were planted to cabbage whereas the remaining eight were planted to one each of okra (*Abelmoschuf esculentus* Moench), garden pea (*Piisum sativum* L.), tomato (*Lycopersicon esculentum* Mill), soybean (*Glycine max* (L) Merill), sweet potato (*Ipomoea batatas* Lam.), brinjal (*Solanum melongena* L.), sweet pepper (*Caspicum annum* L.), and garlic (Allium sativum L). These crops were sprayed once a week with mevinphos, methamidophos or permethrin from planting to harvest. None of the cabbage plots in either section was sprayed with any insecticide. The cabbage and the other crops were raised following the standard cultural practices.

Eight parasite-release stations were set up along the experimental area (Fig. 1). Each station was spaced 4 m away from the experimental plot and 19.5 m distance was maintained between two adjacent stations.

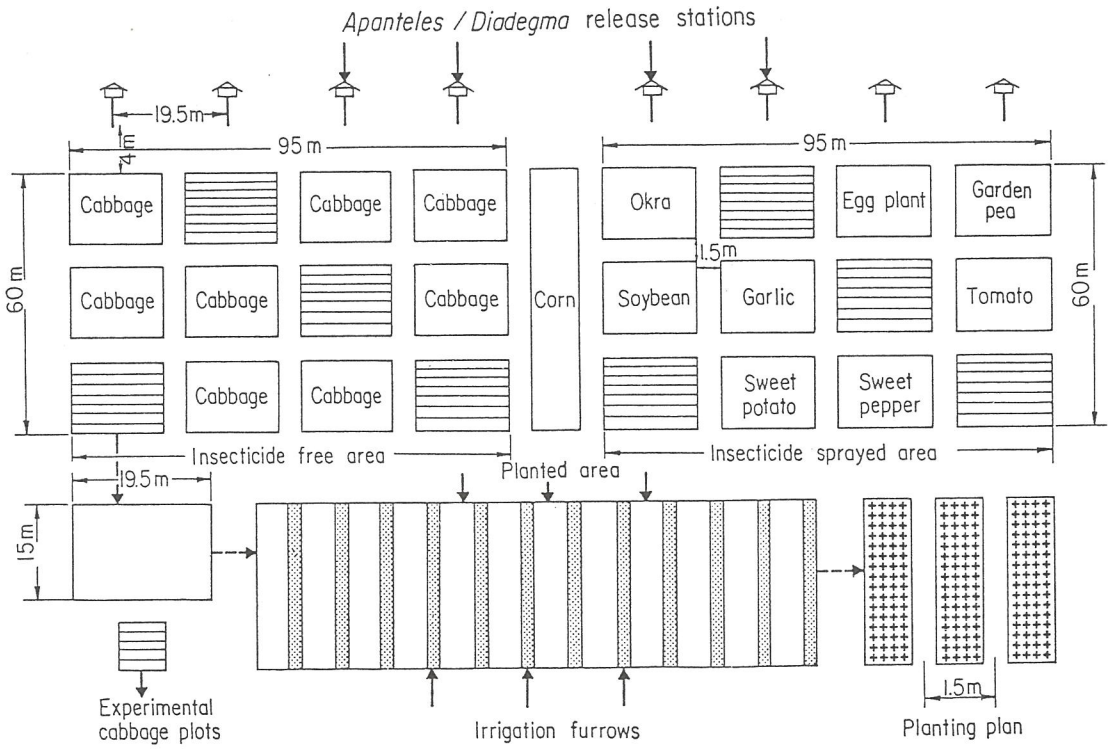

Fig. 1. Experimental field plan for the study of DBM parasitism in crucifer monoculture and mixed cropping.

One week after transplanting, DBM infestation on cabbage plants in experimental plots was assessed by counting the number of DBM larvae and pupae from 20 plants randomly selected. As DBM infestation was very low, an equal number of laboratory-reared DBM adults were released simultaneously in the middle of each experimental cabbage plot on both sides. Further release of laboratory reared DBM was made at intervals in a similar manner. An equal number of pupae of *A. plutellae* or *D. eucerophaga* were placed simultaneously in each release station. The pupae of *D. eucerophaga* and *A. plutellae* released in the parasite-release stations were 19,680 and 7,680, respectively.

Parasitism of DBM by *A. plutellae* and *D. eucerophaga* was determined by collecting 3rd-4th instar DBM larvae; 20 larvae were collected randomly from each cabbage experimental plot and were reared to pupal stage to determine the percentage of parasitism by each parasite. The parasitism rate was calculated by dividing the number of parasite pupae by the total number of DBM + parasite pupae and multiplying the product by 100.

On the 12th week, 30 cabbage plants from each experimental plot were uprooted and the pupae of DBM, *A. plutellae* and *D. eucerophaga* were counted. Percentage of parasitism rate was recorded in the same manner discussed earlier.

Results and Discussion

The data of DBM parasitism by *A. plutellae* and *D. eucerophaga* throughout the growing season are presented in Tables 6 and 7. There was no significant difference in the rate of parasitism, whether cabbage was grown as monoculture where no insecticide was sprayed, or it was grown surrounded by noncrucifers which were frequently sprayed. Observations showed that insecticides sprayed on neighboring crops have no effect on the parasitism rate of *D. eucerophaga* and *A. plutellae* (Table 8). *D. eucerophaga* parasitism rate increased as the growing season of cabbage progressed.

DBM population went up 60 days after transplanting (Table 9), but damage from the pest was low and noninjurious, probably because the cabbage plants were almost mature. *A. plutellae*, a lowland parasite, established much earlier and faster than *D. eucerophaga*. However, *D. eucerophaga* population predominated in the latter part of the growing season.

Substantial number of *D. eucerophaga* adults were found hovering in plots planted to tomato and garlic. Some of these crops are reported to reduce DBM damage when cabbage is intercropped with these crops. Results of this experiment indicated that both parasites are not affected by the growing of cabbage among the noncrucifers or spraying of noncrucifer crops with insecticides. Results showed that these parasites once established will control DBM even when farmers practice mixed cropping and use insecticides on noncrucifers.

Table 6. Evaluation of *A. plutellae* parasitism of DBM larvae collected from each cabbage experimental plot.

Observation Date	Parasitism (%)[z]	
	Mixed cropping	Monoculture
12 Dec. 88	49.9	21.4
19 Dec. 88	29.4	39.3
27 Dec. 88	48.2	29.5
4 Jan. 89	39.8	49.3
9 Jan. 89	34.2	39.2
16 Jan. 89	13.9	20.3
23 Jan. 89	19.0	21.9
31 Jan. 89	25.3	27.0

[z]Planted: 10 Nov. 1988.

Table 7. Evaluation of *D. eucerophaga* parasitism of DBM larvae collected from each cabbage experimental plot.

Observation Date	Parasitism (%)[z]	
	Mixed cropping	Monoculture
12 Dec. 88	–	3.9
19 Dec. 88	–	–
27 Dec. 88	18.2	9.3
4 Jan. 89	11.7	13.5
9 Jan. 89	27.4	24.1
16 Jan. 89	25.1	18.0
23 Jan. 89	29.4	31.2
31 Jan. 89	51.0	48.2

[z]Planted 10 Nov. 1988.

Table 8. *A. plutellae* and *D. eucerophaga* parasitism of DBM larvae collected from 30 plants from each cabbage experimental plot, 82 days after transplanting.

Parasite species	Parasitism (%)[z]	
	Mixed cropping	Monoculture
A. plutellae	2.3	3.2
D. eucerophaga	63.4	57.9

[z]Means in the horizontal column followed by the same letter are not significantly different at 5% level by DMRT.

Table 9. Population of DBM and two parasites on monoculture cabbage.

Observation date	DBM L+P/plant	Parasitism %[z]		Total
		A. plutellae	*D. eucerophaga*	
12 Dec. 1988	0.2	21.5	3.9	37.6
19 Dec. 1988	0.6	39.3	0	34.3
27 Dec. 1988	0.8	29.5	9.3	47.6
4 Jan. 1989	0.7	49.3	13.5	57.2
9 Jan. 1989	4.1	39.2	24.2	62.5
16 Jan. 1989	6.4	20.3	18.0	38.6
23 Jan. 1989	10.7	21.9	31.1	50.7
31 Jan. 1989	6.4	27.0	48.2	76.7

[z]Planted 10 November 1988.

Evaluation of *Bacillus thuringiensis* for Diamondback Moth Control

Summary

Five experimental and three commercial formulations of *Bacillus thuringiensis* were tested along with one insect growth regulator, teflubenzuron, and one fungicide, pyrazophos for the control of diamondback moth (DBM) *Plutella xylostella* on cabbage. The chemicals were sprayed on the plants once a week starting two weeks after transplanting until 10 days before harvest. DBM larvae and pupae per 20-plant sample in each of four plots of each treatment were recorded at intervals. Similar observations were made for imported cabbage worm (*Pieris rapae*). SAN415, a *B. thuringiensis* gave the best control of DBM and ICW. Bt-4 from the National Taiwan University was the next best for the control of both pests. These treatments also gave high cabbage yields. Both products are nontoxic to parasites, thus, ideal for IPM of DBM.

Introduction

Diamondback moth, *Plutella xylostella* (L) (Lepidoptera: Yponomeutidae) continues to be the most destructive insect pest of cruciferous vegetables throughout tropical and subtropical areas in the world. This insect is especially serious in southeast Asia. At present farmers use only chemical insecticides to combat DBM. Due to intensive use of insecticides, the pest has developed resistance to practically all insecticides presently being used. AVRDC aims to develop an integrated pest management with emphasis on biological control. In this approach, at times, DBM population and other insect pests can reach damaging level which requires spraying of insecticides. However, the presently available chemical insecticides are either ineffective to control DBM or highly toxic to predators and parasites. *Bacillus thuringiensis* Berliner, a bacteria, commercially used for the control of a number of caterpillar insect pests, is safe to parasites. In recent years considerable research is being done to improve the efficacy and spectrum of *B. thuringiensis* to get better control of DBM and other pests. AVRDC screened some new preparations of this bacteria in one field test.

Materials and Methods

The land was ploughed and after application of basal fertilizers it was worked into 1.5 m wide beds. The beds were further divided into 15 m^2. plots each consisting of three 3.3 m long, 1.5 m wide beds. One-month-old cabbage seedlings (cv. KY Cross) were transplanted in two rows in each bed in all plots. Necessary cultural practices such as top-dressing of fertilizer, weeding, irrigation when needed, etc. were followed to obtain high yield. There were nine treatments and one control. Each treatment had four replicates and treatments were arranged in a randomized complete block design. Nine treatments consisted of four experimental and three commercial *B. thuringiensis* preparations, one insect growth regulator, teflubenzuron, and one fungicide, pyrazophos, which gave excellent control of agromyzid beanflies in soybean in one of the tests in 1988-89.

Starting two weeks after transplanting, the required quantities of the products were diluted in water and sprayed on designated plots at weekly intervals. One day before the initiation of spraying and once a week thereafter we sampled 20 plants in each plot and recorded the numbers of DBM larvae and pupae. When the population of imported cabbage worm (*Pieris rapae*) was high, the number of larvae and the pupae per plant in the same 20-plant samples taken for DBM evaluation were recorded.

All plants in each plot were harvested and weights of cabbage heads were recorded. Insect count and yield data were analyzed by ANOVA and means were compared by DMRT.

Results and Discussion

Results of the insect control and efficacy of each treatment and yields obtained are summarized in Table 10. It was observed that SAN415, a new commercial preparation of *B. thuringiensis* gave

the best control of DBM and imported cabbage worm. This treatment also gave the highest yield. Another product Bt-4 from the National Taiwan University proved as effective as the commercial product Thuricide in controlling DBM. Both treatments gave practically identical control of imported cabbage worm. Teflubenzuron which until last year was effective against DBM was less effective in 1989. In most locations in southeast Asia, DBM has developed resistance to this chemical. Teflubenzuron, however, gave good control of ICW. The yields in teflubenzuron, Bt-4, and Thuricide treatments were identical. Pyrazophos, which gives excellent control of agromyzids on legumes was found ineffective.

Table 10. Evaluation of *Bacillus thuringiensis* formulations for the control of diamondback moth and imported cabbage worm on common cabbage.[z-t]

Treatments	Rate kg	No. diamondback moth larvae + pupae/20 plants						No. ICW plants[t]	Yield
		89/1/25	2/9	2/22	3/1	3/15	3/30		
Bt-1[h]	1.0	12.0 a	49.5 a	24.0 ab	17.3 ab	42.3 bcd	34.0 ab	30.3 b	67.1 bc
Bt-2	1.0	9.5 a	39.0 ab	22.5 abc	12.0 abcd	51.5 ab	28.7 b	36.3 ab	68.9 bc
Bt-3	1.0	8.5 a	26.5 bcd	15.3 bcd	7.0 bcd	33.7 cde	20.5 c	15.0 cd	75.3 ab
Bt-4	1.0	7.0 a	23.5 bcd	11.0 cde	9.3 abcd	20.5 efg	20.0 c	5.0 e	80.8 a
SAN415	0.5	8.0 a	9.8 d	1.3 e	2.0 d	6.5 g	6.0 d	0.3 e	81.8 a
Thuricide	0.5	9.0 a	15.8 cd	11.0 cde	5.5 cd	17.8 fg	20.0 cd	4.5 e	79.7 a
Dipel	0.5	9.3 a	34.5 abc	19.5 abcd	19.3 a	46.0 abc	26.0 bc	9.0 de	69.0 b
Pyrazophos 30EC	0.5	10.0 a	30.5 abcd	22.0 abc	15.5 abc	47.5 abc	40.0 a	20.5 c	68.4 bc
Teflubenzuron 15SC	0.0375	7.0 a	21.3 bcd	9.0 de	7.8 bcd	29.8 def	22.8 c	2.8 e	79.0 a
Control		12.3 a	50.5 a	29.5 a	19.0 a	59.0 a	24.8 bc	41.3 a	63.3 c

[z]Cultivar: K.Y. Cross. [y]Transplanting date: 89/1/9. [x]Insecticides applied: 89/1/26, 2/2, 2/9, 2/16, 2/23, 3/2, 3/9, 3/16, 3/23. [w]Harvest date:89/4/4. [v]Data are means of 4 replicates. Means within columns are not significantly different by DMRT at 5% probability level. [u]Plot size: 15 sq.m. [t]Observations on ICW (imported cabbage worm), 89/4/3. h Bt-1, Bt-2, Bt-3 and Bt-4 are *B. thuringiensis* cultures from the National Taiwan University, Taipei.

Chinese Cabbage Physiology

Tipburn Susceptibility under Different Nutrient Solutions

Summary

There were varietal differences in tipburn development on five Chinese cabbage cultivars grown under low calcium (Ca) or high ammonium (NH_4) conditions or with roots immersed in a hydroponic system. Shin Chiu and Bin Luh were tolerant to tipburn induced by high ammonium. AVRDC breeding lines, 82-15 and Shin Chiu were tolerant when roots were immersed in low calcium condition. Tipburn-susceptible Summer Light No. 4 and Kang Ping No. 2 had large leaves. NH_4 suppressed Ca accumulation in the leaf due to root damage and/or competitive inhibition of Ca uptake. High NH_4 also reduced potassium (K) uptake, but this seemed to be not related to tipburn development.

Introduction

Tipburn, a nonparasitic disorder, readily develops in Chinese cabbage under hot-wet conditions. It is caused by the unequal distribution of barely re-mobile calcium (Ca) in the plant. The actively transpiring, outer leaves of Chinese cabbage preferentially take up more Ca which causes the nontranspiration of inner leaves deficient in Ca and subsequently conditions the plant for tipburn development. Tipburn is also prevalent in the field with excessive nitrogen (N). In this case, NH_4 toxicity is a direct cause.

Chinese cabbage varieties grown under the same environment differ in their ability to develop tipburn. Large- or round-headed varieties are susceptible to tipburn. To enlighten the relationship between variety and tipburn-conducive conditions, five Chinese cabbage varieties were cultured in low Ca and high NH_4 conditions or had their roots immersed in a hydroponic system.

Materials and Method

Seeds of Summer Light No. 4, Kang Ping No. 2, AVRDC breeding line 82 156, Bin Luh and Shin Chin were first sown in plastic pots filled with smoldered rice hulls. Later seedlings were transplanted into polystyrene boxes (54 × 34 × 25 cm) containing aerated nutrient solutions on 4 April 1989. Each box contained six plants. Complete Hoagland solution (Ca at 160 ppm and NH_4 at 11 ppm) with a 10-cm segment of root system exposed to the air was used as the control. Other treatments included: low Ca with Ca in solution reduced to 53 ppm; NH_4 in solution increased to 70 ppm; and root system completely immersed in a solution. There were three replicates per treatment.

Tipburn development of each plant was examined daily. Two plants per treatment were sampled at 16, 23 and 31 days after transplanting to investigate the number, size, leaf and root weight. Leaves were separated into outer and inner leaves and N, P, K and Ca contents of each part were determined.

Results and Discussion

Varietal differences in tipburn development were observed in various treatments. In general, frequency of tipburn seemed high in Summer Light No. 4 and Kang Ping No. 2, but low in Shin

Chiu (Table 1). Incidence was highest under high NH_4 condition, followed by root immersion, low Ca and control.

Table 1. Effects of low Ca, high NH_4 or immersed roots on tipburn development on five Chinese cabbage varieties.

Entry	Control	Immersed	Low Ca	High NH_4	Mean
Summer Light No. 4	39	61	50	100	62
Kang Ping No. 2	28	39	39	100	51
82-156	17	39	28	78	40
Bin Luh	17	56	39	61	43
Shin Chiu	6	33	28	50	29
Mean	21	46	37	78	

Significant reduction in leaf growth occurred in the high NH_4 solution treatment. N and P contents of outer and inner leaves slightly increased under high NH_4 condition, whereas P content of both outer and inner leaves decreased under immersed roots and high NH_4 condition. On the other hand, K content in the outer and inner leaves slightly increased under low Ca condition. NPK contents corresponded between outer and inner leaves.

Ca content in the outer leaf was four times that of the inner leaf (Figs. 1 and 2). Ca content of both outer and inner leaves decreased under low Ca and high NH_4 conditions. These could be attributed to Ca deficiency in the solution and Ca-NH_4 competition during ion absorption. Greater reduction in Ca content occurred in both outer and inner leaves under low Ca than under high NH_4 condition despite the higher incidence of tipburn in the latter. Results suggested that low calcium may be related to tipburn development. However, NH_4 toxicity in the root systems directly damaged the roots thereby limiting water uptake for normal leaf growth.

No significant differences could be detected in mineral content between tipburn-tolerant and -sensitive entries. Therefore, imbalance in mineral content could partly cause tipburn development. However, tipburn tolerant Shin Chiu had the highest leaf area and most developed petiole. It is possible that tipburn development, although related to Ca, is directly tied in with Ca utilization involving cell wall formation during leaf growth.

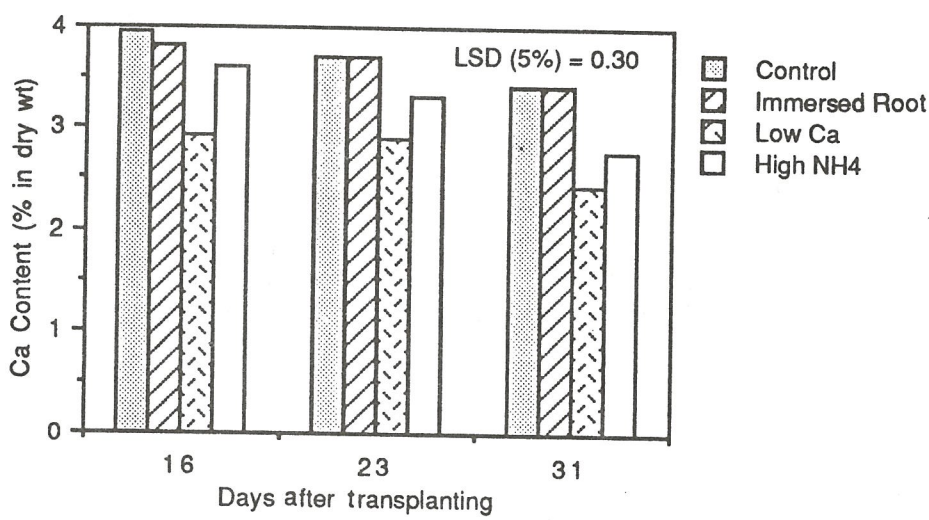

Fig. 1. Mean Ca content in the outer leaves of five Chinese cabbage varieties grown under low Ca or high NH_4 solution in hydroponic system.

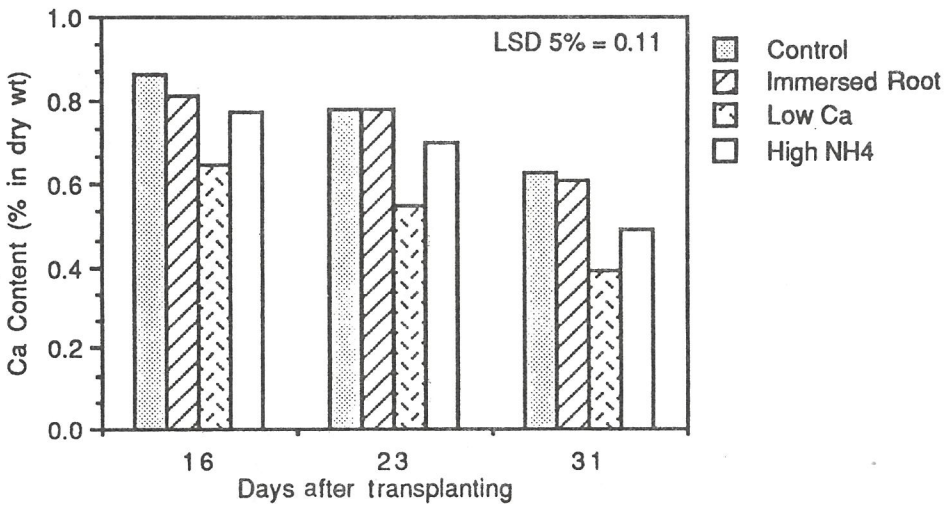

Fig. 2. Mean Ca content in the inner leaves of five Chinese cabbage varieties grown under low Ca or high NH_4 solution in hydroponic system.

Involvement of Gibberellins and Calcium in Tipburn

Summary

Detached Chinese cabbage plant parts incubated for four days in EDTA solution caused lesions on the leaf tips. EDTA is a chelating agent which removes calcium. Gibberellin A_3 (GA_3) alone also enhanced tipburn, but to a lesser extent. The intensity of the damage by EDTA or GA_3 was reduced by including $CaCl_2$ in the solutions. Both EDTA and GA_3 increased electrolyte leakage, but this effect was not diminished by $CaCl_2$. Results suggested that GAs are associated with tipburn in Chinese cabbage by interfering in the cell wall instead of the plasma membrane.

Introduction

Tipburn of heading vegetables is a calcium deficiency-related disorder which is more severe in young, inner leaves. Some environmental conditions are known to favor the occurrence of the disorder. However, the cellular mechanism by which the lesion is induced is not yet fully understood. Gibberellins are known to enhance cell expansion as well as the breakdown of parenchyma tissue. It is possible that GAs weaken the cellular structure by displacing calcium from the cell wall. This study examined whether GAs might be associated with tipburn in Chinese cabbage. Detached plants were used since the exogenous GAs are likely to induce bolting.

Materials and Methods

One-month-old plants of AVRDC Chinese cabbage breeding line, 86/81-D2 were cut at soil surface level. These cuttings were brought into the laboratory and placed in 200 ml of pure water (control), 2 mM ethylene diaminetetraacetic acid (EDTA), 2 mM $CaCl_2$, GA_3 10 mg/l, GA_3 10 mg/l + 2 mM EDTA, 2 mM EDTA + 2mM $CaCl_2$, GA_3 10 mg/l + 2 mM $CaCl_2$, or GA_3 10 mg/l + 2 mM EDTA + 2 mM $CaCl_2$. These were incubated in the dark for four days at 25 -30°C air temperatures and 80 to 100% RH. There were three replicates for each treatment and four plants per replicate.

At the end of incubation period, severity of damage was measured on a scale of 0 to 5 with 5 representing severely affected leaves. Also, four discs (1 cm in diameter) were prepared from the tip region of each leaf and tipburn lesions on each were counted.

Leaf discs, 1 cm in diameter, prepared from the detached treated leaves were incubated at 30°C for 24 h in 3 ml of double-distilled deionized water. The electrical conductivity of the incubation medium was measured with an electrical conductivity meter. The total electrolyte content of the discs was again measured after boiling for 20 min in tubes capped with glass marbles. The data were presented as percent leakage of the total electrolyte content. Measurements were made on four discs per leaf and four leaves of each treatment.

Results and Discussion

Plants placed in either distilled water or 2 mM $CaCl_2$ were not affected with tipburn (Fig. 3). However, the chelating agent, EDTA caused severe necrotic lesions on the leaf tips. It should be noted that after four days of incubation in the EDTA solution, the outer leaves were completely desiccated. GA_3 significantly enhanced tipburn damage but to a lesser extent compared with EDTA. $CaCl_2$ at a concentration of 2 mM attenuated the severity of the necrosis. It seemed that displacement of calcium from the cell wall damaged cellular integrity and caused the tissue to collapse. GA_3 induced the tissue to collapse possibly by increasing Ca displacement from the cell wall.

Severity of the lesions observed in the various treatments was further quantified by electrolyte leakage measurement (Fig. 4). Leakage rates were found high in treatments involving EDTA or GA_3. Although $CaCl_2$ diminished the severity of the necrosis, it did not reduce electrolyte leakage of plants incubated in EDTA or GA_3 solutions. This implied that the capacity of the tissue to bind Ca was impaired. Other structural changes may have occurred as a result of the stress imposed by calcium deficiency such that added Ca was not enough to reduce the damage.

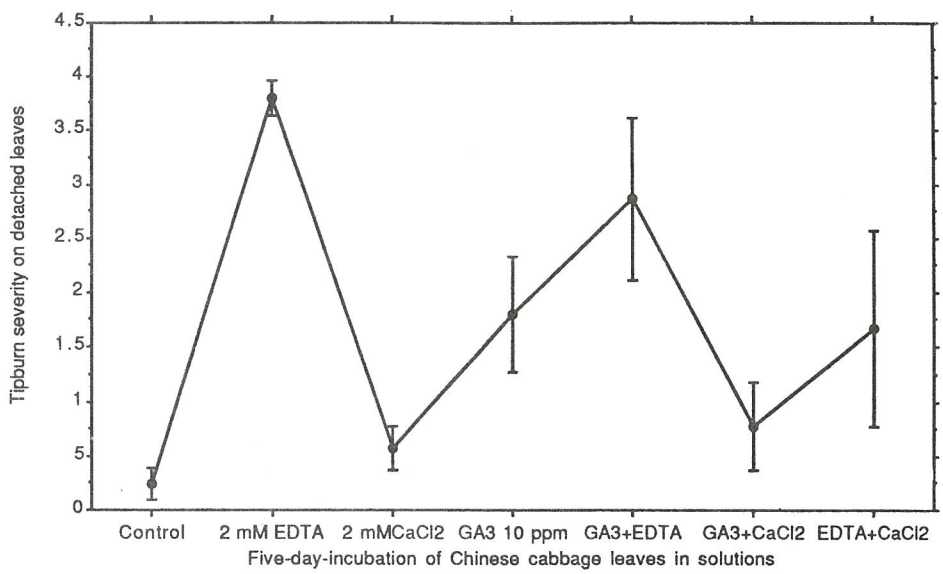

Fig. 3. Effects of EDTA, GA_3 and $CaCl_2$ solutions and their combinations on the development of tipburn in Chinese cabbage leaves.

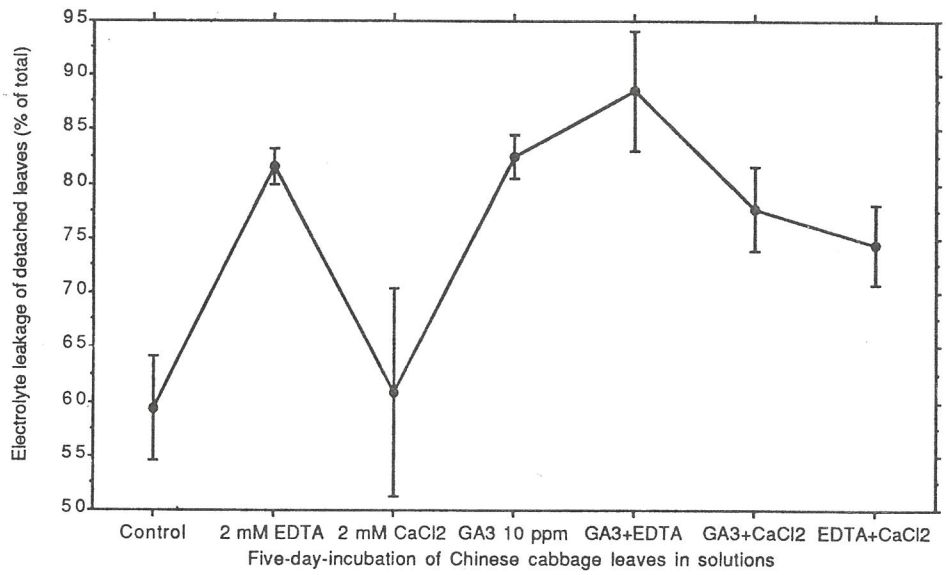

Fig. 4. Effects of EDTA, GA_3 and $CaCl_2$ solutions and their combinations on electrolyte leakage on leaf discs of Chinese cabbage.

Mungbean Breeding

New Germplasm Evaluation

Summary

Eight mungbean mutants from the Bhabha Atomic Energy Research Center in Bombay, India were introduced and evaluated. All were found highly resistant to powdery mildew (PM) but were susceptible to Cercospora leaf spot (CLS). Four yellow mosaic virus-resistant mungbean introductions had been multiplied for testing in the Indian subcontinent.

Introduction

Powdery mildew resistance levels in mungbean varies with season while yellow mosaic virus is a serious problem in the Indian subcontinent. This study aimed to collect new sources of resistance to the above diseases for utilization in the AVRDC breeding program and sharing them with the national cooperators.

Materials and Methods

Eight mutants, namely, RUM-1, -5, -7, -11, -20, -21, -22 and -33 were received from Dr. S.E. Pawar of the Bhabha Atomic Research Center, Trombay, Bombay in India. The seeds were planted in the greenhouse on 15 February 1989 in 21-cm pots. Each entry had five pots with two plants per pot. The potting media contained a mixture of sand, rice hull, compost and soil at the ratio of 1:1:1:3. Observations were made from planting to 50% flowering (DF); from planting to 50% harvest maturity (DM); and 1000-seed weight and plant height at maturity (HM). Data for DF, DM and HM were mean of 10 plants.

The mutants were also planted in the field on 15 August 1989 in 3 × 1 m-row plot in two replications. VC 1560D and VC 1628A were used as resistant and susceptible checks, respectively. The extent of PM infection was observed.

Four entries, namely TV 1132 (TV 79-11), TV 1133 (7704), TV 1134 (TV-79-6) and TV 1135 (CES 55 × MT 3-113F) reportedly resistant to mungbean yellow mosaic virus were received from Sri Lanka. They were planted in the greenhouse on 27 April 1989. Each entry was planted in 10 pots with two plants per pot. The DF, DM and 1,000-seed weight were observed. The TV lines were also planted in the field on 29 June 1989. Each entry was planted on a 4 × 1-m plot. The DF, DM, 1000-seed weight and CLS infection were observed.

Results and Discussion

All RUM entries planted in February flowered in 49.2 ± 1.2 and attained maturity in 67.1 ± 1.0 days. The 1000-seed weight was 26.8 ± 2.6 g. Plant height varied from 11 to 24.7 cm (Table 1). Seeds harvested were evaluated for CLS resistance by artificial inoculation.

All entries in the field were found highly resistant to powdery mildew in autumn. Findings suggested that entries are highly susceptible to CLS. Therefore, these will be utilized in breeding programs

specifically to enhance PM resistance in CLS-resistant lines. Seed samples will be made available to national cooperators.

In the observation trial of MYMV resistant germplasm in the greenhouse the mean, DF, DM, and 1000-seed weight were 35.3 ± 1.5; 51 ± 1.2; 42 ± 5.0, respectively. For the crop planted in the field on 29 June, the DF, DM and 1,000-seed weight were 48.3 ± 1.3; 62 ± 0.8; and 38.5 ± 6.4, respectively. Since the trial in April was grown in the greenhouse, plants matured earlier than those planted in the field in June because of high temperature (Table 2).

Table 1. Observation trial of powdery mildew-resistant germplasm.

Entry	DF[z]	DM[y]	1000 SDWT[x]	PH[w]
RUM-1	48.6 ± 3.1	66.5 ± 2.0	28	12.0 ± 2.9
RUM-5	49.8 ± 4.2	67.1 ± 3.0	24	11.0 ± 1.8
RUM-7	50.4 ± 5.4	67.5 ± 3.1	27	14.4 ± 3.4
RUM-11	47.0 ± 3.3	65.4 ± 1.9	24	13.6 ± 4.0
RUM-20	49.0 ± 1.8	67.8 ± 2.2	26	24.7 ± 2.8
RUM-21	48.5 ± 1.8	66.3 ± 1.6	32	18.4 ± 2.3
RUM-22	50.8 ± 3.3	68.6 ± 2.9	26	15.2 ± 3.1
RUM-33	49.8 ± 3.1	67.6 ± 2.3	27	12.2 ± 2.7

[z]DF = days to flowering [y]DM = days to maturity [x]SDWT = seed weight (g) [w]PH = plant height (cm).

Table 2. Observational trial data for MYMV-resistant germplasm.

Entry	DF	DM	1000 SDWT
TV 1132	37 (50)[z]	52 (63)	47 (43)
TV 1133	34 (47)	50 (62)	36 (33)
TV 1134	34 (48)	50 (62)	40 (33)
TV 1135	36 (48)	52 (61)	45 (45)

[z]Open values of trial planted in the greenhouse; values (in parenthesis) of trial in the field.

Hybridization

Summary

Eight mungbean breeding lines were chosen and a diallel cross was made to produce 56 hybrids to combine high yield, uniform maturity and disease resistance. The F_1s will be intermated and used for a recurrent selection program. Thirty single cross hybrids were made to transfer bruchid resistance from *V. radiata* var. *sublobata* and from *V. radiata*. Eight single cross hybrids were made to transfer beanfly resistance. From inbred populations, plants with desirable traits will be further screened.

Introduction

Specific selections developed during the past decade combined at least two desirable traits. Crosses were made to combine the following traits into a desirable genotypic background, such as high total yield, high percent of first harvest and resistance to PM and CLS.

Crosses were made to incorporate resistance to bruchids from TC 1966 (known to have a single dominant gene for resistance) and two *V. radiata* germplasm to already released cultivars.

Similarly, hybridization was carried out to transfer beanfly resistance.

Materials and Methods

Eight parents were randomly chosen and used for initial diallel crosses. These were VC 4195-B-5-3B and VC 4304-4B (high total yield); VC 4390-B-1-2B and VC 4484-3B (high percent first harvest); VC 4071-3B and Vc 4366-B-4-2B (resistance to CLS); and VC 4041-47 and VC 4532-2-2B (resistance to PM). Selected F_1s derived from them will be intermated to form cycle 1 population for inbreeding.

To transfer bruchid resistance from TC 1966 (*Vigna radiata* var *sublobata*) crosses were made between VC 1178A, VC 1973A, VC 2778A, VC 3890A and V 3476. Similarly, resistance to bruchids from V 2709, V 2802 had been transferred through reciprocal crosses to VC 1973A, VC 3890A, VC 2768A, VC 4532-2-2B, and VC 4304-4B. Thirty crosses were made.

Beanfly-resistant selections, namely, VC 4035-17, VC 4038-37, VC 4041-48 and VC 4041-49 had been crossed reciprocally with VC 3890A to combine high yield, PM and beanfly resistance. Eight crosses were made.

Results and Discussion

An eight-parent diallel crosses with reciprocal matings were made resulting in a total of 8 × (8-1)= 56 matings. The F_1s were raised in autumn. The F_2 generation will be raised in spring 1990.

For bruchid resistance, 15 single-cross hybrids with reciprocal matings were made. F_1s were planted and harvested. The F_2 seeds will be screened for bruchid resistance in 1990. Resistant seeds will be evaluated for other desirable traits. The resulting inbred seeds from single plants will be further screened for bruchid resistance to determine the homozygosity or heterozygosity of the pedigrees. Homozygous bruchid-resistant pedigrees will be used for further agronomic evaluation.

Eight crosses were made for beanfly resistance during summer. The inbred population of these crosses will be advanced without the use of insecticide and will be evaluated in an advanced generation for beanfly resistance.

Evaluation of an Interspecific Hybrid Between *Vigna radiata* and *V. glabrescens*

Summary

Seventeen BCS_1 plants of *V. radiata* (VC 1973A) × F_1 (*V. glabrescens* (V 1160 × VC 1973A) were inbred in the greenhouse and each of them produced good and shrivelled seeds (BCS_2). Large BCS_2 seeds (100-seed weight varied from 6.1 to 8.9 g) were evaluated for resistance to beanflies, bruchids, CLS and PM. All were found susceptible to bruchids, PM and cucumber mosaic virus (needs to be verified). Four progenies appeared moderately resistant to beanflies. These four lines will be further evaluated.

Introduction

An accession of *Vigna glabrescens* from the Philippines identified as a natural polyploid, 2n = 44 (V 1160, PI 207655) was reported to have resistance to major mungbean pests and diseases. However, transfer of these valuable resistance genes from *V. glabrescens* via conventional breeding methods was not successful due to differences in ploidy level between species. In a graduate program, Ms. Chen Hao-Koan, a research assistant of AVRDC worked with Dr. David Mok of Oregon State University (OSU). A few BCS_1 seeds from the collaborative program between Ms. Chen and Dr. Mok were received for evaluation.

Materials and Methods

Vigna glabrescens (V 1160) was crossed with *V. radiata* (VC 1973A) at OSU by Chen and Mok. The hybrid embryos were cultured in a modified Murashige and Skoog medium. The F_1s were backcrossed to *V. radiata* which resulted in two pods bearing 10 seeds (Mok, personal communication).

From ten backcross progenies Chen and Mok obtained 25 inbred pods with 110 seeds (BCS_1). A random sample of 25 seeds was received at AVRDC. Two seeds were broken in transit.

Twenty-three seeds were planted in the greenhouse in 28-cm pots containing sand, rice hull, compost, soil in the ratio 1:1:1:3. Seeds were treated with captan and planted on 28 April 1989. The inbred progeny, BCS_2, from each plant was harvested and good and wrinkled seeds were sorted out.

A random sample of seeds harvested from each BCS_1 plant was screened for bruchids, beanfly, CLS and PM resistance. The 100-seed weight and the total number of good and shrivelled seeds and total seed weight were recorded.

In autumn, BCS_2 progenies were grown both in the greenhouse and in the field to advance the generation and observe their performance. Five pots were planted for each entry from good and shrivelled seeds in the greenhouse on 8 August 1989. In the field, all remaining seeds were planted on 15 August 1989. Resistance to PM was observed.

Results and Discussion

Two of the 25 BCS_1 seed samples received from OSU were broken in transit. Among the 23 seeds sown, two became rotten and did not germinate. Out of 21 which germinated and four seedlings at different stages succumbed to root rot. Seventeen plants reached maturity, grew vigorously. Seeds from each mature plant were harvested separately. In each plant, good seeds, varying from 6.6 to 8.9 g for 100 seeds and wrinkled ones weighing 6.1 to 8.6 g/100 seeds were segregated.

All sample seeds tested were susceptible to bruchids. However, four seeds out of 27 samples had moderate levels of resistance based on the number of larvae and pupae (for details see Entomology report).

During autumn, all BCS_2 entries in the field were severely infected with powdery mildew. Growth of almost all plants was stunted with yellow young leaves and pods. Some samples were found positively susceptible to cucumber mosaic virus.

BCS_2 seeds planted in the greenhouse or in the Entomology group did not show any virus-infection. Therefore, seeds of plants from the greenhouse (BCS_3) will be further evaluated in spring 1990.

Evaluation of Intermated Populations

Summary

Intermated populations from different cycles of intermatings were evaluated and compared in spring and summer. Increased number of intermating tended to improve 1000-seed weight in spring and yields in summer.

When selections within Cycle 4 populations were made for powdery mildew (PM) and evaluated for Cercospora leaf spot (CLS) it appeared that high resistance to CLS and PM could be combined. However, when resistance to PM was high, the yields would decrease significantly.

Introduction

A selective mating of 20 breeding lines and accessions was initiated in 1986 to combine high yields, early and uniform maturity and disease resistance. Four cycles of intermating, selfing and selective mating were completed. This year's experiment aimed to compare Cycle 1 S_4 progenies with Cycle 2 S_3 and Cycle 2 S_2 progenies and try to obtain preliminary information on the direction of progress for different traits.

Furthermore, selections and evaluations were made within Cycle 4 for PM to determine the possibility of combining resistance to PM, CLS and high yields.

Materials and Methods

The materials originated from 1987 crosses. Cycle 1 S_4, Cycle 2 S_3 and cycle 3 S_2 were compared in spring 1989. Cycle 4 was not included because it was too early to evaluate. However, Cycle 1 to Cycle 4 populations were compared in summer 1989. In spring, planting was on 15 March 1989. The plot size measured 5 $\times$ 1 m. The experiment had two replications.

The trial in summer was planted on 28 June 1989. The plot size was 4 × 1 m and there were two replications. However, only one replication was harvested because plants were damaged by a typhoon.

Observations on 1000-seed weight, PM score in the spring season, CLS score in summer season, and total yield were made from sowing to flowering until maturity.

In spring, Cycles 1, 2 and 3 had 20, 33 and 140 lines, respectively. Whereas in summer, Cycles 1, 2, 3 and 4 had 20, 33, 165 and 168 lines, respectively.

Cycle 4 S_2 population was selected in spring for powdery mildew resistance. They were classified as follows: same as the susceptible check VC 1628A; same as resistant check VC 3890A; and more resistant than VC 3890A. The three selected groups were planted on 4 July 1989 in 1 × 1 m plots with two replications. However, only one replication was harvested because plants were damaged by a typhoon.

Results and Discussion

Spring planting. As the number of cycles of intermating increased, both days to flowering and days to maturity tended to decrease due to selection (Figs. 1 and 2). Seed size, as shown by the 1000-seed weight increased as the cycles of intermating and selection in crease. Compared to Cycle 1 and Cycle 3 there was, on the average, 4% increase in seed size (Fig. 3). There was not much difference in PM score (Fig. 4). Although yields increased by 5% from Cycle 1 to Cycle 2, in Cycle 3 the yields decreased significantly (Fig. 5). Therefore, it appeared that during spring season progress can be made in improving seed size by increasing the number of cycles of intermating and selection. However, there were no yield increases beyond Cycle 2.

Summer planting. Although there was no definite trend, in Cycle 4 compared to Cycle 1, the days to flowering and maturity were longer (Figs. 6 and 7). Similar to the experiment in spring, 100-seed weight increased with an increase in the number of intermatings (Fig. 8). Differences between different cycles were not discernible because majority of the parents had high CLS resistance (Fig. 9). However, a dramatic yield increase was observed in summer. From Cycle 1 to Cycle 2 and Cycle 2 to 9 Cycle 3, there was a 12% increase in yields for each cycle. The increase was 25% from Cycle 3 to Cycle 4. This suggested that increased intermating and selection definitely assisted in the recombination of genes for increased yields (Fig. 10).

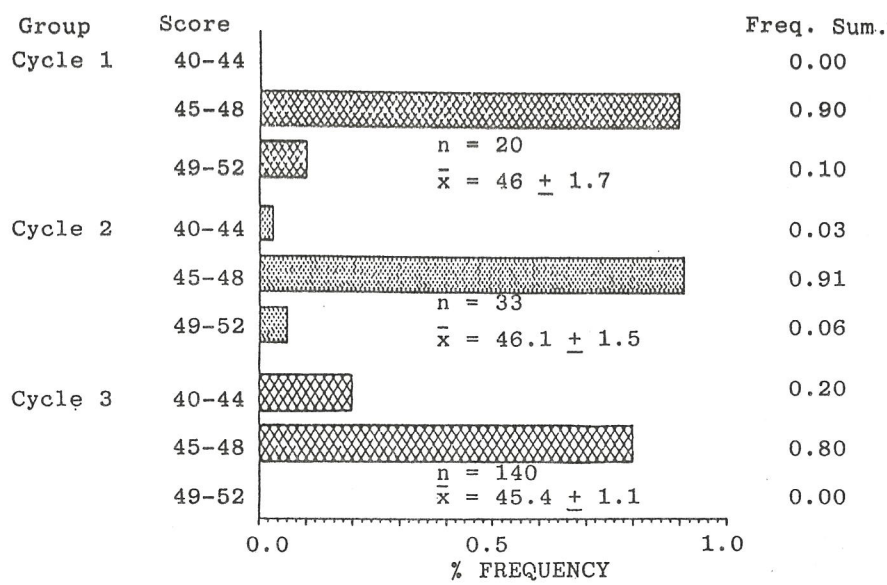

Fig. 1. Comparison of Cycles 1, 2 and 3 populations in days to flowering in spring, 1989.

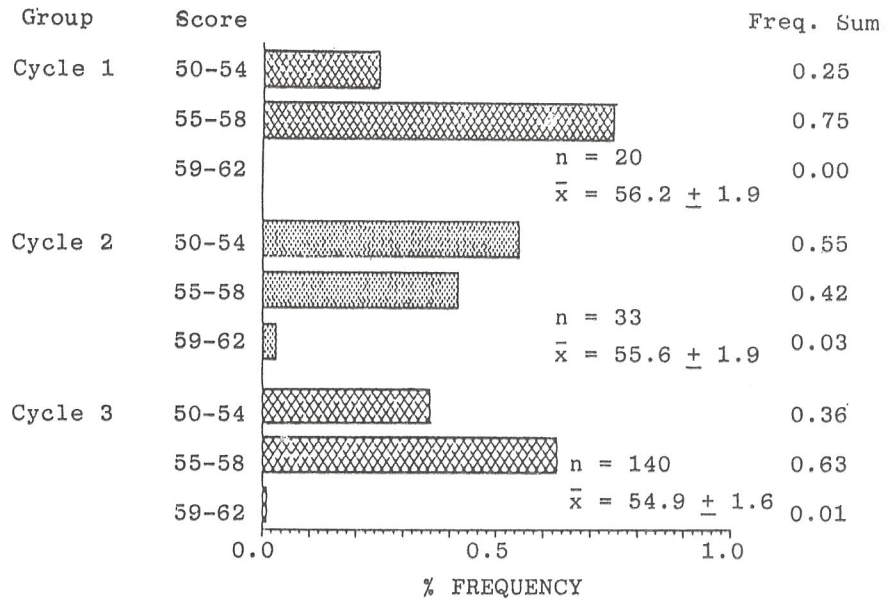

Fig. 2. Comparison of Cycles 1, 2 and 3 populations in days to maturity in spring, 1989.

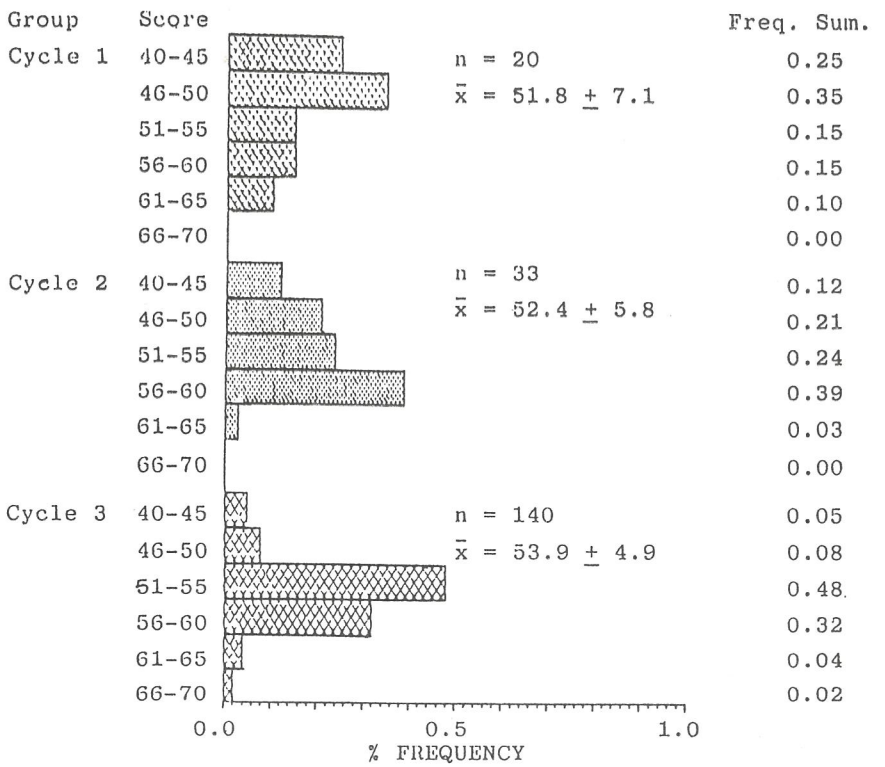

Fig. 3. Comparison of Cycles 1, 2 and 3 populations in 1000-seed weight in spring, 1989.

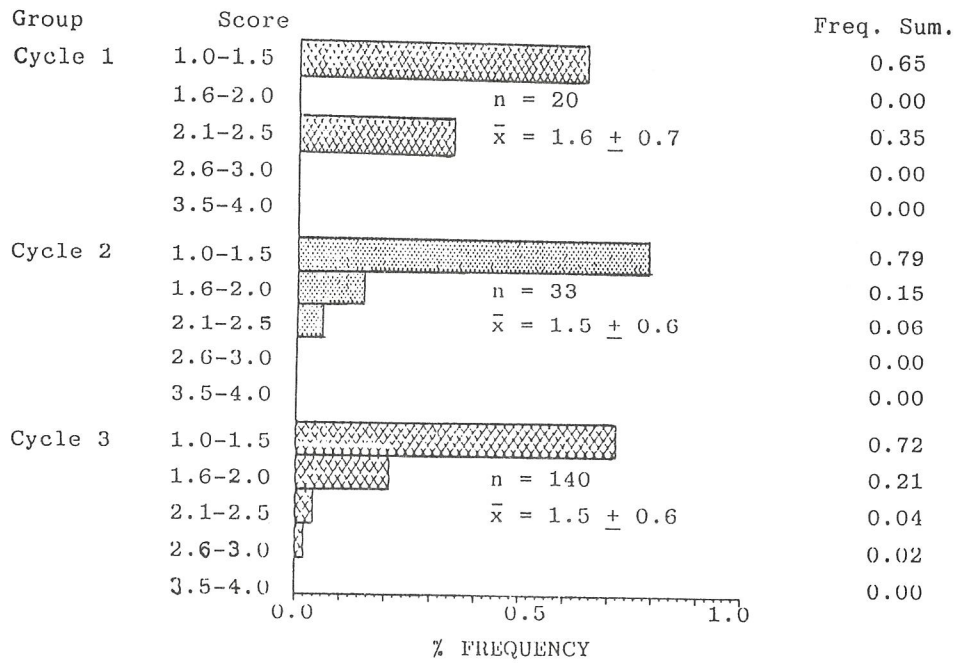

Fig. 4. Comparison of Cycles 1, 2 and 3 populations in powdery mildew disease in spring, 1989.

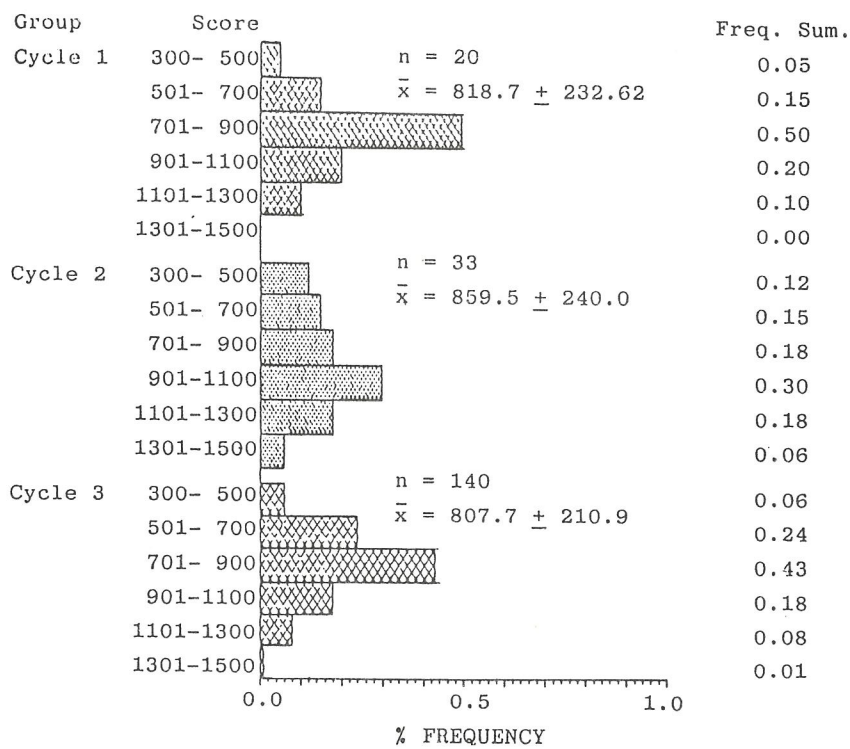

Fig. 5. Comparison of Cycles 1, 2 and 3 populations in total yield in spring, 1989.

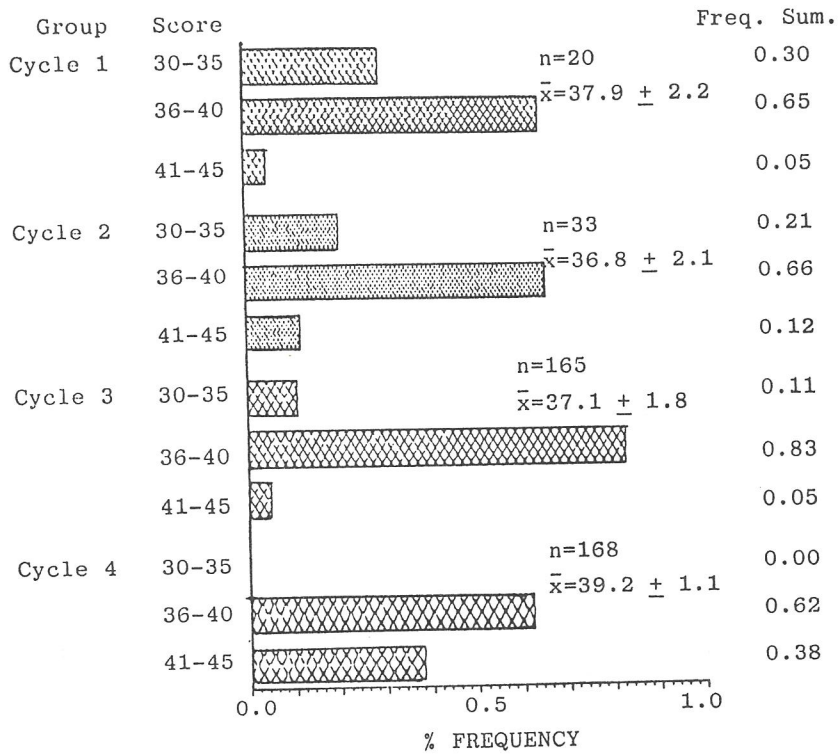

Fig. 6. Comparison of Cycles 1, 2, 3 and 4 populations in days to flowering in summer, 1989.

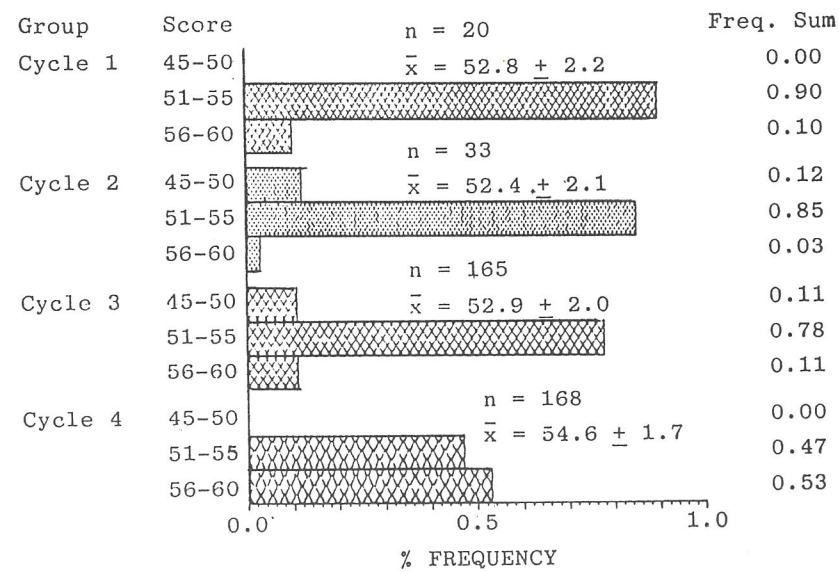

Fig. 7. Comparison of Cycles 1, 2, 3 and 4 populations in days to maturity in summer, 1989.

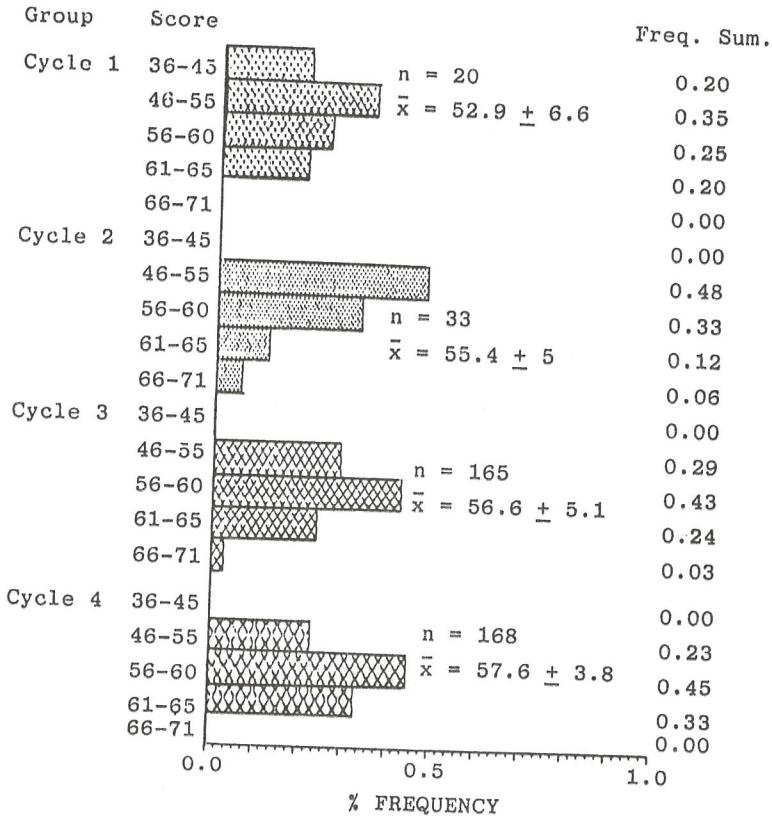

Fig. 8. Comparison of Cycles 1, 2, 3 and 4 populations in 1000-seed weight in summer, 1989.

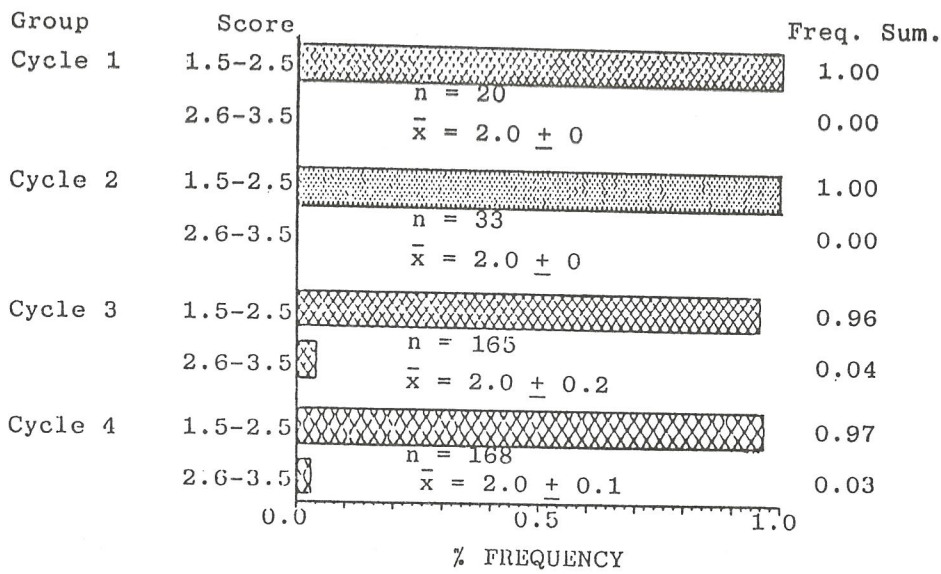

Fig. 9. Comparison of Cycles 1, 2, 3 and 4 populations in CLS in summer, 1989.

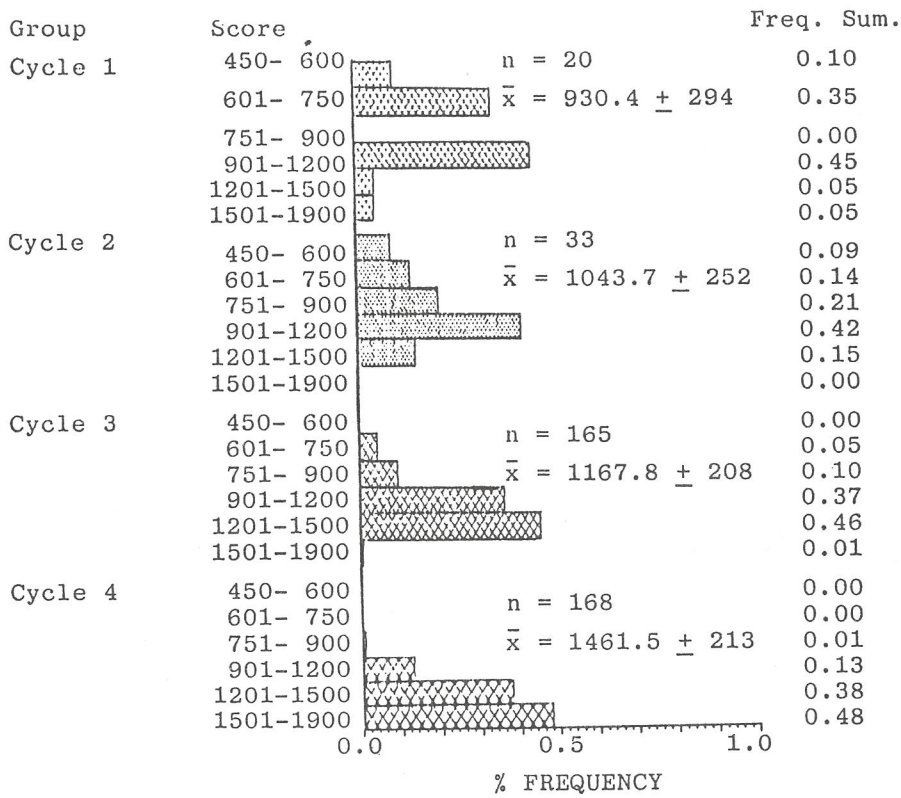

Fig. 10. Comparison of Cycles 1, 2, 3 and 4 populations for total yield in summer, 1989.

The Cycle 4 population which was divided into three groups based on PM resistance showed that the susceptible group flowered and matured earlier than the two resistant groups. The PM susceptible group had a higher CLS score while the other two groups had similar CLS rating. The group with higher resistance to PM had lower yields. These results need further confirmation.

Evaluation of V and VC Lines

Summary

Performance of twenty V lines and 173 improved VC lines developed over the past 15 years were compared in three seasons. As reported in 1988, considerable progress in yield improvement and resistance to CLS has been attained. Seed size has also been improved. Future research should focus on percent first harvest, PM and insect pest resistance.

Introduction

In 1988, results of evaluation of V (germplasm) and VC (selections) lines during spring and summer were presented. Results of evaluation in autumn are presented in this report.

Materials and Methods

The trial comprised 20 V lines and 173 VC lines was planted in a randomized complete block design with two replications. The plot size was 2 × 1 m at a spacing of 50 cm between rows and 10 cm within rows between hills with two plants per hill. AVRDC's suggested cultural practices were used. Observations were made on days to 50% flowering, days to maturity, total yield, percent first harvest yield, 1000-seed weight, plant height at maturity, number of plants harvested, seed quality, and powdery mildew resistant score. Harvesting of pods was done only twice. Moisture content of the seed was determined and the yield was expressed on a 12% moisture content basis. Data on total yield, percent first harvest yield, 1000-seed weight and PM rating are discussed in the following pages.

Results and Discussion

The mean 1000-seed weight for V lines was 52.5 g (n = 20). There was an average increase of 18.3% in seed size for the VC lines developed between 1973-77 and the lines developed between 1978 and 1982 (Fig. 11).

In autumn, the VC lines developed from 1973 to 1977 had an increased yield of 38%. An additional 13% increase in yield was observed among the VC lines developed during 1978-82 (Fig. 12).

In spring, the PM rating of VC lines developed during 1973-82 slightly improved slightly (4.9 to 4.4) and there is a lot of room for further improvement in resistance to PM (Fig. 13). Most V lines fell under the powdery mildew rating of 4 to 5 (susceptible). However, among VC lines there were at least a few which fell under the rating of 3 to 3.5 (moderately susceptible).

As in the past, data from three seasons clearly demonstrate significant differences between seasons for all the characters (Table 3). Summer has the earliest maturing and highest yielding lines with high percent of first harvest.

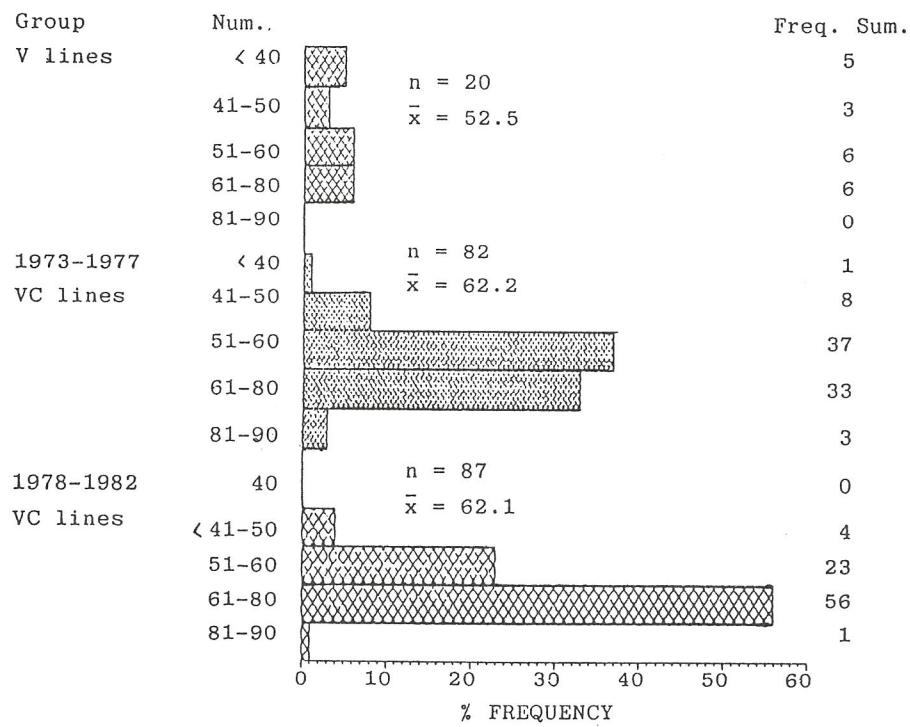

Fig. 11. Progress of improving 1000-seed weight from germplasm (V lines) through breeding (VC lines) at five-year intervals (autumn, 1988).

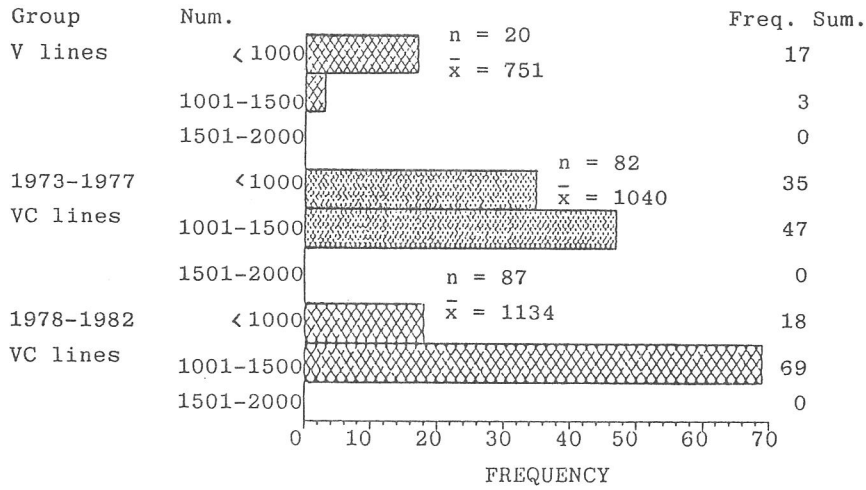

Fig. 12. Progress of improving total yield from germplasm (V lines) through breeding (VC lines) at five-year intervals (autumn 1988).

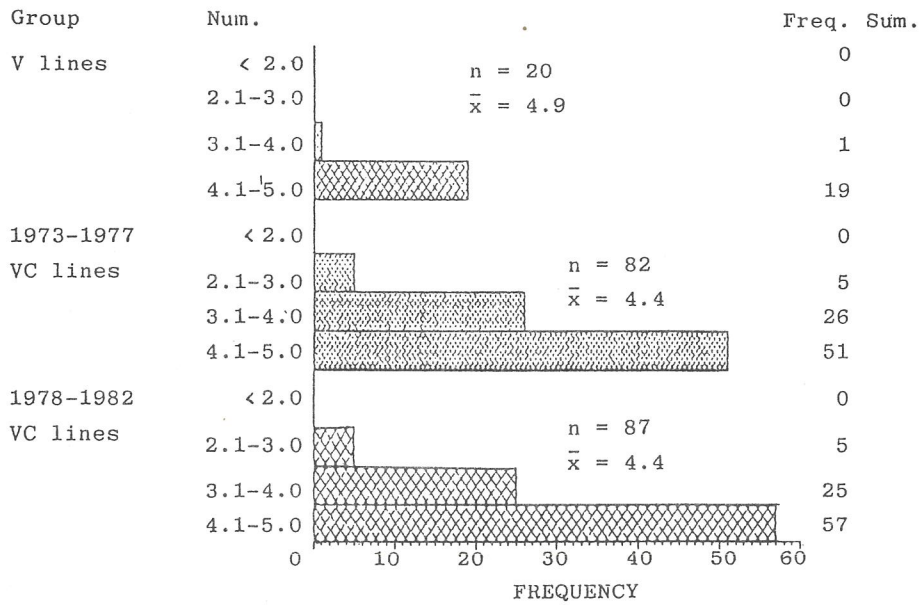

Fig. 13. Progress of PM resistance improvement from germplasm (V lines) through breeding (VC lines) at five-year intervals (autumn 1988).

Table 3. Variations in yield and other characters in V and VC lines among seasons, 1988.

Season	Yield (t/ha)	% first harvest	Days to maturity	1000-seed weight (g)
Spring	2.2 b	37 c	74.9 a	53.6 c
Summer	2.4 a	72 b	59.8 c	55.8 b
Autumn[z]	1.1 c	100 a[y]	71.7 b	60.4 a
Means	1.9 ± 0.3	69 ± 9	68.8 ± 2.9	56.6 ± 2.7

[z]Means are not significantly different by DMRT at 5% probability level. [y]Only one harvest.

Data from three seasons were subjected to pooled analysis of variance. The results suggested that variations in 1000-seed weight could be largely attributed to genotypes. However, variations in total yield and percent of first harvest were predominantly attributable to seasons. The G × S interactions in all traits were low.

Data suggested that the percent of first harvest was largely influenced by photoperiod, temperatures, and possibly other environmental factors and therefore selections should preferably be made in specific seasons and locations.

Inclusion of data in autumn 1988 reconfirmed the findings in 1988 on the progress made to improve yield, resistance to CLS and increase seed size. This prompted the need to further investigate PM resistance and percent of first harvest.

A new cooperative biotechnology project on RFLP mapping of mungbean has been initiated between the University of Minnesota and AVRDC which may focus on two topics above in addition to other priority areas such as resistance to mungbean yellow mosaic virus and to pests.

A catalog of V and VC lines developed from AVRDC has been prepared for publication.

Yield Trials

Summary

In autumn 1988, the 16th international mungbean nursery (IMN) and advanced yield trial (AYT) were conducted. Results of these trials suggested that PM is more severe in autumn than in spring. However, a significant correlation was observed between disease ratings in spring and in autumn. The severity of powdery mildew is not related to yield. In the spring and summer of 1989, the 17th IMN and intermediate yield trial (IYT) were conducted. In the summer of 1989, the selected beanfly resistant entries with and without insecticide applied were evaluated and 32 introduced varieties were evaluated for yield and other traits. From 17th IMN, VC 4059A was identified as high yielding in the spring. VC 4152A, VC 4066A, VC 2768A, VC 3746A, VC 3890A, VC 4111A, VC 3902 and VC 4080 had a low PM rating in the spring. VC 3945A was found to have high protein in the same season. VC 4059A gave 0.4 t/ha protein yield whereas VC 2768A had 0.3 t/ha protein yield. An analysis of findings in the spring and summer revealed that most variations in yield were due to seasons. Variations due to genotype were rather small. In IYT, VC 4443-3B was identified to be high yielding in both seasons. Nine entries had 90% or higher first harvest. Preliminary results indicated that yield potential of beanfly-resistant breeding lines was lower than other improved selections. From 32 newly introduced varieties four have been selected for further evaluation.

Introduction

Promising breeding lines selected from advanced generations were evaluated in different yield trials. Since the mungbean breeding program was scaled down, efforts during the past three years focused on population development through selective intermating. As a result, there were not many advanced lines for yield evaluation. Inbred breeding lines ready for yield testing and disease screening were evaluated in the spring and summer. Yield trials in autumn 1989 were terminated because of the cold weather. Results of the autumn 1988 screening are presented in this report.

Materials and Methods

In autumn 1988, the 16th IMN (with 20 entries) and an AYT (with 35 entries) were conducted in a randomized complete block design. In the spring and summer of 1989, the 17th IMN (20 entries) and an IYT (35 entries) were conducted. In summer, a split plot trial with and without insecticide was conducted to evaluate the yield potential of beanfly resistant materials. Yield trial of introduced varieties was also conducted in summer.

Observations on days to flowering and 50% maturity; yield, percent of first harvest and 1000-seed weight were recorded. The crop in autumn was harvested only once due to the cool weather and the crop's poor growth. In spring, IYT was harvested only once due to continuous rain. The crop in summer was harvested twice.

Results and Discussion

AYT, autumn 1988. The mean yield of 35 entries was 1.2 t/ha. The mean PM rating was 4.4. VC 3984-2B-2-1-3-B and VC 3849A had a rating of 3.0 and 3.3, respectively while VC 4176-1-B-1-3B had a rating of 3.8. Selected promising breeding lines are given in Table 4.

16th IMN, autumn 1988. Two check varieties, V 3726 and V 3476 gave low yields compared to six entries which yielded 1.2 t/ha and above (Table 5).

PM occurs in spring and autumn. The disease was more severe in autumn of 1988 (average rating 4.4) than in the spring (average rating 3.2). Analysis of PM incidence in spring and autumn suggested that there was a highly significant interaction between genotype and season. Of the total variations, 29% and 27% were due to season and genotype, respectively while 13.5% was due to interaction. These results suggested the presence of host-pathogen and environment interaction. There is a need therefore to look for stable resistance to PM. Correlation between PM rating in the spring and that in autumn was highly significant (0.6477**). However, the differences in PM rating between seasons were significant as well. PM rating in spring was significantly lower than in autumn.

Table 4. Promising selections from AYT in autumn 1988.

Cross No.	Yield (t/ha)	Days to maturity	1000-seed weight (g)	PM rating
VC 3945-2B-1-2-2-B	1.6 a[z]	70 c-g	54 mn	4.0 cd
VC 4176-1-B-1-3B	1.4 abc	71 a-e	61 g-i	3.8 d
VC 4143-B-2-3B	1.4 abc	70 c-g	61 g-i	4.0 cd
VC 4019-B-1-1-1-1-B	1.4 a-d	72 ab	62 f-i	4.0 cd
VC 4184-B-3-3B	1.4 a-e	69 f-h	62 f-i	4.0 cd
VC 3984-2B-2-1-3-B	1.3 b-f	73 a	53 n	3.0 e
VC 3849A	1.2 c-j	70 c-g	63 efg	3.3 e
VC 2768A (check)	1.2 e-j	69 f-h	66 cd	5.0 a
VC 3726 (check)	0.9 l	66 i	71 b	5.0 a
Mean	1.2	70	61	4.4
CV	9.9	1.53	2.66	0.12

[z]Values followed by the same letter are not significantly different at 5% level according to DMRT.

Table 5. Promising selections from 16th IMN, autumn, 1988, AVRDC.

Entry	Yield (t/ha)	Days to maturity	1000 seeds weight (g)	PM rating (%)
VC 3737A	1.37 a[z]	69 b-e	56 gh	4.0 c
VC 3902A	1.3 ab	69 b-e	76 a	4.5 abc
VC 3117A	1.2 ab	70 abc	62 ef	4.8 ab
VC 3738A	1.2 ab	70 abc	56 gh	4.0 c
VC 4048A	1.2 abc	65 fg	74 a	4.8 ab
VC 1973A	1.2 abc	69 b-e	68 cd	4.8 ab
V 3476 (ck)	1.1 cde	67 d-f	56 gh	5.0 a
V 3726 (ck)	0.8 f	69 b-e	72 ab	5.0 a
Mean	1.1	69	63	4.4
CV	9.48	2.7	4.7	8.4

[z]Values followed by the same letter are not significantly different from each other at 5% level according to DMRT.

17th IMN, Spring 1989. Results showed that only VC 4059A (1.5 t/ha) significantly outyielded the check VC 2768A (1.3 t/ha) in the spring. The number of days to maturity and 1000-seed weight of VC 4059A were similar to VC 2768A. VC 4059A is a cross between VC 1973A and VC 2768A.

Eight selections, namely, VC 4152A, VC 4066A, VC 2768A, VC 3746A, VC 3890A, VC 4111A, VC 3902A and VC 4080A had a PM rating of 1.5 or less. The powdery mildew-susceptible lines appeared to have higher yield potential than the resistant ones (PM and yield r = 0.554**). Taller plants produced high yields (r = 0.6759**) and these were also more susceptible to PM(r = 0.6024**).

VC 3945A had significantly high protein content (25.2%) compared to VC 2768A (23%). The yield, maturity duration and powdery mildew rating of VC 3945A were similar to that of VC 2768A. VC 3945A is a cross between VC 1000C and VC 1647B. On a per hectare basis the total protein yields from some of the high-protein lines are given in Table 6.

Total protein yield per hectare could be increased by increasing the yield and protein content.

17th IMN, summer 1989. Almost all entries had very low CLS rating. The mean yield of all entries was 1.9 t/ha. The average percent of first harvest was high (78%).

The highest yielding entry VC 4080A gave 2.2 t/ha. None of the entries outyielded either VC 2768A or VC 3890A.

In summer, taller plants yielded very low than shorter ones (r = -0.6236**). The PM-susceptible genotypes gave higher yields than the resistant genotypes. The susceptibility of the crop to CLS significantly reduced the yields (r = -0.7289**).

Findings in the spring and summer showed that differences between the two seasons for most characters were significant (Table 7) whereas differences in yields between genotypes were insignificant. Of the total variations for yield, 66.6% were due to seasons, 10.4% due to G × S interactions while 6.3%, to genotypes.

Plant height at maturity, pods per plant, seeds per pod and 1000-seed weight were positively correlated with yield. However, the number of days to flowering and days to maturity were negatively correlated.

Table 6. Total protein yield per hectare of selected high protein selections.

Entry No.	Grain yield (t/ha)	Protein (%)	Protein yield (t/ha)
VC 3945A	1.2 b-f[z]	25.2 a	0.3
VC 4143A	1.3 a-d	25.1 ab	0.3
VC 4176A	1.4 abc	24.5 abc	0.3
VC 2991A	1.2 cg	24.4 abc	0.3
VC 4059A	1.5 a	23.3 def	0.4
VC 2768A (ck)	1.3 b-f	23.0 ef	0.3

[z]Means are not significantly different by DMRT at 5% probability level.

Table 7. Variations in yield and other characters between spring and summer in the 17th IMN, 1989.

Season	Yield (t/ha)	Days to maturity	1000-seed weight (g)	Pods/plant (cm)	Plant height	Protein (%)
Spring	1.2 b[z]	65 a	51.6 b	6.6 b	47.5 b	23.6 b
Summer	1.9 a	52 b	56.9 a	14.5 a	77.4 a	23.9 a
Mean	1.6	58.5	54.2	10.5	62.4	23.8

[z]Means are not significantly different by DMRT at 5% probability level.

IYT, spring and summer 1989. The results of trial in spring showed that VC 4443-3B (1.4 t/ha) significantly outyielded both VC 1628A (1.0 t/ha) and VC 3890A (1.0 t/ha). In the summer, VC 3890A had the highest yield with 2.3 t/ha. The yield of VC 4443-3B (1.9 t/ha) was not significantly different from that of VC 3890A. Therefore, considering the yields in spring and summer, VC 4443-3B (cross between VC 2750A and VC 3301A) performed better than VC 3890A with an average yield of 1.7 t/ha.

The following nine entries had at least a 90% first harvest. VC 4443-B-6-2B, VC 4192-B-9-3-B, VC 4133-2-B-1-3B, VC 4394-B-8-2B, VC 4394-B-1-2B, KM 83019-4-4B, VC 4532-2-2B, VC 4394-B-8-2B, and VC 4390-B-1-2B.

Analysis of yields in the spring and summer showed that 59% of the total variations were due to season and only 8.9% were attributable to genotypes. Although this generalization is broad, some exceptional genotypes such as VC 4443-3B might have wider adaptation. This needs to be tested for further confirmation.

Evaluation of beanfly resistant breeding lines, summer 1989. Beanfly is not serious during summer. However, summer is the best season to evaluate the yield potential of mungbean. Results (Table 8) showed that compared to VC 1973A and VC 3890A all beanfly-resistant selections attained very low yields. Continuous rain during harvest resulted in poor yields of some entries. Preliminary indications point out that the beanfly-resistant entries did not have the yield potential of some of the other improved lines during summer. Further evaluations during autumn and spring will be conducted.

Table 8. Yields of beanfly resistant entries with and without insecticide application compared with improved breeding lines.

Entry no.	Yield (t/ha)		Mean	% decrease or increase
	With insecticide (A)	Without insecticide (B)		B from A
VC 3785F3-37-4B-2-5B	1.1 b	1.2 bc	1.2 b	+9.6
VC 3786F3-2-4B-3-5B	0.8 b	0.7 de	0.7 c	22.2
VC 3786F3-32-4B-2-5B	0.7 bc	0.9 cd	0.8 c	21.9
VC 3797F3-2-4B-5-5B	0.7 bc	0.6 de	0.7 c	8.6
VC 3797F3-42-4B-1-5B	0.2 d	0.3 ef	0.2 d	+74.8
VC 1560D	1.0 b	1.2 bc	1.1 b	+18.8
V 2396	0.2 cd	0.1 f	0.1 d	45.3
V 3495	0.1 d	0.0 f	0.0 d	25.0
VC 1973A	1.9 a	1.5 ab	1.7 a	21.8
VC 3890A	2.0 a	1.9 a	2.0 a	10.9

Yield trial of introduced varieties, summer 1989. Of the 32 varieties evaluated, VC 3890A gave the highest yields (2.2 t/ha). Uthong 7808, VC 1973A, CV Satin and Pag-asa 5 gave yields of 1.5t/ha.

Entries VC 3890A, Uthong 7808, Pag-asa 5, and Benpote Pisai Nakhon Sawan had low CLS rating (2.0).

NIAB materials from Pakistan may have some levels of resistance to MYMV. These will be distributed to cooperators in South Asia.

International Cooperation

Summary

Three new varieties, one each in the USA (Texsprout), Taiwan (Tainan No. 5) and Solomon Islands (SIROC 1, VC 4080A) were released in 1989. A total of 19 sets of the 17th IMN were distributed to 13 countries. Data for three 15th IMN were received from cooperators. A total of 616 breeding lines and 49 other germplasm were distributed to cooperators in 25 countries. In Thailand VC 2917A and VC 3664A gave significantly higher yields and lower reactions against diseases than local checks. Several entries had no symptoms for CLS or PM or virus diseases. In the Philippines, VC 3004A, VC 3737A and VC 3738A performed well during rainy season. The yield differences between genotypes in Swaziland were not significant. In Vietnam, VC 3012A, VC 3737A and VC 1560D showed resistance to CLS. VC 3541A and VC 3528A gave significantly higher yields than the three local checks. In

Kampuchea, several AVRDC lines appeared promising, of which the seeds of VC 2719A, VC 2778A and VC 2764A have been multiplied. VC 2719A has been distributed to farmers in several locations.

Introduction

In 1989, 19 sets of IMN were distributed to 13 countries. Three 15th IMN findings were sent to AVRDC. Three countries also sent their data from their yield evaluation of AVRDC breeding lines. About 616 breeding lines and 49 other entries were distributed to cooperators in 25 countries.

Materials and Methods

The 17th IMN trials were conducted in a randomized complete block design with three replications; 5 × 2 m plot size; four rows per plot with a between row spacing of 50 cm and two seeds per hill. Observations were made and data were collected on a number of variables by the cooperator.

Results

IMN-Philippines. Mr. Andres C. Pascua from Isabela State University (ISU) conducted the trial planted on 16 June 1989 (rainy season). Pag-asa 5 and CES 1D-21 were used as checks. Compared to the two checks three entries, VC 3004A (o.9 t/ha), VC 3737A and VC 3738A (both 0.7 t/ha) produced significantly higher yields.

IMN-Thailand. Dr. Sadao Hatta from the Agricultural Development Research Center, Khon Kaen, Thailand conducted the 15th IMN. There were no significant differences between local check 1 and other entries. However, compared to the local check 2, VC 2917A and VC 3664A had significantly higher yield and disease reaction for CLS, PM virus and MYMV were all quite low. VC 3664A would probably be more acceptable than VC 2917A for Thailand conditions because VC 3664A had bigger seeds (73 g/1000 seeds).

Six entries, namely, VC 2802A, VC 2917A, VC 3664A, VC 3117A, VC 2768A and VC 3178A had no CLS. VC 2768A did not have any PM. VC 3300A, VC 2917A, VC 1973A, VC 3061A had negligible virus symptoms. Lines VC 2917A, VC 3012A, VC 2768A, local check 2, and V 3476 did not show yellow mosaic symptoms.

IMN-Swaziland. Mr. Sebenzila Matsebula and Mr. Samuel Masuku conducted the trial using one local check. The yields obtained ranged from 0.8 t/ha to 1.1 t/ha. No significant differences were observed between genotypes.

Evaluation of breeding lines

Philippines. Mr. Salvador I. Yebes from IRRI evaluated VC 1560D with Pag-asa 5. Differences in yield between the two were not significant. Both were free from CLS and PM but had some virus symptoms.

Vietnam. Forty-two breeding lines were evaluated by Mr. Duong Minh and Mr. Hanquang Phung of the University of Cantho. In this trial only VC 3012A, VC 3737A and VC 1560D were found resistant to CLS. It appeared that the CLS might be a different race from the one identified at AVRDC. Further investigation is needed to verify this aspect. Among entries, VC 3541A (0.7 t/ha) and VC 3528A (0.7 t/ha) gave significantly higher yield than the three checks.

Kampuchea. Mr. Tat Eng Lay of Kbal Koh Research Station evaluated in two trials 10 AVRDC lines with three local checks.

The yields obtained were low because of drought after planting. Some plots were affected more than others resulting in a higher than normal C.V. of 24% (Table 9).

Line VC 1973A had the highest yield under stress conditions; it had uniform and earliest maturity. Virus incidence was higher (around 8%) than in most other AVRDC lines but was lower than in the

Table 9. Yields of mungbean varieties, Kampuchea dry season 1987-1988.

Variety	Total yield (t/ha)	Disease ratings		Days to first harvest	Remarks
		PM[z]	CLS[y]		
VC 2768A	1.9	2.0	2.0	88	Vigorous plant growth, large seeds
VC 2719A	1.7	3.0	3.0	89	
VC 2778A	1.6	4.0	2.8	89	
VC 2764A	1.5	1.0	3.3	89	
VC 1560D	1.5	3.3	2.5	89	
VC 1089A	1.5	3.0	3.5	87	
VC 1131B	1.3	4.3	1.8	89	
VC 1973A	1.2	3.5	3.0	79	Early and uniform maturity, many plants with virus
Local (preng)	1.2	4.0	3.5	80	
Local (Phes)	1.1	3.0	3.8	84	Many plants with virus symptoms
VC 3178A	1.1	3.5	2.0	81	
VC 1628A	1.0	3.4	2.3	79	Early
M 65010A (ck)	1.0	3.8	4.0	81	
LSD (.05)	0.315	0.8	1.0		
CV	16%	17%	24%		

[z]Powdery mildew ratings: 0 = no symptoms to 5 = most leaves with symptoms. [y]Cercospora leaf spot ratings are based on a scale of 0 = no symptoms to 5 = most leaves covered with lesions.

local checks. Line VC 2719A was also early maturing and showed a very low virus incidence. Virus incidence ranged from 0.9% (VC 2719A and VC 1628A) to 18-28% (local varieties). A late-maturing variety (9-14 days later than other lines) of what appeared to be black gram introduced by UNICEF several years ago) showed absolutely no virus or Cercospora leaf spot symptoms. Although these plants were disease-free, vines were rather long and yields were low. Most AVRDC lines had low CLS rating compared with the local varieties.

Lines VC 3178A, VC 1560D, VC 2778A, and VC 1089A can be eliminated in future trials.

The seeds collected from the 1987 rainy season trial were planted on 5 November 1987; these seeds may not have been as pure or disease-free as the original samples obtained from AVRDC.

Line VC 2768A gave the highest yields in this trial, although not significantly different from VC 2719A. Both lines performed very well in past trials and looked promising. VC 2768A seemed especially tolerant to Cercospora leaf spot and powdery mildew. Powdery mildew tolerance may be important for a variety which would be grown here during the dry season. However, this disease does not appear to be important during the rainy season. VC 2719A was the highest yielding line in the two previous trials. These two lines seemed better adapted to Kampuchean conditions. Meanwhile, seeds of lines, VC 2719A, VC 2778A, and VC 2764A were multiplied in small plots at Dey Eth Station, Kien Svay district.

A trial using seven AVRDC lines and one local check was conducted by Mrs. Suchitra, Mrs. Bon Thon Chan, and Mr. Ung Sa Marom at Kbal Koh Research Station. The trial was planted on 16 March 1989.

Overall, yields were obtained because of the favorable growing conditions and applicable cultural practices. Three AVRDC lines, VC 3737A, VC 1973A and VC 3853A produced significantly higher yields than the local variety. Among these, VC 3717A had the best overall field appearance rating. VC 1973A did well in previous trials but appeared to be more susceptible to virus diseases than other AVRDC lines tested in the past. VC 3746A and VC 3890A performed well but their yields were not significantly higher than the local check.

Lines VC 2719A and VC 2768A (not included in the trial). performed well in the past trials and were multiplied (especially VC 2719A) and distributed to farmers in several locations.

New varieties released. Dr. J.C. Miller, Jr. at College Station, Lubbock, Texas released VC 1973A as Texsprout. At Tainan DAIS, VC 3890A was approved and released in May 1989 as 'Tainan No. 5'. Mr. Y.S. Chen of ROC Overseas Mission in Solomon Island reported that VC 4080A was released as SIROC 1.

Mungbean Entomology

Screening of *Vigna glabrescens* × *V. radiata* for Beanfly Resistance

Summary

Twenty-seven backcross progenies from a cross between beanfly-resistant *Vigna glabrescens* and susceptible *V. radiata* were screened in the field for beanfly resistance. Only four entries showed moderate levels of resistance. These entries will be used for further improvement and evaluation of yield and agronomic characters.

Introduction

Three species of agromyzids, *Ophiomyia phaseoli* (Tryon), *O. centrosematis* (de Meijere), and *Melanagromyza sojae* (Zehntner) (Diptera: Agromyzidae) cause widespread damage in mungbean in tropical to subtropical Asia. The insect larvae bore into the stems of young plants causing the plant to weaken or die, resulting in considerable yield losses. In 1982, AVRDC identified one *Vigna glabrescens* accession which showed high resistance to beanflies and polyphagous insect defoliators both at AVRDC and in Indonesia. In 1988, Dr. David Mok of Oregon State University crossed the resistant accession with a high yielding agronomic mungbean breeding line and sent a backcross progeny to AVRDC. The progeny was selfed and the BC_1S_2 was screened for beanfly resistance.

Materials and Methods

Seeds of 27 BC_1S_2 progeny and two beanfly-resistant and two susceptible checks were planted in a nonreplicated trial in 2-m long, 0.75-m wide beds in late September, the beginning of the peak period of beanfly population in AVRDC. Four weeks after germination plants were uprooted, stems were cut and the number of beanfly larvae and pupae found were recorded. Plants showing beanfly larval damage were counted.

Results and Discussion

Results of beanfly infestation in each entry are summarized in Table 1. The number of beanfly larvae+pupae per 20 plants ranged from 0 to 20 and percent of damaged plants from 67 to 100. Only four entries showed moderate to high resistance levels based on the number of beanfly larvae+pupae per 20 plants. Most of the entries were susceptible. On rating the resistance level, emphasis was given on the number of larvae+pupae per plant rather than the percentage of damaged plants. This was due to antibiosis, which results in mortality of beanfly at early growth stage. The damage done on the plant tissue was still visible at sampling time. These entries will be used for further improvement studies.

Characterization of Defoliator Resistance in *Vigna glabrescens*

Summary

Various studies on plant morphological and insect feeding characteristics were conducted to understand the mechanism of defoliator resistance in *Vigna glabrescens* accession V 1160. Beet

Table 1. Beanfly infestation of BC_1S_2 progeny from *V. glabrescens* × *V. radiata* cross.

Identification	No. L+P/ 20 plants	Resistance Rating	% Damaged plants	Resistance Rating
BC1S2-1:35-44(S)	5.0	MR	87.5	LR
BC1S2-1:64-83(G)	10.0	LR	83.3	LR
BC1S2-2:35-44(S)	20.0	HS	100.0	S
BC1S2-2:64-83(G)	8.3	LR	100.0	S
BC1S2-3:35-44(S)	15.5	S	88.9	S
BC1S2-3:64-83(G)	12.3	LR	92.3	S
BC1S2-4:35-44(S)	10.0	LR	75.0	LR
BC1S2-4:64-83(G)	10.9	LR	81.8	LR
BC1S2-6:35-44(S)	11.1	LR	100.0	S
BC1S2-6:64-83(G)	20.0	HS	84.6	LR
BC1S2-8:35-44(S)	20.0	HS	100.0	S
BC1S2-8:64-83(G)	20.0	HS	100.0	S
BC1S2-9:35-44(S)	16.0	S	100.0	S
BC1S2-9:64-83(G)	15.0	S	100.0	S
BC1S2-10:35-44(S)	20.0	HS	66.7	MR
BC1S2-10:64-83(G)	3.6	MR	90.9	S
BC1S2-11:35-44(S)	12.0	LR	100.0	S
BC1S2-11:64-83(G)	20.0	HS	100.0	S
BC1S2-12:35-44(S)	20.0	HS	100.0	S
BC1S2-12:64-83(G)	15.8	S	94.4	S
BC1S2-13:35-44(S)	16.0	S	100.0	S
BC1S2-13:64-83(G)	20.0	HS	93.8	S
BC1S2-14:64-83(G)	17.5	S	93.8	S
BC1S2-15:35-44(S)	5.7	MR	100.0	S
BC1S2-15:64-83(G)	8.8	LR	68.8	MR
BC1S2-17:35-44(S)	0.0	HR	83.3	LR
BC1S2-17:64-83(G)	13.8	S	92.3	S
V 1160 (res. ck)	0.4	HR	27.4	HR
V 4281 (res. ck)	4.4	MR	69.4	MR
VC 1973A (susc. ck)	8.5	LR	69.2	MR
V 2184 (susc. ck)	15.0	S	89.3	S

(S) = Shriveled seeds. (G) = Good seeds. (res. ck) = Resistant check. (susc. ck) = Susceptible check. HR = highly resistant. MR = moderately resistant. LR = having low resistance. S = susceptible. HS = highly susceptible.

armyworm (BAW), *Spodoptera exigua*, a polyphagous insect, was used in this study. V 1160 had significantly less trichome density on both upper and lower leaf surfaces compared with VC 1973A, a susceptible check. BAW laid significantly less eggs on V 1160 than on VC 1973A. There was a significant positive correlation between trichome density and number of eggs laid. This resulted in lesser insect damage on V 1160 than on VC 1973A. Foliage of V 1160 was as suitable for growth and development of BAW as that of VC 1973A. Low trichome density or the glabrous nature of V 1160 foliage reduced BAW oviposition and infestation.

Introduction

A *Vigna glabrescens* accession, V 1160, has shown high resistance to beanflies (AVRDC 1987)[1] and bruchids (AVRDC 1988)[2]. This accession is being used in AVRDC's breeding program to develop beanfly and bruchid-resistant mungbean cultivars. In the field, this accession also shows very little damage by defoliator insect pests. In this experiment, the resistance to defoliators of this accession was evaluated.

Materials and Methods

Several plants of resistant V 1160 and susceptible VC 1973A were grown in clay pots placed in a greenhouse. Trifoliate leaves were obtained from these plants to study the accessions' resistance mechanism in the laboratory.

[1]AVRDC. 1990. 1987 Progress Report. Asian Vegetable Research and Development Center. Shanhua, Tainan.
[2]AVRDC. 1990. 1988 Progress Report. Asian Vegetable Research and Development Center. Shanhua, Tainan.

Oviposition preference. Six branches from each of the resistant and susceptible accessions with equal number of leaves were cut and immediately placed individually in Erlenmeyer flasks with water. A branch of V 1160 and one of VC 1973A were then placed in a wooden cage covered by fine nylon net. One pair (1 male + 1 female) of freshly emerged BAW adults was then released in each of the six cages. Each cage was considered as one replicate. The egg mass and eggs per egg mass laid on the foliage, cage surface and on the flask with the branches were recorded.

Plant morphology. About 10 fully-developed and freshly-emerged leaves from each of the six plants of V 1160 and VC 1973A were taken to determine their leaf area with a Licor area meter. Simultaneously, the trichome density on upper and lower surfaces of these leaves were determined by counting the number of trichomes in three randomly selected 5 mm^2 areas. Care was taken to avoid inclusion of major veins in the areas chosen for recording the trichome density.

Insect feeding. Fully-opened fresh leaves were collected from the plants grown in pots in the greenhouse. Their leaf area was measured. About two to three leaflets each of VC 1973A and VC 1160 were placed in each of 12 large petri dishes (six accessions). Twenty first instar larvae of BAW were released in each petri dish. The larval mortality and date of pupation were recorded daily. The leaves on which BAW larvae fed were replaced with fresh ones every two to three days. The leaf area of leaves to be discarded and that of the fresh leaves at every replacement was measured. The leaf area consumed was determined by subtraction.

Pupae were removed and their weights were recorded individually. The number of insects that pupated and those that failed to pupate was recorded. The adults were allowed to emerge from the pupae and the percentage that emerged was calculated. The duration of pupal period (from the initiation of pupation to adult emergence) and pupal mortality were also recorded. Adult males and females from each replicate were separately maintained.

Several potted plants of VC 1973A were placed in cages with one plant per cage. One pair of adults, the larvae of which were fed on either V 1160 or VC 1973A, were released in each cage. The egg mass and eggs in each mass laid on the foliage and on cage walls were recorded.

Data on oviposition preference were analyzed by ANOVA and means were separated by DMRT. The rest of the data were analyzed by *t* test.

Results and Discussion

Oviposition preference. Results of the oviposition of BAW on the foliage of V 1160 and VC 1973A are summarized in Table 2. The average number of egg mass was significantly less on V 1160 than on VC 1973A. The number of eggs per egg mass was also less in the egg mass on V 1160 than on VC 1973A. As a result, the total number of eggs on V 1160 was significantly less than on VC 1973A. In fact BAW laid 10 times less eggs on V 1160 than on VC 1973A.

Plant morphology. The morphological characteristics of foliage of BAW-resistant V 1160 and -susceptible VC 1973A are summarized in Table 3. The trifoliate leaflets of V 1160 were significantly smaller than those of the VC 1973A accession. On both leaf surfaces, the V 1160 had significantly lesser trichome density than VC 1973A.

Table 2. Oviposition preference of BAW for two *Vigna* accessions.

Oviposition surface	No. of egg mass	Ave. no. of eggs per egg mass		Total no. of eggs
		Range	Mean	
VC 1973A	27.2 ± 24.8 a	1-165	15.5	421.0 ± 278.0 a
V 1160	3.8 ± 3.6 b	1-48	10.6	40.5 ± 38.1 b
Cage	8.5 ± 4.6 b	1-32	8.7	73.5 ± 56.7 b
Flask	1.0 ± 2.5 b	13-136	49.5	49.5 ± 121.3 b

Data are means of six replicates. Means in vertical columns followed by the same letter are not significantly different by DMRT at 5% probability level.

A significant positive correlation (r = 0.59*) was observed between trichome density and the number of eggs laid (Fig. 1). The higher the trichome density, the greater the number of egg mass and eggs laid. Trichomes are involved in various ways in host-plant insect pest interaction. The glabrous nature of the foliage seemed to have reduced the acceptability of V 1160 for oviposition.

Table 3. Morphological characteristics of foliage of BAW-resistant and -susceptible *Vigna* accessions.

Vigna accession	Leaf area (cm^2/leaflet)	Trichomes (No./25 mm^2)	
		upper surface	lower surface
VC 1973A	20.7 +1.3	26.4 +2.8	16.8 +2.6
V 1160	16.0 +1.5	20.7 +1.8	8.6 +0.7
't' value	5.43**	3.79**	6.78**
Degrees of freedom	10	10	10

**significant at 1% level.

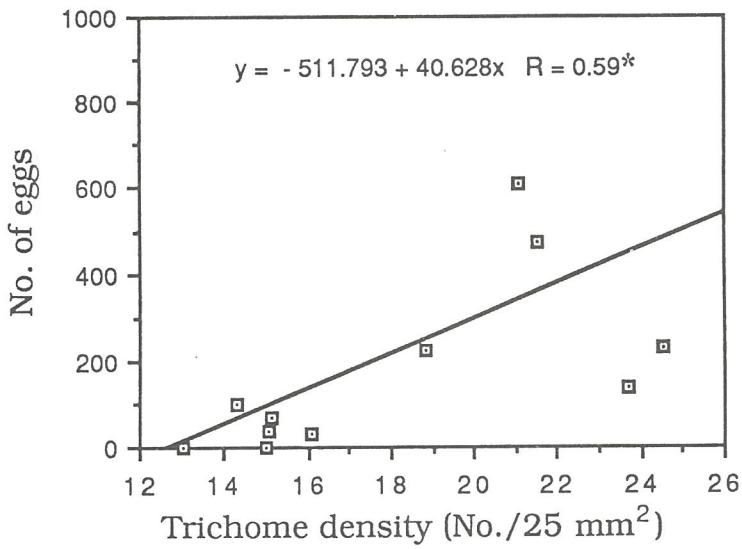

Fig. 1. Correlation between trichome density on leaf surface and number of eggs laid.

Insect feeding. Results of observations on the foliage feeding by BAW larvae, duration of larval and pupal stages and sex ratio are summarized in Table 4. BAW larvae consumed significantly less foliage of VC 1973A than that of V 1160. There were no significant differences in the duration of the larval stages of BAW fed on VC 1973A or V 1160.

Data on larval and pupal mortality and weights of BAW pupae are summarized in Table 5. No significant difference was observed between mortality of BAW larvae that fed on VC 1973A and on V 1160. There was no significant difference between the mortality of BAW pupae raised from larvae fed on VC 1973A and V 1160. BAW pupae, the larvae of which fed on V 1160 were heavier than those fed on VC 1973A. This was perhaps reflected in the greater amount of V 1160 foliage consumed by the insect larvae (Table 4). No significant correlation was observed between the amount of leaf consumption and mortality (Table 5).

BAW adults' life was short. They survived on an average of two days. There was no significant difference in longevity of adults with the larvae fed either on V 1160 or VC 1973A. The BAW adult laid very few eggs. Results of oviposition of BAW fed on V 1160 and V 1973A are summarized in Table 6. BAW adults from V 1160 laid relatively more eggs than those adults from VC 1973A. In both cases most eggs were laid on the cages.

Table 4. Foliage feeding and duration of larval and pupal stages of BAW raised on two *Vigna* accessions.

Accession	Leaf consumption per larva (cm2)	Larval stage duration (days)	Pupal stage duration (days)	Pupa sex ratio (f:m)
VC1973A	69.4 + 6.9	16.7 +1.0	5.0 +0.7	1:0.917
V1160	87.3 +14.1	15.4 +1.3	5.7 +0.4	1:1.250
't' value	2.55*	1.79 NS	1.88 NS	
Degrees of freedom	10	10	10	

*Significant at 5% level. NS (Not significant)

Table 5. Mortalities of larvae and pupae and pupal weights of BAW fed on two *Vigna* accessions.

Accession	Mortality of larva (%)	Mortality of pupa (%)	Pupa weight (mg)
VC1973A	70.0 ± 16.7	40.0 ± 37.0	30.4 ± 4.6
V1160	68.0 ± 16.7	22.0 ± 25.0	48.8 ± 12.0
't' value	0.0189NS	0.0901NS	4.9757**
Degrees of freedom	10	10	10

**Significant at 1% level. NS (not significant)

Table 6. Fecundity of BAW, the larvae of which were fed on VC 1973A and V 1160 accessions.

Oviposition surface	Larvae fed on V1160		Larvae fed on VC1973A	
	No. egg masses	Total no. of eggs/plant	No. egg masses	Total no. of eggs/plant
VC 1973A	0.3 ± 0.6	1.0 ± 1.7	1.0 ± 0.0	8.0 ± 5.3
Cage	10.7 ± 1.5	138.0 ± 33.0	3.0 ± 1.7	17.3 ± 15.4
't' value	8.95**	5.85**	2.63 NS	0.81 NS
Degrees of freedom	4	4	4	4
Total egg masses/plant	11.0 ± 1.7		4.0 ± 1.7 NS	
Total eggs/plant	139.7 ± 35.0		25.3 ± 10.1*	

*Significantly different at 5% level.**Significantly different at 1% level. NS (not significant)

Conclusions

The number of trichomes on the leaf surface seems to play a major role in oviposition and damage by BAW to *Vigna* accessions. V 1160 had significantly lower trichome density than VC 1973A. As a result, BAW laid fewer eggs in V 1160 which resulted in fewer larvae and lesser damage to the leaves of this accession.

Characterization Mechanism for Bruchid Resistance

Summary

The mechanism of resistance to *Callosobruchus chinensis* in the seeds of V 2709, V 2802 and VM 2164 was investigated. Bruchids laid significantly fewer eggs on the seeds and pods of these three resistant accessions than on those of a susceptible check, VC 1973A. Small seeds in resistant accessions did not favor resistance. When artificial seeds made from the susceptible accession were fortified with the resistant accession, the number of bruchid adults that emerged from the seeds decreased with increased proportion of the seeds of the resistant accession. Bruchid adults that developed from the artificial seeds fortified with the resistant accession were significantly lighter than those from the seeds of the susceptible accession. This effect of antibiosis was prominent in VM 2164, a highly resistant blackgram accession. The resistance in seeds of three resistant accessions could not be extracted with cold acetone.

Introduction

Three species of bruchids, *Callosobruchus chinensis* (L), *C. maculatus* (F), and *C. analis* (F) infest mungbean in the field and during storage. Among the three, *C. chinensis* is the most widespread and found wherever mungbean is grown. Primary infestation begins in the field where adults lay eggs on green pods and larvae bore through the pod cover and feed concealed inside developing seeds. When mature mungbean seeds are harvested and stored, the adults come out and infest the neighboring seeds. In two or three months the whole lot can be infested and rendered unfit for human consumption.

The use of insecticide for the control of these pests by farmers is extremely limited because of inadequate storage facilities in the vicinity of their living quarters which tend to expose them to pesticides. In addition, mungbean seeds are stored for a limited time after harvest until the beginning of the next season. Hence, seeds are frequently consumed, increasing the possibility of taking in excessive pesticide residue with the food.

To overcome these problems, AVRDC is trying to develop mungbean cultivars resistant to bruchids, mainly *C. chinensis*. In 1988 AVRDC found two mungbean accessions with consistent moderate to high resistance to *C. chinensis*. These accessions are being actively used in AVRDC's resistance breeding. In 1989, the mechanism of resistance of these accessions to *C. chinensis* was investigated.

Material and Methods

Oviposition. Ten grams of seeds of accessions, V 2709 and V 2802 (with moderate to high resistance), a black gram accession, VM 2164 (highly resistant), and VC 1973A (susceptible) were poured individually into each of four 100-ml Erlenmeyer flasks. Each flask represented one replicate. Ten pairs of freshly emerged *C. chinensis* adults were then released on each seed sample and the flasks were covered tightly with muslin cloth. Four days later, all adults were removed and the eggs per sample and per 100 seeds were recorded. At this time 1000-seed weight of each accession was also recorded.

Resistance characteristic of pods. Ten potted plants of each accession were placed randomly in a large nylon net cage in a greenhouse. Starting at pod formation, an undetermined number of bruchid adults raised on mungbean seeds were released inside the cage at intervals. The pods were harvested in three flushes as they became dry. Pods from each plant were harvested separately. The number of eggs on each pod was recorded. Pods were maintained for five more weeks then the number of adults emerged from the dry pods was recorded.

Seed size. Seeds of each of the resistant and susceptible accessions were ground into fine powder, made into a thick slurry and poured into 9 mm diameter and 6 mm long molds made of Teflon. The molds were placed on dry ice while the slurry was poured and immersed in liquid nitrogen for 10 minutes. The hardened slurry inside the mould was then freeze-dried for 24 h. After freeze-drying, the artificial seeds were removed from the mold and weighed. All seeds were weighed and placed in an enclosed moist chamber where relative humidity was maintained at 100%. After one week all seeds were again weighed and their content was determined. Each mould held nine artificial seeds so nine seeds were subsequently used as one replicate. The seeds were placed in 50 ml Erlenmeyer flasks and five pairs of newly emerged bruchid adults were released on the seeds for oviposition. After one week the adults were removed and seeds were maintained at 30°C for a month. At the end of this period, adults that emerged from each seed sample were recorded.

Seed mixture. The powder from the seeds of resistant accessions V 2709, V 2802, VM 2164 was mixed individually with that of the susceptible accession VC 1973A in the following proportion:

Resistant Accessions (V 2709 or V 2802 or VM 2164)	Susceptible Accession (VC 1973A)
0%	100%
25%	75%
50%	50%
75%	25%
100%	0%

After thorough mixing, the powder was made into artificial seeds as described earlier. Four replicates, each consisting of nine artificial seeds, were placed in 50 ml Erlenmeyer flasks and five pairs of newly emerged adults released on them for one week for oviposition. After one week the adults were removed and oviposited seeds were maintained at 30°C for five more weeks. The number of first generation adults emerging from the seed samples was recorded.

Insect development. Seeds, in powder form, of three resistant and one susceptible accession were mixed in the following proportion: V 2709, 50% + VC 1973A, 50%; V 2802, 50% + VC 1973A, 50%; VM 2164, 25% + VC 1973A, 75%. Artificial seeds of the three mixtures and those of VC 1973A were prepared. Four replicates, each consisting of nine seeds of each mixture and VC 1973A were also placed in individual 50-ml Erlenmeyer flasks and exposed for oviposition by *C. chinensis*. The first generation adults emerging from the seeds in each replicate were collected and dried at 150°C for 24 hours.

The adults were then separated by sex and each insect was weighed. Furthermore, the average weight of each insect of both sexes was computed for each of the four replicates.

Resistance/susceptibility factor. Fine mesh powder of each of the three resistant and one susceptible accession was extracted in cold acetone (-10°C) utilizing a high speed Waring blender. The extract was filtered in No. 2 filter paper. The filtrate was made to volume and saved at 0°C. The acetone extracted powder was dried thoroughly to remove traces of acetone. Half of the dried powder was made into artificial seeds as described above. A 50% acetone extract of the same seed sample was added to the other half of each seed sample. The sample was allowed to dry completely to remove acetone. The reconstituted powder was processed and made into artificial seeds. The original unextracted powder of each seed was also processed and made into artificial seeds

In a separate test, quantities of fine powder of each of the three resistant and one susceptible accession were extracted in cold acetone (-10°C). The acetone extract was made to a known volume and saved at 0°C. The powder was thoroughly dried to remove all acetone and stored in a dry chamber. To equal the quantity of the unextracted powder of resistant accessions, acetone extracts representing an equal quantity of seeds of susceptible VC 1973A was added. The mixture was throughly dried to remove acetone and the dried powder was made into artificial seeds. In the next step, to equal the quantity of cold acetone extracted powders of resistant V 2709, V 2802 and VM 2164, acetone extracts representing and equal quantity of seed powder of susceptible VC 1973A was added. Similarly artificial seeds were made from unextracted and acetone extracted powders of three resistant and one susceptible accession. Moisture content of seeds was adjusted between 12 and 14%; seeds were then exposed to oviposition by *C. chinensis* in 50 ml Erlenmeyer flasks. After a week of oviposition, the seeds were maintained at 30°C for five more weeks and the number of insects that emerged was recorded.

Results and Discussion

Oviposition. Results of oviposition by *C. chinensis* on the seeds of three resistant (V 2709, V 2802, and VM 2164) accessions and one susceptible check (VC 1973A) are summarized in Table 7. The total number of eggs laid on seeds was highest in VM 2164, the most resistant accession, and on V 2709. There was no significant difference between eggs laid on V 2802 and the susceptible VC 1973A. On per seed basis, bruchid egg laying was significantly correlated to seed size. Even the smallest seed had about two eggs, enough food to sustain the growth of one insect per seed. However, very

few insects emerged from the small seeded resistant accessions, indicating that other factors rather than seed size influence resistance.

Table 7. Oviposition of bruchids on seeds of resistant and susceptible accessions.

Accession	No. eggs/ 10 g seed	1000-seed weight (g)	No. eggs/ seed
V2709	696 ab	28.8 d	1.9 c
V2802	557 c	38.6 b	2.2 bc
VM2164	708 a	34.2 c	2.5 b
VC1973A	548 c	62.5 a	3.4 a

Data are means of four replicates. Means in columns are not significantly different by DMRT at 5% probability level.

Resistance characteristic of pods. The number of eggs laid on pods and the number of first generation adults that emerged from the pods of various accessions are summarized in Table 8. *C. chinensis* laid significantly fewer eggs on the pods of two resistant accessions than on the pods of the susceptible VC 1973A. The pods of both resistant accessions are slightly smaller than that of the susceptible check but the several-fold difference in eggs laid cannot be explained by the physical size of the pods. Other factors seem to restrict oviposition of bruchid on pods of the resistant accessions. The number of adults that emerged from the pods of resistant accessions was significantly less than that of susceptible VC 1973A. When data were calculated based on 10 locules to compensate for the differences in pod size, the number of insects that emerged from the resistant accessions was still significantly less than that from the susceptible VC 1973A even if the locules of pods of resistant accessions were only slightly smaller than those of the susceptible ones. This indicated that the developing seeds of resistant accessions are already resistant.

Table 8. Bruchid infestation on pods of resistant and susceptible mungbean accessions.[z]

Accession	No. of eggs/pod	No. of adults/pod	No. of adults/10 locules
		First flush	
V2709	6.0 b	0.0 b	0.0 b
V2802	14.8 b	1.4 b	1.5 b
VC1973A	44.3 a	25.8 a	29.1 a
		Second flush	
V2709	14.7 c	0.0 b	0.0 b
V2802	24.5 b	0.9 b	1.0 b
VC1973A	74.7 a	25.3 a	30.1 a
		Third flush	
V2709	17.9 b	0.0 b	0.0 b
V2802	18.2 b	0.5 b	0.7 b
VC1973A	25.8 a	14.3 a	19.4 a

[z]Data are means of 15-20 replicates, one plant per replicate. Means in columns are not significantly different by DMRT at 5% probability level. VM 2164 did not set pods until harvest of the third flush hence, it was excluded from the observation.

Seed size. Seeds of three resistant accessions are distinctly smaller than those of susceptible VC 1973A. This prompted the investigation into whether seed size has any influence on bruchid infestation. Artificial seeds of the same size were made from the seeds of the cut accessions. Even when seeds of resistant and susceptible entries of the same size were exposed to bruchid infestation, the number of first generation adults that emerged from the susceptible accession was greater than that from the resistant ones (Table 9). Insects failed to infest the artificial seeds of the resistant accessions but flourished on the artificial seeds of susceptible VC 1973A. This shows that bruchid resistance in V 2709, V 2802, VM 2164 is not due to small size of the seed.

Seed mixture. The emergence of first generation bruchid adults on artificial seeds of the susceptible accession mixed with increasing concentrations of resistant seeds are summarized in Figure 2.

Table 9. Emergence of first generation of bruchid adults from artificial seeds of resistant and susceptible accessions.

Accession number	No. of adults/replicate (i.e. 9 seeds)
V 2709	0.0 b
V 2802	0.0 b
VM 2164	0.0 b
VC 1973A	53.3 a

Data are means of four replicates. Means followed by the same letter are not significantly different by DMRT at 5% probability level.

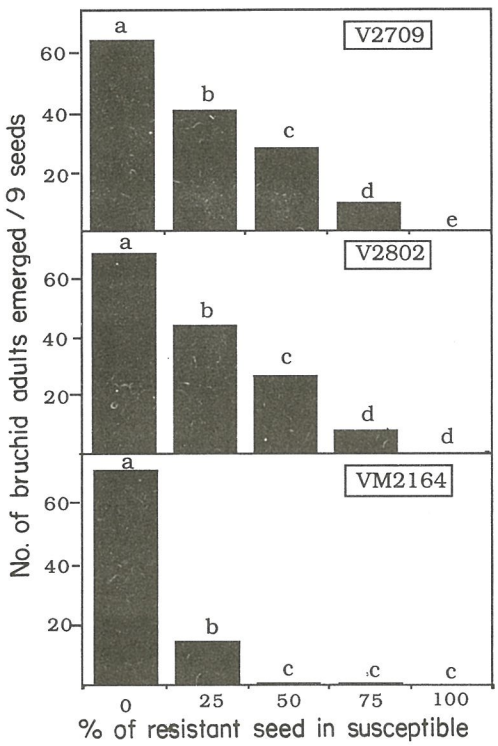

Fig. 2.
Emergence of bruchid adults from artifical seeds of susceptible accessions containing varying levels of seeds of resistant accessions.

In three resistant accessions, the number of first generation adults emerging from the seed decreased as the proportion of their seed in the mix increased. There was a highly significant negative correlation between the proportion of seed of V 2709 and that of VC 1973A (r = -0.989), and seed of V 2802 and the seed of VC 1973A (r = -0.986). An addition of a mere 25% VM 2164 to the susceptible seed drastically decreased adult emergence. Among three resistant accessions, VM 2164 was most resistant. Results demonstrated that there is an antibiosis in resistant accessions which adversely affects bruchid growth and feeding on the seeds.

Insect development. The effect of the feeding of adult bruchids which developed from larvae feeding inside the seeds on susceptible mungbean seeds fortified with 50% V 2709 or V 2802 or 25% VM 2164 are summarized in Table 10. Both male and female insects fed on susceptible seeds fortified with resistant seeds were significantly lighter than those insects fed solely on susceptible seeds. Results were pronounced in females since these are responsible for oviposition. These data further confirm the earlier findings that resistant accessions are antibiotic to bruchids.

Resistance/susceptibility factor. Extraction of mungbean seed powder with cold acetone neither altered the resistance of resistant accessions nor the susceptibility of the susceptible check.

Adding extract of VC 1973A to acetone extracted powder of any one of the three resistant accessions did not change the resistance reactions of these accessions. The resistance factor does not seem to be a small peptide; it could be a chemical which is not extractable by cold acetone.

Table 10. Weights of bruchid adults, the larvae of which were fed on artificial seeds of susceptible accessions fortified with resistant accessions.

Seed fortification	Insect weight mg/insect	
	Male	Female
VC 1973A	0.90 a	0.94 a
VC 1973A, 50% + V2802, 50%	0.86 ab	0.87 b
VC 1973A, 50% + V2709, 50%	0.81 bc	0.82 bc
VC 1973A, 75% + VM2164, 25%	0.77 c	0.81 c

Data are means of four replicates. Means in columns followed by the same letter are not significantly different by DMRT at 5% probability level.

Screening of *Vigna glabrescens* × *V. radiata* Backcross Progeny for Bruchid Resistance

Summary

Backcross progenies of a cross between *Callosobruchus chinensis*-resistant *Vigna glabrescens* accession, V 1160 and high yielding mungbean line, VC 1973A were screened for resistance to *C. chinensis*. Bruchid adults laid eggs on all seeds. One to three adults emerged from each seed indicating that all progenies were susceptible.

Introduction

Accession V 1160, which is highly resistant to agromyzid beanflies that attack mungbean plants at seedling stage also shows a moderate level of resistance to bruchid, *Callosobruchus chinensis* (L) (Coleoptera: Bruchidae), which attacks mungbean seed during storage. Preliminary studies at AVRDC revealed antibiosis as the mechanism of resistance. Most but not all bruchid larvae feeding inside the seed die before pupation.

Because of its resistance to agromyzid beanfly, this accession was crossed with one high yielding breeding line, VC 1973A, and the progeny was backcrossed to VC 1973A. The subsequent progeny was selfed. A part of the BC_1S_2 population for resistance to bruchid in seed was screened.

Materials and Methods

Ten to 20 seeds of each of 28 BC_1S_2 and 20 seeds each of resistant check, V 1160 and susceptible check, VC 1973A were confined in individual 50 ml Erlenmeyer flasks. Five pairs of bruchid adults were released over the seeds for oviposition for one week. The adults were then discarded and the seeds were held for an additional four weeks at 30°C. The number of first generation adults that emerged from each seed sample was recorded five weeks after the introduction of bruchids. Each seed was observed and the presence of bruchid holes in the seeds through which the adults emerged from larvae and pupae was recorded.

Results and Discussion

A large number of eggs were laid on all BC_1S_2 entries. All seeds were damaged and each had from one to three insect escape holes. This level of damage was identical to that in VC 1973A, a susceptible parent. In V 1160, only 12 insects emerged from 20 seeds. Each of the twelve seeds had one escape hole. Eight seeds were not infested despite the presence of more eggs.

Pepper Breeding

New Crosses

Priority objectives of the AVRDC hot and sweet pepper breeding program have been defined and the strategies to achieve these goals were established by the end of 1987. There was a lag in making new crosses in 1989 because conclusive results for important traits to be used in making meaningful crosses are still being derived. Several genotypes reported resistant to cucumber mosaic virus (CMV), potato virus y (PVY), pepper veinal mottle virus (PVMV), chili veinal mottle virus (CVMV) and *Phytophthora capsici* were confirmed by AVRDC pathologists. Other genotypes reported resistant to viruses, *Phytophthora* rot and bacterial leaf spot were planted and will be screened and multiplied once confirmed by the pathologists.

A total of 21 accessions transferred by plant pathologists after screening were planted in October for observation and multiplication after further screening. Of these 21, seven each were resistant to CVMV and PVY, six to *Phytophthora* rot and one to PVMV.

New crosses for sweet pepper will be made with Blue Star, Abdera and other promising cultivars as recurrent parents. For hot pepper, Passion, Szechuan (P_3 generation) and other desirable cultivars will be used. The accessions resistant to CVMV, PVMV, PVY and *Phytophthora* rot will be used as donor parents for specific disease resistance.

Advanced Germplasm Evaluation

Summary

The selected varieties from previous observation trials and the 1988 cultivar exhibition trial were planted in 1988-89 winter season and in summer of 1989. Yield of sweet pepper was generally lower in summer, while that of hot pepper did not appear to be drastically reduced. The best sweet pepper entries in all trials generally outperformed Blue Star (check) significantly in both total and marketable yields. Often, the yield advantage is expressed in terms of greater number of fruits per plant but this was compensated by a concomitant reduction in mean fruit weight, except in the hot season trial. The outstanding hot pepper cultivars in all trials significantly outyielded the check Szechuan. In contrast to sweet pepper, however, the yield advantage over the check of the leading entries was expressed in terms of greater number of fruits per plant and heavier fruit weight. Of the sweet pepper varieties tested, Key Largo appeared to be the most adapted to the hot season as evidenced by its high yield in the spring-summer trial coupled with its high heat tolerance. On a similar basis, the best-adapted hot pepper genotypes were 88P40, One Thousand and possibly Red Horn. Pungency of hot pepper measured in these trials ranged from 1.5 to 7.6 mg capsaicin/g dry matter. Further studies on the cultivars identified as heat tolerant in the above trials and the various important factors which depress yield in the hot and humid season are needed.

Introduction

Both hot and sweet pepper genotypes selected from the 1988 cultivar exhibition trial (planted for the March, 1988 Tomato and Pepper Symposium and observation trials) were planted again in the

cool dry (fall 1988 to spring 1989) and hot humid (spring to summer 1989) seasons to evaluate their yields and other horticultural traits. The Center's plant physiologists studied heat tolerance and other factors affecting the adaptability of both types of pepper to hot and humid conditions.

The project aimed to define the adaptability of pepper cultivars to the tropics by comparing their performance in both cool and hot seasons.

Materials and Methods

Forty-seven entries of sweet pepper, of which 21 were also used in the 1988 cultivar exhibition trial for the TPS, were grown in the cool dry season from late September of 1988 to mid-June of 1989. Of the 47 entries, 33 plus four newly selected entries were grown again in the hot-humid season from mid-April to mid-September in 1989.

Thirty-seven entries of hot pepper, of which 12 were used in the 1988 symposium, were grown in the cool dry season. Of the 37, 29 were also grown in hot humid season.

Passion (commercial F_1) and Szechuan (OP), the varieties commonly planted in Taiwan, were used as checks for hot pepper, while Blue Star (commercial F_1) was used for sweet pepper.

Seeds were sown in flats. Seedlings were grown in plastic pots (9 cm in both height and diameter) of sterilized standard mixture composed of soil, compost, sand and rice hull. Seedlings were transplanted to the field 40 days after sowing.

Spacing was 45 cm between hills within the row and 50 cm between two rows within a bed. Two-row plots of 12 and 16 plants, for cool and warm plantings, respectively, on beds 1.5 m apart from center to center were used.

Beds were mulched with grayish silver PE film and PE film plus rice straw for cool and warm season, respectively. Staking, pest and disease control, irrigation and other cultural practices were managed according to the tentative recommendations of AVRDC. The experimental design was randomized complete block with three replications.

Unadjusted total and marketable yield data, mean fruit weight, total and number of marketable fruit per plant were obtained by analyzing the total and number of marketable fruits and weight of each harvest. Fruit length and fruit length:width ratio obtained from 10 samples in each replicate were also analyzed using ANOVA. No combined data analyses were carried out because a number of entries among the three-season trials were not common. However, general data comparisons were made between trials. An index of hot season performance or heat-tolerance (HT) index, based on the relative comparison of yields in the cool and hot season trials, was calculated:

$$\text{Heat-tolerance (HT) index} = (\text{yield in hot season}/\text{yield in cool season}) \times 100$$

Heat-tolerance index was determined for each cultivar and ranked accordingly; this ranking was then compared with the absolute yield ranking to identify varieties that excel in both categories. These varieties should be classified as most adapted to the hot and humid season.

Results and Discussion

Mean yields of sweet pepper cultivars were generally high in the cool season (winter-spring planting); however, yield during the fall-spring planting was unexpectedly low, even lower than in spring-summer (Fig. 1). As there was no dramatic disease epidemic to explain the low yields in the fall-spring trial, it was suspected that the abnormally suboptimal temperatures (below 10°C) during the nursing of seedlings and during much of the early vegetable period (November 1988 to January 1989) in the fall-spring trial were the primary yield-depressing factors.

In contrast to sweet pepper, the yields of hot pepper cultivars during the hot season did not seem to be drastically reduced compared to that of the relatively cooler winter-spring planting. Again, yields during the fall-spring planting were much lower than in the other two seasons (Fig. 2).

The most outstanding sweet pepper cultivars in the trials are given in Tables 1 to 3; those in the hot pepper group are given in Tables 4 to 6. The best sweet pepper entries in all trials generally outperformed Blue Star (check) significantly in both total and marketable yields. Often, the yield advantage is expressed in terms of greater number of fruits per plant. This is especially true during

the cool season trials. There appeared to be a compensatory decrease, however, on the average fruit weight, with the exception of the leading entries during the spring-summer planting.

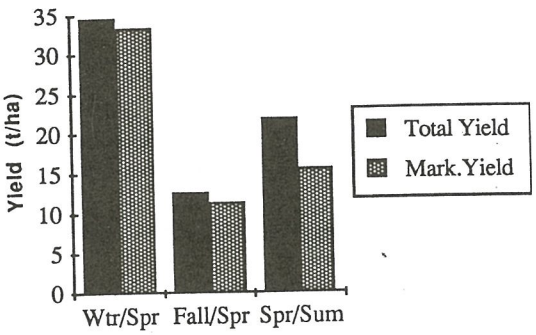

Fig. 1. Comparative yields of sweet pepper cultivars in different seasons.

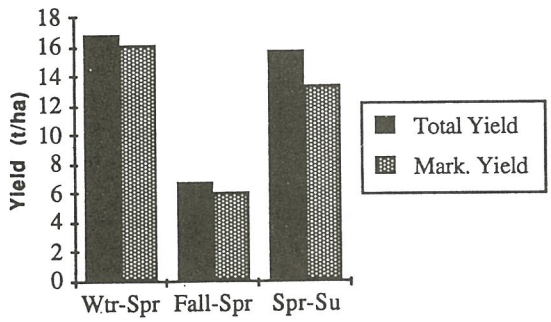

Fig. 2. Comparative yields of hot pepper cultivars in different seasons.

Table 1. Best five sweet pepper entries vs. check in winter 1987 to spring 1988 trial.

Cultivar	Yield (t/ha)		Fruit no./plant		Single fruit weight (g)	Marketable fruit			
	Total	Market-able	Total	Market-able		Length (cm)	Width (cm)	L:W ratio	Thickness (mm)
Annabell	45.9 a	43.7 a	18.6 bc	16.9 b	78.4 i-m	9.8 h-m	7.4 k-o	1.3 e-g	5.5 c-g
Green Bell	44.6 ab	43.3 ab	11.0 f-j	10.4 d-h	108.7 c-f	11.7 d-g	8.7 b-e	1.4 e-g	5.8 a-d
Portos	43.0 a-c	40.3 a-c	11.3 f-j	9.6 e-j	119.6 a-d	10.6 f-j	9.1 b	1.2 g-j	6.5 ab
E 1821	40.9 a-d	40.0 a-c	9.0 i-m	8.5 g-j	121.0 a-d	9.9 h-m	8.9 b-d	1.1 h-k	6.6 a
Queen Star	40.8 a-d	39.9 a-d	8.2 j-m	7.8 h-j	119.7 a-d	13.6 c	8.3 d-h	1.6 d	5.5 c-h
Blue Star (ck)	28.4 f-h	27.8 g-l	7.2 m	6.8 j	112.5 b-e	12.3 c-e	8.7 b-f	1.4 e	5.7 b-f

Table 2. Best five sweet pepper entries vs. check in the fall 1988 to spring 1989 trial.

Cultivar	Yield (t/ha)		Fruit no./plant		Single fruit weight (g)	Marketable fruit			
	Total	Market-able	Total	Market-able		Length (cm)	Width (cm)	L:W ratio	Thickness (mm)
Gypsy (multiplied)	20.1 ab	18.5 ab	12.6 a-e	10.2 c-e	48.7 g-j	9.72 e-k	4.98 l-p	1.9 fg	3.50 b-k
Agronomico 10G	17.6 a-d	16.5 a-c	13.1 a-d	11.3 a-c	44.0 h-j	12.13 c	4.90 m-p	2.5 d	3.00 i-p
Key Largo	21.3 a	20.5 a	11.6 a-g	10.4 b-d	52.5 e-i	16.61 b	4.53 o-r	3.7 b	3.60 a-j
Pacific	16.3 b-f	15.8 b-e	5.5 h-k	5.0 i-m	85.7 a-c	10.11 d-i	6.66 a	1.5 h-n	4.23 a
Chung Chiao No. 4	18.3 a-c	16.7 a-c	8.4 c-k	6.5 f-i	71.2 b-g	7.89 l-o	6.33 a-d	1.2 m-r	3.80 a-f
Blue Star (ck)	16.3 b-f	15.2 b-g	6.3 f-k	5.1 h-m	83.9 a-c	11.00 c-f	6.41 a-d	1.7 g-i	3.97 a-e

Table 3. Best five sweet pepper entries vs. checks in the spring 1989 to summer 1989 trial.

Cultivar	Yield (t/ha)		Fruit no./plant		Single fruit weight (g)	Marketable fruit			
	Total	Market-able	Total	Market-able		Length (cm)	Width (cm)	L:W ratio	Thickness (mm)
Atol	27.1 ab	22.0 a	13.5 e-h	9.4 d-g	85.2 a	10.0 b	6.6 a	1.5 de	4.6 ab
Gypsy	27.4 ab	22.3 a	41.6 a	29.2 a	42.3 hi	8.6 c	4.8 hi	1.8 b	4.4 a-c
Blue Star (ck1)	20.3 c-f	15.3 b-d	11.1 f-h	7.0 g	72.3 c	9.8 b	6.0 b-e	1.6 cd	4.0 c-g
Lipari	29.1 bc	22.0 ab	19.7 b	14.4 bc	44.3 b-d	15.1 a	4.2 c	3.6 a	3.1 ef
Queen Star	31.8 ab	22.8 ab	18.5 b	11.9 c-e	69.0 a	10.1 d	6.1 a	1.7 c	3.6 cd
Qiei Men	21.1 d	16.8 c	18.1 b	13.0 cd	38.3 d	5.4 gh	5.6 b	1.0 e	4.4 a
Blue Star (ck2)[z]	10.9 f	8.0 d	6.1 d	3.7 h	69.4 a	8.0 f	6.0 ab	1.3 d	4.1 ab

[z]First transplanting of seedlings to the pots of Blue Star (ck2) was later than others.

Table 4. Best five hot pepper entries vs. check in the winter 1987 to spring 1988 trial.

Cultivar	Yield (t/ha)		Fruit no./plant		Single fruit weight (g)	Marketable fruit	
	Total	Marketable	Total	Marketable		Length (cm)	Width (cm)
HP 621	25.5 a	24.7 a	45.2 g-i	42.9 g-i	17.4 c	16.9 a	2.1 d
PP 1	25.9 a	23.6 ab	19.0 i	16.4 k	48.9 a	15.4 b	4.0 a
Long Chili	22.1 ab	21.8 a-c	65.2 d-g	63.3 ef	10.6 d	13.0 c	1.6 d-f
88P40	20.8 bc	20.3 a-d	74.4 c-f	70.7 de	9.2 d-g	9.6 f-g	1.6 d-f
Pical	22.1 ab	20.2 a-d	30.4 hi	26.1 jk	28.1 b	14.3 b	3.3 b
Szechuan (ck)	19.2 b-d	18.3 cd	92.5 c	84.8 cd	8.4 d-g	11.0 de	1.3 e-g

Table 5. Best five hot pepper entries vs. checks in the fall 1988 to spring 1989 trial.

Cultivar	Yield (t/ha)		Fruit no./plant		Single fruit weight (g)	Marketable fruit			
	Total	Market-able	Total	Market-able		Length (cm)	Width (cm)	L:W ratio	Thickness (mm)
Long Chili	12.4 a	11.6 a	50.3 c-f	43.4 c-g	11.7 d-f	15.65 b	1.59 e-j	9.8 a	2.10 c-e
Passion (ck)	12.1 ab	11.1 ab	42.7 d-h	36.7 d-h	12.7 c-e	12.74 de	1.67 e-h	7.6 b-f	2.60 bc
One Thousand	10.7 a-d	10.3 a-c	83.9 b	75.2 b	6.5 kl	12.99 c-e	1.47 h-j	8.9 ab	1.37 f-i
Long Fruit (A)	11.5 a-c	9.8 a-d	49.3 c-g	40.4 c-g	11.3 e-g	13.68 cd	1.57 e-j	8.8 a-d	–
Long Fruit (B)	9.7 b-e	8.9 b-e	38.0 e-j	32.2 d-i	12.5 c-e	14.35 bc	1.67 e-h	8.7 a-d	2.23 cd
Szechuan (ck)	6.1 g-l	5.7 f-l	62.7 b-d	52.6 cd	4.8 l-o	10.25 f-i	1.18 lm	8.7 a-d	1.77 d-g

Table 6. Best five hot pepper entries vs. checks in the spring 1989 to summer 1989 trial.

Cultivar	Yield (t/ha)		Fruit no./plant		Single fruit weight (g)	Marketable fruit		
	Total	Marketable	Total	Marketable		Length (cm)	Width (cm)	Thickness (mm)
Passion (ck)	19.7 bc	16.8 bc	73.2 d-j	51.0 d-i	10.8 a-c	10.7 d-g	1.97 de	2.9 b
Red Horn	20.1 ab	15.2 b-d	98.1 c-e	67.0 c-g	8.4 de	10.2 gh	1.80 e-g	2.2 ef
Seoul Hot	18.7 bc	17.8 b	167.3 a	156.5 a	4.0 gh	8.6 ij	1.40 lm	–
88P40	23.1 a	22.0 a	96.6 c-e	89.0 c	8.7 de	10.6 e-g	1.97 de	2.0 f
One Thousand	19.5 bc	17.9 b	100.3 cd	87.6 c	7.3 ef	12.6 bc	1.51 j-l	–
Szechuan (ck)	11.6 g-k	8.6 j	120.5 bc	57.1 d-h	5.4 f-h	11.3 d-f	1.23 mn	2.0 f

The outstanding hot pepper cultivars in all trials significantly outyielded the check (in this case, Szechuan). In contrast to sweet pepper, however, the yield advantage of the outstanding entries over the check was expressed in terms of greater fruit number per plant and heavier fruit weight (Tables 4 to 6).

In identifying pepper cultivars which are adapted to the hot season, only the winter-spring trial was considered as the cool season reference data because of the unusually low yield of the fall-spring trial. Moreover, only marketable yield was considered in these analyses so that other factors depressing commercial yield could be considered.

Key Largo appeared to be the best adapted sweet pepper genotype to hot and humid season as evidenced by its high absolute yield rank in the spring-summer trial combined with its high heat tolerance (Fig. 3). Other cultivars with fairly consistently high absolute yield and HT index were Queen Star, Gypsy, Lipari and Atol. In contrast, Annabell and Blue Star (check) showed not only lower yield in summer but also greatly depressed yield relative to their cool season performance (i.e. lower HT index).

In contrast to sweet pepper, the hot pepper cultivars that were best adapted to the hot season did not appear to lose any marketable yield at all relative to the cool season planting (Fig. 4). In fact, two entries, 88P40 and Sunrise, had slightly higher yields in the hot season. In relative consistency of absolute yield against HT index, the best-adapted genotypes were 88P40, One Thousand and possibly Red Horn. In contrast to these cultivars, HP 621 and Jalapa had depressed yields in the hot season vis-a-vis cool season, indicating that they favor a milder climate. Cultivar Sunrise was an unusually low yielder in both seasons. Szechuan, the check cultivar, was typically

heat-sensitive, generally showing great yield depression (low HT index) and low absolute yield during the hot season.

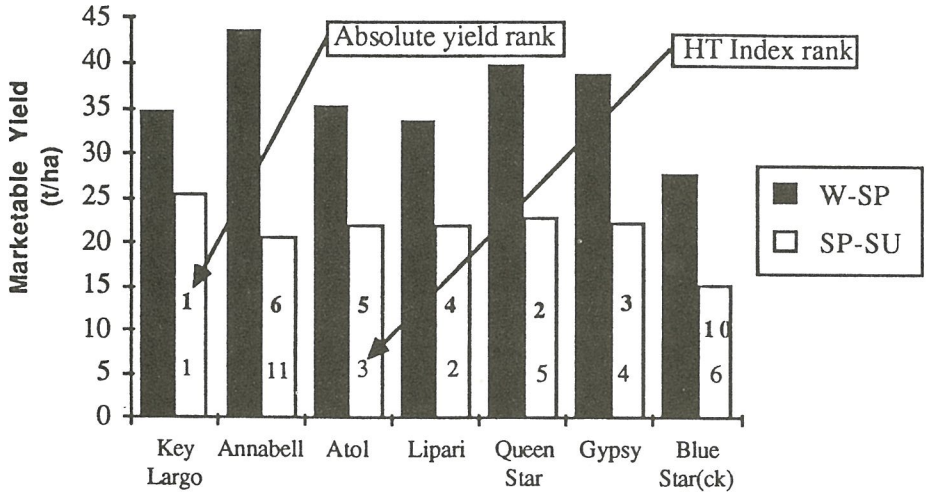

Fig. 3. Comparative marketable yields of selected sweet pepper cultivars in the cool season (winter-spring trial) vs. hot season (spring-summer trial).

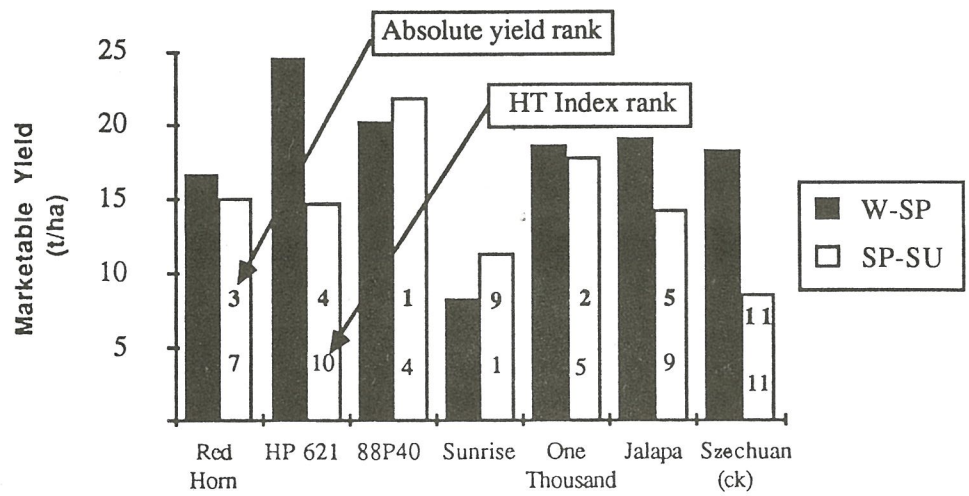

Fig. 4. Comparative marketable yields of selected hot pepper cultivars in the cool season (winter-spring trial) vs. hot season (spring-summer trial).

Based on this result, high temperatures and humidity adversely affected yield of peppers. Further studies on the cultivars identified as heat-tolerant in the above trials and the various important factors which depress yield in the hot and humid season are needed.

In the above trials, the virus complex was the most serious disease encountered. Once virus symptoms were widely spread, yield loss and decrease in marketable fruits, caused mainly by deformed fruits, became apparent. The infected plants in trials transplanted in May died mainly of Southern blight (*Sclerotium rolfsii*), with a few mortality due to Phytophthora rot.

Pungency of hot pepper was measured using the Near Infrared Reflectance technique. Capsaicin content was used as an indicator of pungency. The contents of capsaicin in this trial ranged from about

1.5 to 7.6 mg capsaicin/g dry matter (Table 7). Compared to other varieties surveyed in 1989 (value as high as 10.5 mg/100g DM observed), the varieties in Table 7 exhibited only moderate pungency.

Table 7. Pungency of hot pepper varieties grown in summer 1989.

Variety	Pungency[z] mg capsaicin/g DM[y]
Passion (ck)	5.3
Szechuan (ck)	3.7
Cili Putih Kelantan	5.4
Unknown 41	7.6
HP 621	5.0
Seoul Hot	6.5
Pical	4.5
Jalapa	7.1

[z]Average of 3 replicates. Only Jalapa consisted of two reps. [y]DM: dry matter.

Identification, Collection, Multiplication and Partial Purification of INTHOPE Entries

Summary

Selfed seeds of 21 varieties from nine countries were collected for further multiplication and evaluation at AVRDC prior to distribution to INTHOPE collaborators. General information on maturity and survival rate during the monsoon season (especially after typhoon) was obtained. Pungency of INTHOPE entries appeared to be relatively higher than Szechuan (check), ranging from 2.1 to 5.9 mg capsaicin/g DM versus 1.9 for the check. Only a few varieties produced limited amount of selfed fruits in the 1989 summer planting because the root systems were weakened by strong wind and most of the entries did not produce sufficient flowers following the typhoon which damaged the planting.

Introduction

Hot pepper has been adapted to various growing environments of the tropics for several hundred years and has evolved into diverse land races in different areas. It is expected that among this natural variation, some land races adapted to some countries could perform well and possess traits acceptable in other areas. The International Network for Tropical Hot Pepper (INTHOPE), therefore, aims to lead hot pepper programs in many countries by mediating the exchange of germplasm and data. After identification, purification and multiplication, seeds of the varieties will be sent to the participating countries of the Network. The collection of the AVRDC Genetic Resources and Seed Unit can also be included in this project.

Materials and Methods

Twenty-two entries of hot pepper from nine countries were sown in September 1988 and transplanted 44 days later. Each plot comprised of six rows, 15 plants to a row, without replicates; a screen net was built for the two central rows. Data were collected from the remaining rows. Both selfed and open-pollinated seeds were collected because some varieties did not produce enough selfed seeds. The seeds from this trial were planted again in late May and transplanted 39 days after being sown. One variety was lost because no seeds were obtained in the first planting. In the second planting, each plot consisted of two rows of 30 plants. The experimental design used was a randomized complete block with three replications. Spacing and cultural practices followed were those recommended by AVRDC. Data were collected for the following traits: earliness, pungency and infection of viruses, fungi and bacteria on seeds. Unfortunately, data collection was incomplete due to typhoon damage.

Results and Discussion

Despite typhoon damage, some varieties such as those from India and Thailand still produced flowers (Table 8). In contrast, varieties such as Gwangju and Cheongryong, both from Korea, were almost totally destroyed by typhoon with less than 30% survivors in all replicates and one replicate, respectively. Tabasco did not perform well and produced very few fruits from the very beginning. IAC Ubatuba Cambuci (from Brazil), Atarodo (from Niger), Nainang Local and Safi (from Senegal) did not produce abundant fruits during the entire growing season and were late maturing (Table 9). Varieties which were evidently earlier than Szechuan (check) were 'Gwangju', 'Extra Long Selection', 'Punjab Lal' and 'Salmon'.

The pungency of varieties which produced sufficient fruit sample for analysis was measured (Table 10). All entries showed relatively stronger pungency than the check, Szechuan.

Seed samples of varieties with sufficient seed stocks will be provided to plant pathologists in 1990 for evaluation of reaction to viruses (CVMV, CMV, PVY, TMV), Phytophthora rot and bacterial leaf spot.

Table 8. Survival rates of INTHOPE accessions (range of three replications).

Varieties	Survival rate (%)	Country of origin	Remarks
Jawahar 218	97-100	India	Still produced flowers
Extra Long Selection	100	India	Still produced flowers
Ludhiana Long Selection	100	India	Still produced flowers
Punjab Lal	97-100	India	Still produced flowers
Huaruar	93-100	Thailand	Still produced flowers, healthy
KKU Cluster	100	Thailand	Still produced flowers
Haue See Toan	100	Thailand	Still produced flowers
Szechuan (ck)	86-90	Taiwan	
Cheongryong	13-80	Korea	
Gwangju	13-30	Korea	

Table 9. Days to maturity of INTHOPE entries.

Variety	Days to maturity[z]
Gwangju	63
Extra Long Selection	63
Punjab Lal	63
Salmon	63
Szechuan (ck)	75
IAC Ubatuba Cambuci R.	>80
Tabasco	>80
Atarodo	>80
Nainang Local	>80
Safi	>80

[z]On the day of recording, more than 50% of plants had mature fruit for harvest.

Table 10. Pungency of INTHOPE accessions compared to the check, Szechuan.

Variety	Pungency mg capsaicin/g DM
Punjab Lal	5.9
Huaruar	5.6
Jawahar 218	3.7
Extra Long Selection	3.7
Cheongryong	3.2
Long Fruit (A)	3.1
Ludhiana Long Selection	3.1
MC 5	3.0
MC 4	2.5
Yangjiao	2.1
Long Fruit (B)	2.1
Gwangju	2.1
Szechuan (ck)	1.9

Pepper Entomology

Screening of Insecticides to Control Flower Thrips

Summary

Nine insecticides which had given some control over thrips on various crops were screened for their efficacy in controlling thrips on sweet pepper. The chemicals were sprayed on the crops once every week starting 10 days after transplanting or applied in soil soon after transplanting five weeks later. The thrips found in the flowers and aphids on the entire plant were recorded. Two synthetic pyrethroids, deltamethrin and Karate gave the best control over both thrips and aphids and produced the highest yields. Oxamyl also gave satisfactory control and produced similar yields.

Introduction

In 1987, both hot and sweet peppers were planted once a month throughout the year in an insecticide-free field. Incidence of various insects was recorded. Thrips were the most frequently observed. An AVRDC survey of pepper pests on farmers' fields in Taiwan also revealed thrips as the most common and destructive pest. Samples of insects were collected and identified.

Thrips scrape the buds and feed on oozing cell sap. As a result, flower buds and in some cases, open flowers drop off. Their feeding inside vegetative buds makes the leaves crinkle. This can be mistaken as virus infection. In 1988-89, an insecticide screening to develop an interim chemical control package for combating thrips was undertaken at AVRDC.

Materials and Method

Nine insecticides which had given some control over thrips on other crops were included in this screening. These included formetanate hydrochloride 50 WP, oxamyl 24EC, Karate 2.8EC, terbufos 10G, cartap 50WP, carbosulfan 48EC, deltamethrin 2.8EC, teflubenzuron 13.6SC and methamidophos 50EC.

The land was plowed, rototilled and worked into 1.5 m beds. These beds were further divided into 4.5 × 3.3 m plots spaced 1.5 m apart. There were 10 treatments including one untreated check, each replicated four times and arranged in a randomized complete block design. One-month-old sweet pepper (cv. Blue Star) seedlings were transplanted in two 3-m rows on each of three beds in each plot. All standard cultural practices such as weeding, fertilizer application, irrigation and spraying of fungicide to control diseases were followed.

A predetermined quantity of each chemical, except terbufos, was diluted in water and sprayed evenly on each plot until the liquid started dripping. An appropriate quantity of terbufos was applied 3-4 cm deep around each plant soon after transplanting and again six weeks later.

At intervals, 20 flowers were plucked from each plot and the number of thrips found was recorded. During the season, aphids were also observed. In each plot, 10 randomly selected plants were selected and the number of aphids feeding on them was recorded. The plants that had 0, 1-10, 11-100, and 101-1000 aphids in a 10-plant sample were recorded. At intervals, marketable fruits were harvested and their weights were recorded to determine the yield per plot.

The effectiveness of insecticide and yield data were subjected to analysis of variance and means were separated by DMRT.

Results

Data on the effectiveness of insecticides and fruit yields are summarized in Table 1. Two synthetic pyrethroids, deltamethrin and Karate gave the best control over both the thrips and aphids. These two treatments also gave the highest yield. Oxamyl gave the next best control over both insects. The yield from this treatment was also at par with deltamethrin and Karate. Application of terbufos to the soil was not effective in controlling either thrips or aphids. Yields in all plots were relatively low since flowers were plucked to record the number of thrips.

Table 1. Evaluation of various insecticides for the control of thrips and aphids on sweet pepper.

Insecticides	Rate AI kg/ha	No. of thrips/ 20 flowers		Number of plants/10 with estimated number of aphids				Yield t/ha
		23 Dec. 1988	12 Jan. 1989	0	1-10	11-100	101-1000	
Formentane 50WP	0.5	1.4 cd	1.5 bc	7.3 ab	2.8 ab	0.0 b	0.0 a	4.1 bc
Oxamyl 24EC	0.5	1.8 cd	2.8 b	9.3 a	0.8 bc	0.0 b	0.0 a	6.7 a
Karate 2.8EC	0.1	0.2 e	0.3 c	10.0 a	0.0 c	0.0 b	0.0 a	7.1 a
Terbufos 10G	2.0	6.5 a	1.2 bc	5.8 b	2.8 ab	1.5 ab	0.0 a	3.5 c
Cartap 50WP	0.5	3.5 bc	1.8 b	5.3 bc	3.8	1.0 ab	0.0 a	3.8 bc
Carbosulfan 48EC	0.5	2.7 c	4.5 a	9.8 a	0.3 bc	0.0 b	0.0 a	6.1 ab
Deltamethrin 2.8EC	0.1	0.2 de	1.2 bc	10.0 a	0.0 c	0.0 b	0.0 a	8.1 a
Teflubenzuron 15SC	0	6.5 a	0.9 bc	3.3 c	4.5 a	2.3 a	0.0 a	3.5 c
Methamidophos 50EC	0.5	0.4 de	2.5 b	8.8 a	0.0 c	1.3 ab	0.00 a	5.9 ab
Control		5.5 ab	1.0 bc	5.8 bc	3.5 a	0.5 ab	0.3 a	2.7 c

[a]Cultivar: Blue Star. [b]Transplanting date: 2 November 1988. [c]Insecticide application dates: 11, 18, 25 November; 2, 9, 16, 23 and 30 December 1988. Terbufos was applied 11 November and 16 December 1988. [d]Observation dates: thrips = 23 December 1988, 12 January 1989; aphids = 23 December 1988. [e]Data are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at 5% level according to DMRT. [f]Plot size: 4.5 m × 3.3 m.

Pepper Pathology

Bacterial Spot Races of Pepper in Taiwan

Summary

Three races of *Xanthomonas campestris* pv. *vesicatoria* were found to occur in Taiwan. Race 1 predominated from those isolated from pepper, while race 3 predominated from strains isolated from tomato. Race 1 was widely distributed throughout the island.

Introduction

Bacterial spot caused by *Xanthomonas campestris* pv. *vesicatoria*, is a major disease of pepper (*Capsicum annuum* L.). Different races of the pathogen have been described. Race 1 is predominant worldwide in most pepper production areas (Cook et al. 1982[1]). Race 2 is found in Brazil, Florida, Guadeloupe and Taiwan, but appears to have limited distribution. Race 3 was recently identified, but distribution is limited (Hibberd et al., 1987[2]). Race 4 has only been reported from pepper breeding lines in Australia (Hibberd, personal communication 1989). Bacteria strains isolated recently from tomato were shown to be predominantly Race 3 on pepper (Hartman and Yang 1990[3]). This study identified the races present in Taiwan, investigated their distribution and maintained the isolates for further use in screening for resistance.

Material and Methods

In 1989, an additional 36 isolates were collected from infected pepper and tomato plants from eight locations in Taiwan. Bacteria were isolated by washing pieces of infected tissue and dipping them in 70% alcohol for 1 min and rinsing twice in sterilized distilled water. The tissue was macerated with a drop of sterilized distilled water using a sterile spatula. A bacterial loop was used to pick up a drop of suspension and to streak the suspension onto a PDA plate. A single colony was selected based upon the color and shape of the colony (yellow-round). Cells were transferred to 523 slant for 24 h at 32°C.

The inoculum and inoculation procedures used were described in the 1988 Progress Report, except that inoculated plants were incubated at a temperature of approximately 28°C. Race identification was done using pepper lines with the *Bs*1, *Bs*2, *Bs*3 genes and Early Calwonder with no known genes for resistance.

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

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

[3]Hartman, G. L. and C.H. Yang. 1990. Occurrence of three races of *Xanthomonas campestris* pv. *vesicatoria* on pepper and tomato in Taiwan. Plant Disease. 74:(in press).

Results and Discussion

Race 1 was found in 70% of the strains from pepper, while races 2 and 3 were 10 and 20% of the strains, respectively. The tomato strains were mostly race 3 (80%) and only 13 and 7% of the races were races 1 and 2, respectively.

Results of this study showed that race occurrence of bacterial spot in Taiwan is determined by factors other than dominant resistant genes since there are no commercial resistant varieties. This study also showed that tomato strains of bacterial spot can infect pepper. Thus, breeding for resistance must consider the races of the pathogen that occur in the targeted area for breeding improvement.

Inoculation Procedures for Evaluating Resistance to Bacterial Spot

Summary

The disease index for plants rated for bacterial spot using four inoculum concentrations was greatest at 10^8 and 5×10^8 cfu/ml on susceptible plants. Plants with a major dominant gene for resistance were slightly infected at 5×10^8 cfu/ml, but not at 10^8 cfu/ml. The range of disease index varied depending upon inoculation pressure with less variation at 1.5 kg/cm^2. Older inoculated plants were less susceptible to bacterial spot, while young plants were highly susceptible. The best age for evaluating resistance in plants was 30-40 days.

Introduction

Xanthomonas campestris pv. *vesicatoria* causes bacterial spot on pepper and tomato. The disease is widespread. It drastically reduces yields. Often, fruits are infected, thus reducing their quality and market value. There are some sources with a major gene for resistance to one of the three races although methodologies in screening for dominant and partial resistance need further development. This study aimed to confirm the best method for inoculation based on the test in 1988 and to determine what screening procedure is most effective in detecting plants with dominant resistance.

Materials and Methods

A strain of bacterium (XVP-16, race 1) was increased on 523 medium. The susceptible plants used in the following three studies were Blue Star, Florida VR2 and Early Calwonder, except in one of the experiments dealing with inoculum concentration. A power sprayer was used to inoculate bacterial suspensions in all experiments.

Inoculum concentration. Forty-four-day-old plants with five to seven true leaves were power atomized (1.5 kg/cm^2) with the following concentrations of bacteria: 10^6, 10^7, 10^8, and 5×10^8 cfu/ml, along with sterilized water as a check. Each treatment had six plants. Fifteen days after inoculation, the percent area infected and defoliation were recorded. A disease index (DI), based upon the summation of severity (percent leaf area infected) and percentage of defoliation [(DI = % area infected + defoliation (%)] was used.

Forty-nine-day-old plants with five to seven true leaves of ECW-10R (*Bs*1 no resistance to race 1), line 3-25-7 (*Bs*2 resistant to race 1) and Early Calwonder (no known genes for resistance) were inoculated with a power sprayer (1.5 kg/cm^2) with one of the following concentrations 10^5, 10^7, 10^8, and 5×10^8, along with sterile water as a check. Thirteen days after inoculation, plants were rated by estimating the percent of leaf area infected (severity).

Inoculation pressure. Forty-six-day old plants with five to seven true leaves were power atomized with a bacterial concentration of 10^8cfu/ml using the following pressures: 0.5, 1.5, and 3.0 kg/cm^2. For each pressure a sterilized water check was added. There were six plants per treatment. Plants were rated 15 days after inoculation. Disease index was devised as described in the previous section on inoculum concentration.

Plant age. Twenty, 30, 40, 60, 80 and 100-day old plants were inoculated with a bacterial suspension of 10^8 cfu/ml by a power atomized sprayer (1.5 kg/cm^2). Plants were evaluated as described previously.

Results and Discussion

Inoculum concentration. The highest DI was obtained from inoculum concentrations of 10^8 and 5×10^8 cfu/ml on susceptible plants (Table 1). Plants with dominant resistant genes had 0% severity at 10^8 and 6% severity at 5×10^8 cfu/ml (Table 2). The severity values of the resistant line (*Bs2*) were easily differentiated from the susceptible plants at an inoculum concentration of 10^8 cfu/ml.

Inoculum pressure. Plants inoculated with water controls had no symptoms of bacterial spot. The highest DI occurred on Florida VR_2 at 0.5 kg/cm^2, and the lowest on Early Calwonder at 3.0 kg/cm^2 (Table 3). DI values ranged from 21 to 73, but were not consistent by variety or pressure. The quantity of inoculum was difficult to control of 0.5 kg/cm^2 and plants inoculated with 3.0 kg/cm^2 had atypical damage on the new leaves. An inoculum pressure at 1.5 kg/cm^2 was most suitable.

Plant age. Data from 30 and 40-day-old inoculated plants had more stable disease indices than plants of other ages. Infection by *Xanthomonas campestris* pv. *vesicatoria* was affected by age of plants. The highest DI value occurred on plants 20 days after sowing seeds and decreased to 3.3 on 100-day-old plants (Fig. 1).

Table 1. Effects of inoculum concentration of *Xanthomonas campestris* pv. *vesicatoria* on the severity and disease index of bacterial spot on three susceptible pepper varieties.

Variety	Inoculum Concentration (cfu/ml)[z]							
	10^6		10^7		10^8		5×10^8	
	Sev. (%)	DI[y]	Sev. (%)	DI	Sev. (%)	DI	Sev. (%)	DI
Blue Star	10[x]	15	20	42	18	31	20	42
Early Calwonder	9	11	15	18	27	44	26	61
Florida VR2	10	17	17	20	31	70	28	72

[z]Colony forming units per ml. [y]Disease Index (DI) = severity (%) + defoliation (%). [x]Each number is the mean of six plants.

Table 2. Effects of inoculum concentration of *Xanthomonas campestris* pv. *vesicatoria* race 1 on bacterial spot severity on three pepper lines.

Line	Inoculum Concentration (cfu/ml)[z]			
	10^5 Severity (%)	10^7 Severity (%)	10^8 Severity (%)	5×10^8 Severity (%)
Bs1	0.3[y]	2.3	19.2	30
Bs2	0	0	0	6
ECW	0.5	4.2	19.5	16

[z]Colony forming units per ml. [y]Each number is the mean of six plants.

Table 3. Effects of inoculation pressure on the disease index of bacterial spot on three susceptible pepper varieties.[z]

Variety	Pressure (kg/cm^2)		
	0.5	1.5	3.0
Blue Star	32[y]	36	43
Early Calwonder	32	21	19
Florida VR^2	73	32	45
Mean	46	30	36

[z]Disease index = severity (%) + defoliation (%). [y]Each number is the mean of six plants.

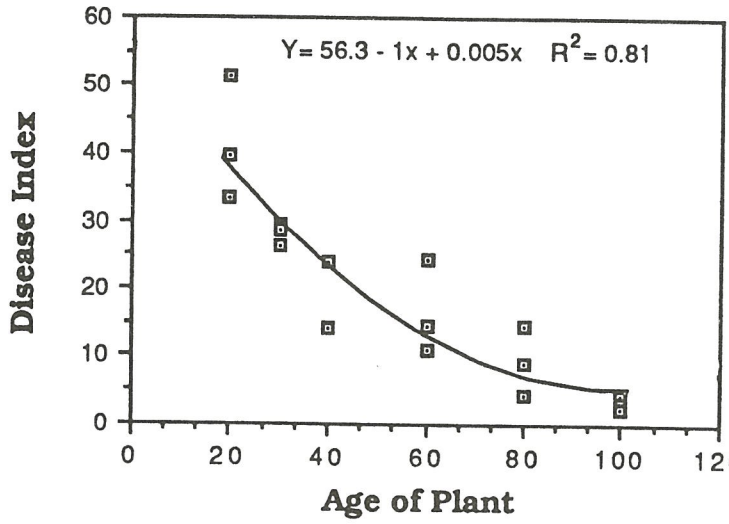

Fig. 1.
Effects of plant age on the disease index of bacterial spot on three susceptible pepper varieties.

These data strongly indicated that early control of bacterial spot on pepper is important and needed when plants are most susceptible. Data from inoculated 30 and 40-day-old plants had more stable disease indices than plants of other ages. Therefore, it is suggested that plants in preflowering stage (with 5-7 true leaves) are optimal for evaluation of resistance.

Disease Survey of Anthracnose and Identification of Species

Summary

Anthracnose on pepper fruits at a wholesale market occurred on approximately 20 to 30% of the total fruits. The causal fungus from infected fruit samples was *Colletotrichum gloeosporioides*. Surveys of pepper fields in highland production areas of Taiwan revealed 1 to 20% of the fruits infected with anthracnose. Most fruits were infected with *C. capsici*.

Introduction

The occurrence of anthracnose on pepper in Taiwan is most prevalent under high temperatures and wet conditions. Symptoms are primarily observed on the fruit. Farmers discard infected fruits in the fields before transporting the farm produce to the market. The fungus causes latent infection on the fruit, and because of this, losses during transit and storage are probably underestimated. This study collected field and market samples of pepper fruits to determine the occurrence of anthracnose and identify the presence of *Colletotrichum*.

Materials and Methods

A survey of pepper fields and a vegetable wholesale market was conducted on 22 and 23 September 1989 in Hsi Hu, Puli, Chin Ching and Chuan Yang. More than 100 infected ripe fruits of hot pepper were collected from Hsi Hu market. The fruits were harvested from the fields and transported to the market one day before and on the day of collection. Estimates were made on percentage of anthracnose on three large piles of hot pepper fruits from which wholesalers culled out infected fruits.

A field of sweet pepper in Chin Ching (highland) was surveyed and infected fruits were collected. Hot and sweet pepper fields at Chuan Yang (highland) were surveyed and 44 infected fruit samples were collected. One hot pepper field at Puli (highland) was also surveyed and 66 infected fruits were collected.

Results and Discussion

Infected fruits from Hsi Hu market had *C. gloeosporioides* (Table 4). Between 20 to 30% of the fruits were infected by anthracnose. These were discarded at the market before redistribution.

From fields in Chin Ching, anthracnose was less than 1% in two sweet pepper varieties, P17 and Blue Star. Of the nine fruits collected, three were infected with *C. gloeosporioides* and none was infected with *C. capsici*. At Chuan Yang, hot pepper field had 20% fruit infection while sweet pepper (P17 and Blue Star) had <5% incidence (Table 4). Of the 44 hot pepper fruit samples from Chuan Yang, 75% were infected with *C. capsici* and none with *C. gloeosporioides*. A hot pepper field in Puli had 30 to 40% fruits infected with anthracnose and of the 66 samples collected, 94% were infected with *C. capsici* and 2% with *C. gloeosporioides*.

Although the survey covered only a few locations and the number of samples collected were limited, findings indicated that estimates of losses due to anthracnose should include field, transit and post-harvest. It is also evident that *Colletotrichum* spp. can vary in their occurrence from location to location. For example, all infected samples from Hsi Hu had *C. gloeosporioides*. These fruits were harvested from the lowlands, whereas *C. capsici* was found in fruits collected from the highlands.

Farmers normally spray fungicides to control this disease (one to six applications). Disease surveys that record incidence of anthracnose vary greatly depending upon control practices. Diseases like anthracnose of pepper are often underestimated because of the rigorous use of fungicides.

Table 4. Occurrence of *Colletotrichum* spp. on infected pepper fruits collected from a wholesale market and from fields located in high elevated regions in Taiwan.

Location	*C. capsici* (%)	*C. gloeosporioides* (%)	Others (%)
Puli[z]	94	2	5
Chuan Yang-1[y]	75	–	25
Hsi Hu[x]	0	100	3

[z]A total of 66 fruits of Szechuan were examined. [y]A total of 44 fruits of an unknown pepper variety were examined. [x]These were rejected fruits (n = 62) samples from a wholesale market.

Occurrence of *Colletotrichum* spp.

Summary

Incidence of *Colletotrichum capsici* and *C. gloeosporioides* on pepper fruit was 18% and 20%, respectively. Lines C00015A and C00679-1 had no infection while the highest incidence was 80% on C00004. When fruits without symptoms were incubated, occurrence of *C. gloeosporioides* was 10 times greater than *C. capsici*. Most fruits without symptoms had some latent infection caused by *Colletotrichum* spp. with an average of 41% of the fruits infected.

Introduction

Pepper fruits are commonly infected by several pathogens. *Colletotrichum* spp. infects the fruit and all vegetative parts of pepper. The disease is often underestimated based on symptoms alone because infection is often latent. This experiment evaluated the ripe fruits (with and without symptoms of infection) to determine the incidence of disease and identify the species of *Colletotrichum*.

Materials and Methods

Each of the 35 ripe pepper fruits from 30 accessions was randomly collected from AVRDC germplasm and hot pepper advanced evaluation trials. Fruits were divided as to those with and without symptoms. The causal organisms from fruits with symptoms were identified in dissecting and compound microscopes. Incidence was recorded. Ten fruits without symptoms from each accession were washed with tap water, dried on a paper towel, and incubated under high humidity in closed containers for one week. The percentage of fruit infection from the total was recorded. The causal organism was identified.

Results and Discussion

Incidence of infected fruits with visible symptoms ranged from 0 to 92% with an average of 46% (Table 5). In most cases, *C. capsici* or *C. gloeosporioides* predominated and only six lines had mixed infection. C00015A and C00679-1 had no infection, while the highest incidence was 80% on C00004. When fruits without symptoms were incubated, *C. gloeosporioides* occurred 10 times more than *C. capsici*. Twenty-four lines had infected fruits after seven days of incubation; only four lines had no infection. Other fungi isolated were primarily *Phomopsis*. spp. Line C00015A had the highest incidence (92%), while 17 lines had no infection.

From these results, *C. gloeosporioides* and *C. capsici* had nearly equal average occurrence of fruits with symptoms. However, *C. gloeosporioides* occurred with more latent infection, which was important. For example, C00679-1 fruit had no visible symptoms, but when incubated, 30% of the fruits had symptoms.

Table 5. Incidence of *Colletotrichum* spp. and other fungi on mature pepper fruits collected from AVRDC germplasm.

Accession/ Line no.	Fruits with symptoms				Fruits without symptoms	
	Incidence (%)	Cc[y] (%)	Cg (%)	Other (%)	Cc (%)	Cg (%)
C00005	72	0	32	40	0	57
C00015A	92	0	0	92	0	50
C00004	80	32	48	0	0	0
C00014-1	48	24	24	0	20	40
C00015	56	16	40	0	0	40
C00015-1	56	8	44	4	0	70
89017	80	8	52	20	0	0
C00017-2	72	44	16	12	0	60
C00022	28	24	0	4	0	10
C00095	56	32	8	16	0	10
C00104-1	36	4	32	0	10	70
C00105-3	64	16	48	0	0	100
89142	48	48	0	0	0	8
89172	68	68	0	0	0	0
89205	52	52	0	0	0	0
C00538	12	12	0	0	0	10
C00659	48	28	20	0	10	0
C00661	12	4	4	4	0	40
C00661	52	44	4	4	0	90
C00661-1	56	8	48	0	10	60
C00661-1	52	40	12	0	–[3]	–
C00662	56	0	56	0	10	60
C00662-1	60	0	56	4	–	
C00664	12	8	0	4	10	80
C00665-1	44	0	8	36	0	90
C00668-1	12	0	12	0	20	60
C00677	28	8	20	0	10	0
C00678	8	0	4	4	0	60
C00674-1	16	0	16	0	0	40
C00679-1	0	0	0	0	0	30
Average	46	18	20	8	4	41

[z]From each accession, 35 fruits were randomly sampled. [y]Cc: *C. capsici*; Cg: *C. gloeosporioides*; Other: Primarily *Phomopsis* spp. [x]No sample taken.

Incidence of *Colletotrichum* and *Phomopsis* Species

Summary

Colletotrichum spp. occurred on 96% of the lower petioles and 55% of the upper petioles of pepper. More *Colletotrichum* spp. were found on samples from Big Star and New Star than in Blue Star and

Szechuan. *C. capsici* and *C. gloeosporioides* were recorded on 51% and 30% of all samples assayed, respectively. Regardless of variety, *C. capsici* was more prevalent than *C. gloeosporioides*. In all samples, New Star had the most infection followed by Big Star, Blue Star and Szechuan. *Phomopsis* spp. were found most frequently on upper petioles (40%). Blue Star had 35% fruit infection with *Phomopsis* spp. The other varieties had no infection.

Introduction

Anthracnose of pepper, caused by several species of *Colletotrichum*, occurs throughout the subtropical and tropical regions of pepper production. The disease is one of the most important constraints in pepper production. There is little information regarding the epidemiology of anthracnose of pepper. *Phomopsis* spp. also causes fruit rot in pepper. However, there is no information on the distribution and importance of this disease. This experiment determined the occurrence of species of *Colletotrichum* and *Phomopsis* on the fruit, fruit stalks and petioles of four pepper varieties.

Materials and Methods

Twenty samples each of the fruits, fruit stalks, lower and upper petioles were randomly taken from four pepper varieties grown in pots outside the greenhouse. Fruit stalks and petioles were cut into 5-cm long, wrapped in cheesecloth and washed in a pipette washer for 1 h. The samples were placed in a large beaker with 1% NaOCl for 20 min, mixed frequently, dipped in a paraquat solution (1 paraquat: 40 water) for 1 min, and then rinsed in sterilized water two times for 2 min each. Samples were placed on moistened filter paper in 15-cm diameter petri dishes. Dishes were placed inside plastic bags and incubated at 28°C for six days. The incidence (number of samples infected) of species of *Colletotrichum* and *Phomopsis* was recorded.

Results and Discussion

Lower petioles had the highest incidence of *C. capsici* (71%), while upper petioles had the lowest incidence (Table 6). Big Star and New Star had the most number of *Colletotrichum* spp. (average) over all tissues. Szechuan had the lowest. *C. capsici* occurred on 51% and *C. gloeosporioides* in 30% of the samples assayed. *C. capsici* was greater than *C. gloeosporioides* in all tissues sampled except fruit. *C. capsici* was greater in two sweet pepper varieties in all tissues. However, occurrence of *C. gloeosporioides* was higher in hot pepper fruits.

Incidence of *Phomopsis* spp. was less than *Colletotrichum* spp. and averaged 15% in all tissues (Table 6). *Colletotrichum* occurred mostly on upper petioles and least on fruit stalks and lower petioles. *Phomopsis* spp. were only found on fruit of Blue Star and not the other varieties. Incidence was generally highest on Blue Star in other tissues.

Although samples were taken from tissues without symptoms, a high level of infection was detected. Lower petioles had the highest incidence probably because the tissue was older, closer to a potential inoculum source and the environment may have been more favorable to infection in the lower plant

Table 6. Percentage of *Colletotrichum* and *Phomopsis* spp. incidence on the fruits, fruit stalks, and petioles collected from four pepper varieties.[z]

Variety	Type of tissue sampled														
	Fruits			Fruit stalks			Upper petioles			Lower petioles			Average		
	Cc[y]	Cg[y]	Ph[y]	Cc	Cg	Ph	Cc	Cg	Ph	Cc	Cg	Ph	Cc	Cg	Ph
Blue Star	50	25	35	50	20	10	20	10	50	100	10	15	55	15	30
Big Star	95	65	0	70	0	0	55	53	5	90	0	5	80	20	10
New Star	25	70	0	50	35	15	35	55	0	45	55	0	40	55	5
Szechuan	15	60	0	55	20	0	15	20	60	40	25	0	30	30	15
Average	45	55	10	55	25	5	30	25	40	71	25	5	51	30	15

[z]Percentage of incidence based on an average of 20 samples. [y]Cc: *Colletotrichum capsici*; Cg: *Colletotrichum gloeosporioides*; Ph: *Phomopsis* spp.

canopy. *Phomopsis* spp. occurred more frequently on upper petioles than *Colletotrichum* spp. Reports have not shown the competition between these two pathogens on pepper, but rather in other crops. *Phomopsis* spp. were not identified in this study, but there are reports of several species infecting pepper.

Initial Infection of *Colletotrichum* spp. on Field-grown Plants

Summary

Petioles of hot pepper varieties, Szechuan and C00104-2 had lower incidence and severity of *Colletotrichum* spp. than in sweet peppers, C00161-3 and C00157-4. Older plants had 15-20% of petioles infected compared to <5% for younger plants. Disease severity was as high as 70% on C00161-3 compared to 17% on Szechuan at 102 days after planting.

Introduction

Anthracnose is a major disease in pepper. Its symptoms occur in all parts of the plant, but infection is not visible in mature fruits. Little information is known on the epidemiology of this disease. However, it is not known where the initial inoculum that causes fruit infection comes from, or the relationship between infection of vegetative plant parts to fruit infection. This experiment evaluated the infection of anthracnose on young plants and determined if early infection of vegetative plant parts relates to later infection of the fruit.

Materials and Methods

Two hot peppers (C00104-2 and Szechuan) and two sweet pepper varieties (C00161-3 and C00157-4) were transplanted to the field on 19 May 1989 in a randomized-complete block design with three replications. Twenty samples of the lowest attached petiole were collected from each pepper entry in each replication. Petioles were cut into 5 cm long, wrapped with cheesecloth, washed in a pipette washer with tap water for 1 h, and placed in a large beaker with 1% NaOCl solution for 20 min with frequent mixing. Samples were dipped in a paraquat solution (diluted 1 to 40 with sterile water) for 1 min and rinsed in sterilized water two times for 2 min each and placed in sterilized petri dishes (15-cm dia.) on moist filter paper. Dishes were placed inside plastic bags and incubated at 28°C for six days. The incidence (number of samples infected) and severity (% of tissue infected) of *Colletotrichum* spp. was recorded.

Results and Discussion

Szechuan and C00104-2 had lower incidence and severity values than C00161-3 and C00157-4 (Table 7). The petioles from older plants in four entries had a higher incidence and severity of *Colletotrichum* spp. than petioles from younger plants. Over 75% of the petioles were infected 102 days after transplanting. The accession C00161-3 had the highest incidence with 70% of the tissues infected.

Table 7. Mean incidence and severity of *Colletotrichum* spp. on petioles collected from a noninoculated field, 1989.[z]

Accession/ Variety	46 days after transplanting		102 days after transplanting	
	Severity (%)	Incidence (%)	Severity (%)	Incidence (%)
Szechuan (hot)	5	3	17	15
C00104-2 (hot)	<1	<1	25	15
C00161-3 (sweet)	9	3	70	20
C00157-4 (sweet)	16	5	56	18

[z]Means are based upon 20 samples of three replications each.

This experiment showed that under field conditions (without inoculation) sweet pepper varieties are more susceptible to infection than hot pepper. The incidence and severity of infection increased in both hot and sweet peppers indicating that infection increases over time. How this early infection relates to later infection of fruit is still under investigation. It is likely, however, that infection of vegetative tissues may provide inoculum for fruit infection.

Effects of *Colletotrichum* and *Phomopsis* Spp. Infection on Seed Germination

Summary

Colletotrichum spp. occurred on 93% of the infected pepper fruits while 9% were infected by *Phomopsis* spp. Lesions on the fruit developed mostly on the distal position. *C. gloeosporioides* occurred more frequently than *C. capsici*. Seed germination averaged 26% from infected fruits and was only 38% in fruits that had <20% severity.

Introduction

Anthracnose can be a limiting factor in pepper production. Besides plant dieback, the pathogen also infects the fruit. Often more than one pathogen is associated with the fruit infection. Several *Colletotrichum* spp. cause fruit infection. However, there is limited information on which species predominates and if fruit infection deters seed germination.

This study investigated the occurrence of species causing fruit infection and determined the effect of fruit infection on seed viability.

Materials and Methods

One-hundred sixty-three infected fruits of hot pepper, Szechuan were randomly collected from a breeding selection plot. Fungi-causing fruit lesions were examined in the microscope to determine the percentage of fruit infection caused by *Colletotrichum* and *Phomopsis* spp. Those infected with *Colletotrichum* were divided into four classes of severity based on the percent area of infected fruit: <20%, 20-40%, 40-60%, and >60%. The lesion in each fruit and microscopic mounts of the fungus causing the lesion were evaluated within each class.

To determine the relationships between fruit infection, seed germination and fungal colonization of seed, 200 seeds were randomly harvested from infected fruits of each severity class. Seeds from each class were wrapped in cheesecloth, dipped in 1% NaOCl solution, agitated for 1 min, and rinsed in sterilized water twice for 2 min each time. Seeds of each class were placed on acid PDA. Data on percentage of seed germination, number of bacteria and fungi on seeds, and the occurrence of *Colletotrichum* spp. were collected one week later.

Results and Discussion

Colletotrichum spp. occurred on 93% of the fruits, while 9% had *Phomopsis* spp. (Table 8). Percentage of fruit infection by *C. gloeosporioides* was 72% compared to 21% for *C. capsici*. Lesion on the fruit were greatest at the distal end of the fruit (73%) when severity was less than 60% (Table 9). Severity of *C. gloeosporioides* was greater than *C. capsici* (Table 10).

Table 8. Fungi causing lesions on fruits of Szechuan collected from a selection trial, AVRDC, 1989.

Causal organism	No. of fruits infected	% of total
C. capsici	34	21
C. gloeosporioides	118	72
Phomopsis spp.	15	9
Total	163	

Table 9. Location of lesions on pepper fruit caused by *Colletotrichum* spp. at four levels of severity.

Severity[z]	Location of infection		
	proximal	center	distal
< 20%	1	5	14
21-40%	3	3	17
41-60%	5	0	15
>60%	9	13	7
Total	18	21	53

[z]Twenty fruits were examined per class of severity.

Table 10. Occurrence of two *Colletotrichum* spp. on infected pepper fruit at four levels of severity.[z]

Severity of Fruit	*C. capsici*	*C. gloeosporioides*
< 20%	2 (10%)	18 (90%)
21-40%	2 (10%)	18 (90%)
41-60%	7 (35%)	13 (65%)
>60%	7 (35%)	17 (85%)
Total	18 (22.5%)	66 (82.5%)

[z]Twenty fruits were examined per class of severity.

Seeds extracted from infected fruits had poor germination in all severity levels. The overall germination of seeds from fruits infected with *C. capsici* was 21% (n = 107), and 31% (n = 539) for fruits with *C. gloeosporioides*. Even at low severity (<20%), the average seed germination was 38% (n = 103).

Under these field conditions, *C. gloeosporioides* occurred more frequently than *C. capsici* as reported in the 1988 Progress Report. However, reports from other countries and AVRDC field surveys indicated that *C. capsici* predominates in certain locations. It is clear that both species are important, although the reason why one species predominates over another is not understood. Factors like alternative hosts, environment, and survival may have some influence.

Findings of the study showed that under low severity, the distal end of the fruit is infected more than the proximal or middle portion because free water accumulates longer at the distal end. This condition favored a more suitable environment for germination and penetration of the conodia.

Seed infection is important to the dispersal of the pathogen and can be devastating to seed production. Results indicated that even under low severity of infection, seed viability was reduced. It is felt, however that further studies are needed to determine if latent infection on the fruit reduces seed viability.

Effects of Inoculation Time and Species of *Colletotrichum* on Germination and Infection of Seed

Summary

Seed germination without inoculation was 83%. It was reduced to 70% when seeds were inoculated for 1 min in a conidial suspension of *Colletotrichum* spp. Only 45% of the seeds germinated when soaked for 30 min in a conidial suspension of *C. capsici*. Inoculated seeds had over 99% infection regardless of soaking time, fungal species used for inoculation or variety.

Introduction

Colletotrichum spp. are seed-borne contaminants on pepper seed. The relationship between fruit infection, seed infection and germination of seeds is unknown. Pepper seeds are often treated with fungicides or hot water to reduce seed-borne pathogens. Heavily infected fruits normally have nonviable seeds. This study determined the effect of seed inoculation on seed germination, seedling and infection.

Materials and Methods

Seeds of sweet peppers, Big Star and Beautiful Star and hot pepper varieties Golden Heat and New Comer were inoculated with *C. capsici* and *C. gloeosporioides*. Twenty seeds of each variety were wrapped in cheesecloth and soaked in a conidial suspension (3×10^6 conidia/ml) of each species for 1, 10 and 30 min. The seeds from each bag were placed on top of sterilized and moist filter paper inside a petri dish. Noninoculated controls were soaked in sterilized water. Plates were kept at constant moisture inside plastic bags and incubated at 28°C for one week. The percentage of seeds infected and germination rate of seeds for each variety inoculated with each isolate were recorded after incubation.

Results and Discussion

Germination of the control seeds without inoculation was 83% compared to an average of 64% of the inoculated seeds (Table 11). The lowest germination (45%) occurred when seeds were soaked for 30 min in a conidial suspension of *C. capsici*. Overall soaking time of the seeds inoculated with *C. capsici* had reduced germination rate more than *C. gloeosporioides* (69 vs. 59%).

There were interactive effects of cultivars and isolates. Of the four cultivars, Golden Heat had the highest seed germination rate averaging over 90% in all treatments. The cultivar seemed more vigorous than others and germinated well despite infection.

Seed inoculation reduced germination. However, since infection levels were close to 100%, seed germination remained relatively high, at least in certain lines. This seed inoculation procedure may not be useful in screening for resistance, but may be helpful in screening isolates for virulence.

Table 11. Effects of soaking the pepper seed at 1, 10, and 30 min in a conidial suspension of *Colletotrichum* spp. on seed germination and infection of seedlings.[z]

	Length of Soaking (min)			
	0	1	10	30
Germination	83	70	66	57
Infection	0	99	100	100

[z]Percentages are means of 160 seeds (four varieties and two species of *Colletotrichum*).

Latent Infection of *Colletotrichum capsici* and *C. gloeosporioides* on Seedlings

Summary

Anthracnose symptoms were not detected on seedlings in 20 days after inoculation. However, all vegetative tissues were infected with *Colletotrichum* spp. Severity of infection on sampled tissues was higher in *C. capsici* compared to *C. gloeosporioides*. Incidence of *C. capsici* was highest on the petioles (86%) and lowest on the shoot tips (63%). Incidence of *C. gloeosporioides* was greatest on the leaves (43%) and lowest on the shoot tips (22%).

Introduction

Colletotrichum spp. can infect all parts of pepper plants. The fungi-causing anthracnose on fruit causes latent infection and symptoms on vegetative tissues. There are reports on seedling infection which causes reduction of plant vigor or death of infected tissues. This study determined the effects of inoculating seedlings on infection and whether this technique may apply to resistance screening.

Materials and Methods

Twenty-six-day-old pepper seedlings (C00104-2, C00157-4, C00161-3 and Szechuan) were inoculated with sterilized water, *C. capsici*, or *C. gloeosporioides*. Two conidial concentrations

(3×10^6 and 3×10^7 conidia/ml) were used for each fungal species. There were three replications of 20 plants each.

The inoculum source was prepared by washing the conidia from six day-old cultures of *C. capsici* and *C. gloeosporioides* with 10 ml of water in a glass slide to dislodge the conidia. Seedlings were atomized with a conidial suspension or water control until run-off. Incubated plants were kept in a growth room at 28 ± 2°C and 90 ± 10% relative humidity for 20 days. Plants were evaluated within 20 days for the development of symptoms.

Nine plants were sampled from each variety within each species and the water control treatment 20 days after inoculation. A leaf disk (1.9 cm dia.), petiole, stem and shoot tip were cut from each plant and wrapped in a piece of cheesecloth. Plant samples were washed in a pipette washer with tap water for 1 hr, removed and placed in a large beaker with 1% NaOCl for 20 min and mixed frequently. Samples were dipped in a paraquat solution (diluted 1 to 40 with sterile water) for 1 min then rinsed in sterilized water two times for 2 min each. Samples were placed in sterilized petri dishes (15 cm dia.) on top of moistened filter paper. Petri dishes were enclosed in a transparent plastic bag and incubated at 28°C for six days. Percentage of infected tissue and the incidence of *Colletotrichum* spp. were recorded.

Results and Discussion

No symptoms were detected within 20 days after inoculation. Incidence of *C. capsici* from samples of four varieties was higher than *C. gloeosporioides* and the control (Table 12). Petioles and stems had a higher incidence of *C. capsici* than leaves and shoot tips. Incidence of *C. gloeosporioides* was greatest on the leaf disks followed by petioles, stem, and shoot tips. The noninoculated plants also had some infection, but the incidence was always lower than on samples from inoculated plants. Line C00104-2 had the highest overall infection.

Table 12. Incidence of *Colletotrichum* spp. on tissues of inoculated seedlings of pepper.[z]

Accession/ Variety	Isolate[y]	Leaf[x]	Petiole[x]	Stem[x]	Shoot Tip
C00104-2	Cc	90	92	89	61
C00157-4	Cc	70	85	85	61
C00161-3	Cc	51	65	66	74
Szechuan	Cc	86	100	89	57
Average		72	86	82	63
C00104-2	Cg	45	18	56	68
C00157-4	Cg	46	8	12	14
C00161-3	Cg	32	57	37	4
Szechuan	Cg	48	49	23	0
Average		43	33	32	22
C00157-4	CK	45	17	3	0
C00161-3	CK	60	0	0	23
Szechuan	CK	17	17	17	17
Average		43	9	12	17

[z]Each number is the mean of nine samples from three replications. [y]Cc = *C. capsici*; Cg = *C. gloeosporioides*. [x]Sample taken from the same relative position of the plant.

There was no evidence showing the role of latent infection on the epidemiology of pepper anthracnose especially as it relates to fruit infection. In this study, even noninoculated plants had some latent infection. Apparently, plants had some latent infection previous to incubation or were contaminated during inoculation. Lack of available information regarding the importance of latent infection makes it imperative to investigate this phenomenon further and to determine the role of latent infection of vegetative tissue on the epidemiology of the disease.

Evaluation of Resistance to Anthracnose

Summary

A total of 1,084 pepper accessions were evaluated for resistance to anthracnose. Six accessions, namely, C00104-3, 105-2, 376, 532, 533 and 755 had no lesions after inoculation. Eighty-one accessions had lesions of less than 0.5 cm diameter. More than 68% of the accessions were susceptible.

Introduction

Anthracnose in both hot and sweet peppers (*Capsicum* spp.) occurs throughout the subtropical and tropical regions of production. Yield losses of over 50% have been reported. Anthracnose of pepper is normally controlled by farmers with multiple applications of fungicides. Developing resistance in commercial varieties may enhance and reduce costs of control. This study identified the resistance sources to anthracnose.

Materials and Methods

A total of 1,084 pepper accessions were assessed by inoculating detached pepper fruits. From the field, 10 ripe fruits of each entry were washed in tap water, dried on paper towels, punctured with five pins (5 mm dia), and placed on a layer of stainless mesh in plastic trays (20.5 × 12.0 × 6.5 cm) containing 50 ml of sterilized water.

The conidia from four-day-old cultures of *Colletotrichum capsici* and *C. gloeosporioides* grown on PDA plates were washed into a beaker. The conidial concentration was adjusted to 3×10^6 conidia/ml. The inoculum was dropped on the punctured region of each fruit. The plastic trays were sealed in a plastic bag to maintain high humidity at room temperature (28°C ± 3).

Diameter of the lesions on each fruit was measured 7 and 14 days after inoculation. The lesion sizes were grouped as follows: very highly resistant (VR) = lesion failed to develop; highly resistant (HR) = lesion diameter of 0-0.5 cm; moderately resistant (MR) = lesion number of 0.5-1 cm; moderately susceptible (MS) = lesion number of 1-2 cm; and highly susceptible (HS) = lesion diameter larger than 2 cm.

Results and Discussion

Accessions, C00104-3, 105-2, 376, 532, 533 and 755 had no lesions on any of the inoculated fruits and were rated as very highly resistant. Eighty-one accessions (7%) had lesions of less than 0.5 cm in diameter (limited to the original inoculated point). Most accessions were susceptible (68%). Those accessions that were rated VR and HR will be evaluated again.

There are different techniques in evaluating anthracnose resistance in pepper. The pin-prick method is perhaps the most quantitative, although it has limitations like other screening techniques that use detached fruits. Most techniques do not account for fruit size and shape or use uniform fruit age. All *in vitro* techniques need to correlate with field results to be effective. More emphasis in the future will be placed on investigating how field tests may be utilized and correlated with laboratory results.

Evaluation of Resistance to Phytophthora Blight

Summary

A total of 300 pepper accessions were screened for resistance to Phytophthora blight in 1989. No highly resistant materials were identified in the trials, but 10 accessions (C00352, C00082, C00071, C01176, C00588, C00226-1A, C00226-1B, C00536, PBC 93A and PBC 93B) were rated moderately resistant.

Introduction

Phytophthora blight of pepper (*Phytophthora capsici*) causes considerable losses under warm and wet conditions. Most commercial varieties are susceptible and under extreme conditions, *P. capsici* overcomes resistance. There are only a few sources of stable resistance to this pathogen. This study focused on screening AVRDC accessions for additional resistance to Phytophthora blight.

Materials and Methods

A total of 300 pepper accessions were screened on separate occasions. The initial 100 accessions were sown on 3 July, and 200 more on 5 August 1989. Three checks, PI 201234 (highly resistant), Szechuan (moderately susceptible) and Blue Star (highly susceptible) were used in each experiment. Ten seedlings of each accession (in two replications) were grown in plastic flats (32 × 48 cm) using sterilized soil-mixture in the greenhouse. The fungus (isolate Yang-1) was grown on V-8 juice agar for one week to produce sporangia. The agar was cut into four equal pieces and moved to empty petri dishes and cut into approximately 1 cm^2 pieces with a sterilized knife. The procedure was repeated after addition of sterilized water to each dish for 10-15 min. Sterilized water was poured in the petri dish to the surface of the agar block; the petri dishes were incubated at 28°C for 24 h of light for one day and then moved to a temperature of 4±1°C for 45 min. The petri dishes were moved back to room with sterilized water containing a zoospore suspension. Drops of the suspension were placed on a hemacytometer and moved to 4±1°C for 5 to 10 min to stabilize the zoospores for counting. Zoospore concentration was adjusted to 10^3 zoospores/ml.

Each flat with 30 to 36-day-old seedling was inoculated by adding 250 ml of the zoospore suspension. The disease reaction was evaluated once a week for one month after inoculation. Plants were rated according to: highly resistant (HR) = mortality PI 201234(<20%); moderately resistant (MR) = mortality Szechuan (20-50%); moderately susceptible (MS) = mortality Szechuan (50-70%); and highly susceptible (HS) = mortality Blue Star (>70%).

Results and Discussion

No highly resistant materials were identified in either set. However, 10 accessions were rated moderately resistant. Nine and 281 accessions were rated moderately and highly susceptible, respectively. All moderately resistant accessions will be evaluated in the future.

In agreement with past studies, optimum concentration for inoculation was 10^3 zoospores/ml using 30 to 40-day-old plants. No highly resistant materials were identified in these tests and since only few highly resistant materials were obtained in past two years, more accessions will be screened to broaden the available material for breeding for resistance to phytophthora blight. AVRDC has more than 5,000 pepper accessions that need screening for resistance.

Screening of Germplasm for Resistance to Viruses

Summary

Four viruses, namely, cucumber mosaic virus (CMV), potato virus Y (PVY), cucumber veinal mosaic virus (CVMV) and tomato mosaic virus (ToMV) are commonly found in pepper in Southeast Asia. Germplasm with reported resistance to some of these viruses has been collected. Thirty-seven lines were screened for resistance to CMV, 15 for pepper veinal mottle virus (PVMV) and 17 for CVMV. One line (VC 35a) was identified resistant to PVMV, and two lines (VC 58a, VC 86), to CVMV. One line (VC 58a) was resistant to both the Malaysian and the Taiwan CVMV isolate. Three lines originating from Korea, had a high number of CMV-resistant plants compared to 100% infected plants in all other lines.

Introduction

About 100 *Capsicum* spp. with reported resistance to different viruses were collected from various cooperators abroad to test their resistance to the most commonly occurring viruses, namely CMV, PVY, CVMV and PVMV. The first two occur worldwide, whereas CVMV has so far only been reported in Southeast Asia. PVMV is common in several tropical African countries.

Materials and Methods

Pepper seedlings at four-leaf stage (approximately 1 month after sowing) were mechanically inoculated in an insect proof screenhouse using a Q-tip. Twenty to 48 plants per accession were used. The inoculum consisted of a homogenate of one part virus-infected leaves in five parts buffer. The following buffers were used:

- CVMV and PVMV: 0.01 M phosphate buffer pH 7, containing 0.5% Na-diethyldithiocarbamate, 0.5% Na_2SO_3 and 0.01% activated charcoal.
- CMV: 0.03 M phosphate buffer pH 7, containing 0.5% Na_2SO_3, 0.017 g/l Na-DIECA, 0.5% caffeine and 0.01% activated charcoal.

The plants were inoculated again one week after the first inoculation. Two weeks after the second inoculation, a DAS ELISA test was performed on individual plants. Plants with negative ELISA reactions were cut between the second and third node and the new shoots that developed were again inoculated. This third inoculation was followed two weeks later by another ELISA test.

Results and Discussion

Results of the screening are shown in Tables 13, 14 and 15. Most of the lines screened for CMV resistance were found susceptible (Table 13). Four lines (VC 58a, VC 61, VC 83a and VC 185a) had 58, 30, 36 and 77% resistant plants. These will be subjected to a second screening.

In last year's CMV screening test, three lines from Korea were found to have some levels of resistance. Seeds of these plants were saved for a second screening and were again found to contain 50% or more resistant plants. These lines may be tolerant to the virus, having a longer latent period than other lines.

One line (VC 35a) was identified resistant to PVMV. Another line (VC 58a) was found resistant to both the Malaysian and the Taiwan isolate of CVMV. Several lines (VC 38a, 39a, 43a, 49a) were found to contain some plants resistant to both the Malaysian and the Taiwan isolate of CVMV, indicating some degree of tolerance or lack of genetic purity.

Two lines (VC 35a, HDA 832) resistant to PVMV and seven lines with CVMV resistance (VC 35, 36, 37, 40, 41, 58a, 66) are now available for use in the resistance breeding program. Lines with acceptable levels of resistance to CMV have not been identified. Further screenings will be necessary.

Improvement of Cucumber Mosaic Virus and Chili Veinal Mottle Virus Screening Method

Summary

Previous resistance screening evaluated the inoculation of plants at four-leaf stage and an ELISA rating two-three weeks later. An experiment was conducted to study whether screening time could be shortened and inoculation could be possible using a power sprayer. For CMV and CVMV, inoculation by power sprayer at 40 kg/cm^2 using 0.3 ml sap/plant was proven inefficient than manual inoculation using a Q-tip. Inoculation of CMV at cotyledon stage gave 100% infection. Inoculation at later growth stages above the first leaf was found ineffective. For CVMV, inoculation at the third leaf stage was effective at earlier stage. However, 100% infected plants were detected only when the ELISA test

Table 13. Classification of lines according to CMV resistance.

Line	Description	Disease reaction infected plants # inoculated plants	
VC 3a	*C. annuum* Serrano Vera Cruz	54/54	
VC 6a	*C. annuum* Yolo Y 082 1001	48/48	
VC 10a	*C. annuum* Yolo Wonder HDV	47/47	
VC 19a	*C. annuum* Serrano 1534	47/47	
VC 31a	*C. annuum* Serrano	20/20	
VC 38a	*C. annuum* HDA 260	46/48	
VC 39a	*C. annuum* HDA 268	48/48	
VC 40a	*C. annuum* HDA 273	27/48	
VC 42a	*C. annuum* PI 109252	48/48	
VC 43a	*C. annuum* PI 264281	44/47	
VC 44a	*C. annuum* PI 163201	49/49	
VC 45a	*C. annuum* PI 183441	46/46	
VC 47a	*C. annuum* PI 169133	42/43	
VC 49a	*C. annuum* PI 169122	47/48	
VC 50a	*C. annuum* PI 178847	47/47	
VC 50a	*C. annuum* PI 178847	67/70	
VC 51a	*C. annuum* PI 171553	41/42	
VC 52a	*C. annuum* PI 175622	49/49	
VC 53a	*C. annuum* PI 159266	48/48	
VC 58a	*C. annuum* HDA 832	16/38	
VC 60a	*C. annuum* Turrialba	48/48	
VC 61	*C. annuum* Jangsugochu	16/23	
VC 83a	*C. annuum* var. aviculare	59/92	
VC 100a	*C. baccatum* var. pendulum 159235	51/52	
VC 101a	*C. baccatum* var. pendulum 152234	15/15	
VC 170a	*C. frutescens* Tabasco	48/48	
VC 172a	*C. frutescens* Tabasco	48/48	
VC 175a	*C. frutescens* Tabasco	45/48	
VC 176a	*C. frutescens* 'Known You'	53/54	
VC 177a	*C. frutescens* 'Known You'	26/26	
VC 178a	*C. frutescens* 'Known You'	21/21	
VC 179a	*C. frutescens* PI 431604	48/48	
VC 185a	*C. frutescens* PI 3222727 Saegochu	5/15	
Blue Star	Taiwan, Known You	49/49	
KHN 11	Korea	3/14	9/18[z]
KHN 15		6/16	17/32[z]
KHN 25		9/13	18/49[z]

[z]Seeds from resistant plants of the first screening.

Table 14. Classification of lines according to PMV resistance.

Line	Description	Disease reaction infected plants # inoculated plants
VC 35a	*C. annuum* HDA 2480	0/48
VC 40a	*C. annuum* HDA 273	15/20
VC 44a	*C. annuum* PI 163201	47/47
VC 49a	*C. annuum* PI 169122	48/48
VC 50a	*C. annuum* PI 178847	23/23
VC 50a-1	*C. annuum* PI 178847	47/47
VC 50a-2	*C. annuum* PI 178847	22/22
VC 51a	*C. annuum* PI 171553	43/43
VC 51a-1	*C. annuum* PI 171553	16/16
VC 52a	*C. annuum* PI 175622	48/48
VC 53a	*C. annuum* PI 159266	45/45
VC 53a-1	*C. annuum* PI 159266	19/19
VC 83a	*C. annuum* aviculare	24/44
VC 112a	*C. chinense* PI 159236	32/32
VC 172a	*C. frutescens* Tabasco	33/33

Table 15. Screening for CVMV resistance.

Line	Description	Disease reaction infected plants inoculated plants	
		AVRDC isolate	Malaysian isolate
VC 19a	*C. annuum* Serrano 1534	48/48	48/48
VC 38a	*C. annuum* HDA 260	7/42	30/46
VC 39a	*C. annuum* HDA 268	21/72	6/46
VC 42a	*C. annuum* PI 109252	72/72	48/48
VC 43a	*C. annuum* PI 264281	29/69	42/48
VC 49a	*C. annuum* PI 169122	49/71	34/48
VC 57a	*C. annuum* Tisana	24/24	24/24
VC 58a	*C. annuum* HDA 832	0/52	0/43
VC 60a	*C. annuum* Turrialba	72/72	48/48
VC 61	*C. annuum* Jangsugochu	28/28	NT[z]
VC 85	*C. annuum*	7/9	NT
VC 86	*C. annuum* Serrano Huasteco	0/12	NT
VC 87	*C. annuum* Cili Padi 6	5/9	NT
VC 170a	*C. frutescens* Tabasco	24/24	NT
VC 175a	*C. frutescens* Tabasco	48/48	24/24
VC 177a	*C. frutescens* Tabasco	24/24	24/24
VC 179a	*C. frutescens* PI 431604	24/24	24/24

[z]Not tested.

was conducted around three-four weeks after inoculation. This indicates that it takes CVMV longer to get established, translocated and multiply in infected plants than CMV.

Introduction

Various inoculation methods for virus resistance screening have been described in literature. Some plants are inoculated at cotyledon stage, others at later growth stages. In previous screenings at AVRDC, plants were inoculated at four-leaf stage. After one week the plants were again inoculated and infectiveness was rated by DAS ELISA two weeks after the second inoculation. This study investigated the effectiveness of inoculations made at earlier growth stages and determined the appropriate time to conduct the ELISA test after inoculation. The efficiency of power inoculation was also investigated.

Materials and Methods

Capsicum annuum lines, namely, Perennial HDV (VC 16a) and HDA 295 (VC 41a), both previously found resistant to CVMV and partially resistant to CMV, and Tisana (VC 57a) and Florida VR-2 (VC 23a), previously found susceptible to both viruses were used.

Inoculations by Q-tip and pressure (4 kg/cm^2/ 20 cm distance) were made at the cotyledon, first true leaf, third true leaf and the fifth true leaf stages. The propagation host for both viruses was *N. glutinosa*.

Inoculum for both methods consisted of a homogenate of one part virus-infected leaves homogenized in five parts 0.01 M phosphate buffer pH 7.0 containing 0.5% Na-diethyldithiocarbamate, 0.5% Na_2SO_3 and 0.01% activated charcoal.

The Q-tip and pressure methods used 0.2 ml and 0.3 ml inoculum per plant, respectively. In mechanical inoculation treatments, plants were dusted with carborundum before inoculation. In pressure inoculated plants, 1.5% celite was added to the plant sap. Eight plants were inoculated per treatment and three replications were made.

The plants were tested by DAS ELISA one, two, three and four weeks after inoculation. In the case of cotyledon inoculation the first, third, fifth and seventh leaves were tested by ELISA. In plants where the first true leaf was inoculated, the second, third, fifth and eighth leaves were tested; when the third leaf was inoculated, the fourth, seventh, ninth and 12th leaves were tested. In plants where the fifth leaf was inoculated, the sixth, ninth, 13th and 16th leaves were tested by ELISA. One leaf per plant was used for every ELISA test.

Results and Discussion

Inconsistent results were obtained using pressurized inoculation. For both viruses, the Paasch airbrush inoculation at a pressure of 40 kg/cm^2 and 0.3 ml sap/plant was found inefficient than manual inoculation using a Q-tip. For CMV, inoculation of susceptible lines VC 23a and VC 57a at the cotyledon and first leaf stages resulted in 100% virus-infected plants. The virus was detected as early as one week and as late as four weeks after inoculation. Efficiency of inoculation seemed to decrease when plants were inoculated at later growth stages. When inoculated at the fifth leaf stage, only 70% of the plants were found CMV-positive at the first ELISA test conducted on the sixth leaf.

For CVMV, inoculation at the first, third and fifth true leaf stage was found more effective than inoculation at the cotyledon stage. Older plants appeared more susceptible to virus infection. CVMV did not seem to move within the plants as fast as CMV which was detected in 100% of the plants one week after inoculation. One week after inoculation, ELISA tests showed 13, 79, 94 and 74% infection in susceptible plants inoculated at the cotyledon, first true leaf, third and fifth leaf stages, respectively. Detection of CVMV was best between three and four weeks after inoculation when plants were inoculated at the first and third leaf stages.

This study suggests that different viruses require different inoculation and rating methods. CMV seems to be more aggressive than CVMV in pepper plants. Therefore, for CVMV resistance screening, the ELISA test should be conducted at a longer time interval after inoculation, i.e. between three and four weeks later.

Detection of Potato Virus Y Pathotypes

Summary

Pathotypes 0 and 1 of potato virus Y (PVY) are most common in temperate countries. Pathotype 1-2 has only occasionally been detected. The 24 isolates collected in Taiwan last year belong to pathotype 0. Ten additional isolates collected in 1989 were also identified as pathotype 0, following inoculation of a set of five *Capsicum* spp. The reason why pathotype 1 has not been found yet in Taiwan is not clear. One explanation could be that cultivars of the Yolo Y type (resistant to PVY-0 and PVY-1) which might favor selection of pathotypes other than PVY-0 are not commonly grown in Taiwan.

Introduction

Potato virus Y occurs worldwide on peppers. PVY-resistant cultivars mostly bred in temperate countries are already available. Brazil is the only tropical country with a strong breeding program for PVY resistance. Resistance is mainly against pathotypes 0 and 1, the common pathotypes in temperate countries. Pathotype 1-2 rarely occurs and has been reported only in the south of Spain and Italy. Information on PVY pathotypes in the tropics is not available.

Last year 29 isolates, of which 25 could be grouped under pathotype 0 were subjected to straintyping. The reaction of the remaining four isolates was not clear. Four isolates were tested again in 1989 and additional isolates were collected for pathotype identification.

Materials and Methods

Ten PVY isolates were isolated from pepper samples collected from various locations in Taiwan (Taiwan: isolate no. 4, 429, 615, 1492, 1497; Hualien: isolates 117, 939, 979; Pingtung: isolate 188; Hsilo: isolate 711). They were purified by two single local lesion passages on *Solanum demissum* A6 followed by two local lesion transfers on *Chenopodium amaranticolor*. These and the four questionable isolates from the previous year were used to inoculate the following *Capsicum* cultivars recommended for the differentiation of PVY pathotypes: Serrano VC, Delray Bell, Yolo Wonder, Yolo Y, Florida VR-2 and Perennial HDV. Ten plants of each cultivar were inoculated with each virus isolate. Symptoms were recorded and all plants were tested by DAS ELISA.

Results and Discussion

All isolates only infected Yolo Wonder. This indicates that they are pathotype 0.

All 35 pure PVY isolates collected so far are pathotype 0. Pathotype 1 which infects pepper genotypes such as Yolo Y and is quite common in temperate countries has not been encountered, because peppers of the genotype Yolo Y which might favor pathotypes other than PVY 0 are not commonly grown in Taiwan.

Identification of Tobamoviruses

Summary

Five tobamoviruses, namely, tobacco mosaic virus (TMV), tomato mosaic virus (ToMV), bell pepper mottle virus (BPeMV), pepper mild mottle virus (PMMV) and tobacco mild green mosaic virus (TMGMV) infect *Capsicum* spp.. The 22 tobamoviruses isolated from pepper in 1988 were all ToMV. Additional samples were collected in 1988. Two isolates were characterized as PMMV by different hosts, agargel immodiffusion and ELISA. These two isolates reacted strongly in DAS ELISA tests using PMMV antiserum; ToMV and TMV controls reacted very weak. ToMV antiserum did not react with isolate 1504 but reacted strongly to isolate 1508 which suggests that the latter may be a mixture of PMMV and ToMV or TMV. ToMV and TMV can not be readily distinguished from one another by DAS ELISA using ToMV antiserum.

Introduction

Tobamoviruses, TMV, ToMV, PMMV, BPeMV and TMGMV are known to infect *Capsicum* spp. (Wetter et al. 1987)[4].

In 1988 survey, 22 tobamovirus isolates were recovered from pepper samples in Taiwan. These were identified as ToMV strains 0 and 1 which are also commonly found on tomato in Taiwan. Several additional tobamovirus isolates were recovered from pepper this year and further investigated.

Materials and Methods

The tobamoviruses were recovered from pepper samples showing mosaic and producing local lesions on *N. tabacum* Xanthi. Following four single local lesion transfers on the same host the isolates were maintained in *N. tabacum* Samsun. The isolates were inoculated on a set of different plants proposed by Wetter et al.[4] for the differentiation of tobamoviruses: *L. esculentum* (cultivars TK 70 and Bonnie Best) *C. frutescens* Tabasco, *N. glutinosa*, *Petunia hybrida*, *N. sylvestris*, and *N. tabacum* White Burley. The isolates were further tested by direct and indirect ELISA using ToMV and PMMV antiserum (provided by Dr. Wetter, F.R.G.). Plant sap dilutions of 1:50, 1:100, 1:500, 1:100 and 1:2000 and immunoglobulin and enzyme conjugate dilutions of 1:500, 1:1000, 1:2000 and 1:3000 were used for the test. SDS agargel immunodiffusion tests, using a medium of 0.9% agarose and 0.4% SDS were also done using a sap dilution of 1:1 and undiluted antiserum.

Results and Discussion

The host range of the tobamovirus isolates is shown in Table 18. From their reactions on the differential hosts it was suspected that isolate 1504 might be PMMV and isolate 1508 TMV. This was further confirmed by direct ELISA tests using PMMV and ToMV antisera.

However, isolate 1508 also reacted with ToMV antiserum, suggesting that 1508 possibly consisted of a mixture of more than one tobamovirus, possibly PMMV and ToMV or TMV.

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[4]Wetter, C. I., I. Dore and M. Bernand. 1987. Bell pepper mottle virus, a distinct tobamovirus infecting pepper. Journal of Phytopathology 119(4):333-344.

Table 16. Reactions of tobamovirus isolates on different hosts proposed by Wetter et al., 1987.

Different hosts	Isolates					
	478 3M 1485	1516 1520	1504	1508	1511	1519
C. frutescens Tabasco	NLL[z]	N,M	NLL/M	NLL/M	N,M	N,M
L. esculentum						
TK 70	M	M	–	M	M	M
Bonnie Best	M	M	–	M	–	M
N. sylvestris	LL	LL	LL	LL	LL	LL
N. glutinosa	NLL	NLL	NLL	NLL	NLL	NLL
N. tabacum White Burley	M	NLL/M	M	NLL/M	M	M M
Petunia hybrida	NLL	NLL	ys, M	ys, M	VN	NLL

[z]NLL = necrotic local lesion, LL = local lesion, M = mosaic, ys = yellow spot, = no infection, no ToMV detected by inoculation to *N. glutinosa*.

Agargel immunodiffusion tests showed that isolates 1504 and 1508 gave a strong precipitin line with PMMV antiserum. Neither of the two isolates reacted with ToMV antiserum. Isolate 1508 in DAS ELISA reacted with ToMV antiserum but did not give precipitin line with ToMV antiserum in the agargel test, because ToMV or TMV constituted only a small percentage of the two viruses which could be detected by DAS ELISA but not by the agargel test.

DAS ELISA was thus useful in distinguishing PMMV from other tobamoviruses such as ToMV and TMV. It could detect mixtures of PMMV with ToMV or TMV. By indirect ELISA, all isolates reacted similarly with either PMMV and ToMV antiserum. Thus, indirect ELISA was not useful in distinguishing among different tobamoviruses. All other isolates showed weak reactions toward ToMV and TMV antisera and were suspected to be ToMV because they infected tomato systemically and *N. sylvetris* showed lesions. Antisera to BPeMV and TMGMV were not available and thus could not be tested.

Further Studies on Chili Veinal Mottle Virus

Summary

Surveys at AVRDC have shown that CVMV which was originally reported only in Malaysia also occurs in Taiwan and other Southeast Asian countries. The virus isolates from Taiwan were further characterized. The isolates from Malaysia and Taiwan were found to infect the same hosts. Five species, reported to be nonhosts of CVMV were found infected with both isolates. Strains of the virus seem to exist as evidenced by one isolate (1062) which infected *Capsicum* line VC 35a. The other 35 Taiwan isolates did not infect VC 35a. In DAS ELISA serological tests, both Taiwan and Malaysian CVMV isolates reacted positively only with the homologous antiserum. Other viruses, such as PeMV, PVY, PVMV, TEV, TVMV and isolate 697 did not react with CVMV antiserum. Necrosis can be produced in several *Capsicum* lines by CVMV alone and by CVMV plus TMV.

Introduction

CVMV, originally reported to occur in Malaysia, was recently detected on peppers in Taiwan and other Southeast Asian countries. Studies were thus conducted to determine whether the isolates from Taiwan are the same as those from Malaysia and whether different strains exist among the Taiwan isolates. Necrotic symptoms frequently observed in screenings for CVMV resistance by artificial mechanical inoculation were also investigated. Such symptoms have never been observed in Malaysia where the virus is endemic.

Materials and Methods

Comparison with Malaysian isolate. A comparative host range test was conducted using several hosts, some of which had been included in the original host range studies and several new host plant species and cultivars. Five plants of each species or cultivar were inoculated mechanically at the first true leaf stage and at the fourth true leaf stage with a CVMV isolate from Taiwan (CVMV-AVRDC) and with an isolate from Malaysia (provided by Dr. Fujisawa, Japan). The plants were observed for symptom expression and tested by DAS ELISA for the presence of CVMV. Both virus isolates were propagated in *Nicotiana glutinosa*.

Strain detection. To detect possible strains, the *Capsicum* lines C 16a, C 17a, C 35a, C 36a, previously found resistant to the Taiwan CVMV isolate and one line previously found susceptible were inoculated with the 29 pure CVMV isolates recovered from pepper in Taiwan. Twenty-four plants of each line were inoculated as described earlier with each of the CVMV isolates. A DAS ELISA test was conducted two weeks after the second inoculation.

Investigation of necrotic symptoms. Untreated seeds of several different *Capsicum* lines were sown in flats of autoclaved soil in an insect proof screenhouse. The plants were mechanically inoculated with CVMV at the first and fourth true leaf stage. Symptoms were observed for four weeks following the second inoculation. An ELISA test, using six pooled leaves per plant (2 leaves each from the top, middle and bottom section) was also conducted four weeks after the second inoculation.

The same pooled leaves were also used to inoculate detached leaves of *N. tabacum* Xanthi and test for the presence of TMV in these plants.

Serological tests. DAS ELISA tests were conducted using CVMV antiserum and PeMV, PVY, PVMV, TEV, TVMV and 697 as antigens. Antigen dilutions used were 1:50, 1:100, 1:500, 1:1000, 1:2000. Immunoglobulins and enzyme conjugates were used at 1:500 dilution.

Results and Discussion

Comparison with Malaysian isolate. The isolates from Malaysia and Taiwan infected the same hosts and produced almost identical symptoms on all hosts tested. With the exception of *Sesamum indicum*, the host range was confined to the Solanaceae. *N. glutinosa*, *N. tabacum* Xanthi, *D. stramoniun* and *L. esculentum*, the nonhosts of CVMV were found infected with the two isolates tested. Although the virus infected these hosts in the experiment, it is not known whether they are also natural hosts of the virus. Other hosts infected by both isolates were *Capsicum annuum* (VC 5a, 6a, 8a, 10a, 15a, 21a, 23a, 27a, 40a, and 170a); *L. frutescens*; *Nicandra physaloides*; *N. tabacum* Samsun, Sylvestris, White Burley, Xanthi NC, Samsun NN; *N. benthamiana*; *N. clevelandii* and *Petunia hybrida*.

Strain detection. With one exception, neither the isolates from Taiwan or Malaysia were able to infect three *Capsicum* lines previously found resistant to a CVMV isolate from Taiwan. However one isolate, 1062, produced necrosis on line C 17a on which all other isolates produced mosaic and infected line C 35a, which no other isolates were able to infect. The isolate also reacted with necrosis in some of the plants of C 36a.

It can be concluded that the Taiwan CVMV isolates, with the exception of isolate 1062 are identical to the CVMV isolate from Malaysia and that strains of the virus seem to exist, as evidenced by isolate 1062 from Taiwan. Isolate 1062 infected *C. annuum* line C 35a which is resistant to all other isolates recovered in Taiwan.

Investigation of necrotic symptoms. Necrotic symptoms were observed in most lines tested. Although plants were only inoculated with CVMV many were infected not only with CVMV, but also with TMV. Necrotic symptoms or mosaic and necrosis were present in plants infected with TMV and CVMV and those with CVMV only. This suggests that CVMV alone can cause necrosis in pepper cultivars. Three lines (Acc. 486, 104-1 and 481) infected with CVMV alone showed severe necrosis. There was high TMV contamination because seeds used had not been treated with sodium triphosphate prior to sowing, which is usually done to eliminate TMV from seeds.

Serological tests. In DAS ELISA tests only the homologous antigen (at concentrations of 1:50, 1:100 and 1:500) reacted to CVMV antiserum. None of the other antigens reacted to CVMV antiserum suggesting that CVMV is not serologically related to PeMV, PVY, PVMV, TEV, TVMV and isolate 697.

Seed Transmission of Chili Veinal Mottle Virus

Summary

Seed transmission has not been reported in CVMV. An investigation was conducted to verify preliminary findings on seed transmission. No seed transmission was found among plants grown from seeds of 10 original AVRDC accessions from Malaysia. Fifteen accessions (in which seed transmission was detected last year) had no CVMV, although a high percentage of virus-positive seeds was obtained by ELISA test. However, with a few exceptions no virus was detected in seed coats, hypocotyls or rootlets of moist paper germinated seedlings of lines in which a high percentage of ELISA positives were obtained by grinding the whole seeds.

Introduction

CVMV was previously detected in plants grown from seeds harvested from artificially inoculated *Capsicum* plants at AVRDC. Since seed transmission had not been reported for this virus, further investigations were made to verify these preliminary findings.

Materials and Methods

Testing of germplasm accessions from Malaysia and Thailand. Ten original accessions from Malaysia (Acc. 104, 105, 325, 326, 327, 328, 329, 330, 331, 332) and 11 from Thailand (435, 436, 439, 441, 466, 467, 473, 470, 474, 477, 491) were tested. Forty plants of each accession were sown without prior seed treatment in sterile soil in an insect proof screenhouse. Ten weeks after sowing the plants were tested individually by DAS ELISA for the presence of CVMV. Three leaves each from the top, middle and bottom of each plant were collected and pooled for ELISA test.

Retesting of accessions where seed transmission was previously detected. Thirteen accessions (Acc. 17B, 104, 436, 441, 467, 480, 483, 485, 486, 487, 492, 559 and 564) in which seed transmission of 11, 32, 7, 13, 23, 39, 4, 17, 19, 25, 2, 40, 42%, respectively was detected in a previous preliminary test were retested. Two accessions, 481 and 488, in which seed transmission had not been detected were used as controls. Seeds of noninoculated plants of line HN-15 kept in an insect proof screenhouse served as the negative checks.

Seeds were treated for 2 h in sodium triphosphate and sown in autoclaved soil in an insect proof screenhouse. These were inoculated twice with CVMV at the fourth and fifth-leaf stages. Four weeks after the last inoculation these were tested by DAS ELISA for the presence of CVMV. CVMV-positive plants were used for seed production. The flowers of these plants were bagged to assure purity of the seeds. Seeds of five randomly selected individual fruits per plant were harvested and used for testing. Seed transmission was investigated by a growing out test, a whole seed test using pregerminated seeds and by testing buffer in which individual seeds had been soaked overnight.

Growing out test. Forty-eight seeds of each line were harvested, sundried and sown immediately in autoclaved soil in an insect proof screenhouse. When the plants reached the eighth-leaf stage they were tested individually by ELISA. Two leaves from the top, middle and bottom part of each plant were collected and pooled for the ELISA test. Plants showing symptoms were also tested for the presence of seed-transmitted TMV by inoculation of detached leaves of *N. tabacum* Xanthi.

Whole seed test. Individual whole seeds were soaked overnight at 4°C in 0.3 ml extraction buffer, crushed and ground with a glass rod and tested individually by ELISA.

Germinated seedling test. Seeds were placed on moist filter paper in petri dishes. When seeds germinated and produced hypocotyls of approximately 3-4 cm long, these were separated into seed coat, hypocotyl and rootlet and tested individually by ELISA.

Soaking seed test. Individual seeds were placed in 0.3 ml extraction buffer at 4°C. The buffer was removed and tested by ELISA.

The regular extraction buffer with no additives was used in all ELISA tests. Preliminary tests showed that extraction buffer with albumin and 0.01 M Na DiECA added gave results comparable to extraction buffer without additives.

Results and Discussion

Testing of germplasm accessions from Malaysia and Thailand. There was no indication of seed transmission in the accessions tested. Plants grown from these seeds had no symptoms and ELISA tests were negative.

Retesting of accessions where seed transmission was previously detected. None of the 15 lines (VC 436, 441, 467, 480, 481, 483, 485, 486, 487, 488, 492, 564, 559, C 104, C 176) tested showed any evidence of seed transmission. None of the plants reacted positively by ELISA. A few plants which showed various degrees of mottling were found infected with TMV or ToMV as evidenced by local lesions on *N. tabacum* Xanthi.

No virus was detected in the buffer in which 50 seeds of each line were shaken overnight, indicating that there was probably no surface contamination of CVMV on the outside of the seed coats.

However, a high percentage of ELISA-positive seeds was obtained from seeds of some fruits when ground seeds were tested. Germinated seedlings of these seeds generally were either ELISA-negative or had a much lower percentage of ELISA-positive values.

This study suggests that although a virus may be detectable in ground seeds, it may become inactivated by enzymatic activity as the seed germinates. This is evidenced by the low percentage of ELISA-positive germinated seedlings compared to the high percentage of ELISA-positives among ground seeds. The virus also did not seem to get established in the growing plant because seedlings originating from infected seeds did not show any symptoms and were found virus-free. It can however not be completely ruled out that the grinding up of seeds of fruits of certain cultivars released substances which could have interfered with the ELISA test.

High percentage of seed transmission of CVMV in plants grown from seeds of infected plants last year is not clearly understood. One explanation may be the temperature difference of seed drying in the batches of seeds harvested in September/October 1988 and those harvested in June/July 1989. Temperature has effects on seed transmission of viruses, with high temperatures frequently minimizing seed transmission. Cooper (1976)[2] has demonstrated that cherry leaf roll virus transmission was 100% and 0% in seed collected from tobacco plants grown at 20° and 30°C, respectively.

Resistance to Important Pepper Viruses

Summary

The CVMV resistance of nine *Capsicum* lines was investigated. Resistance to CMV, PVY and ToMV was also tested. Plants were mechanically inoculated at second-leaf stage with individual viruses. ELISA test was conducted above the inoculated leaves (second, sixth and eighth leaves).

[2]Cooper, V.C. 1976. Studies on the seed transmission of cherry leaf roll virus. Ph.D. thesis, University of Birmingham.

All lines were found susceptible to ToMV; the virus was detected by ELISA in all leaves above the inoculated leaf. In lines previously found resistant to CVMV, all leaves above the inoculated leaf tested negatively compared to the susceptible check plants in which all leaves had high ELISA absorbance values. Most of the lines were also resistant to PVY with no virus detected at any of the leaf positions tested.

All lines were found susceptible to CMV. However, some lines had very low ELISA values in the leaves above the inoculated plants compared to the highly susceptible checks. This study confirmed that the CVMV-resistant genotypes previously identified are highly resistant, with no virus detectable throughout the plant. The study showed that several lines resistant to CVMV also offer resistance to PVY and tolerance to CMV.

Introduction

In previous preliminary screening for resistance, several *Capsicum* lines were identified with various degrees of resistance to the viruses screened. This study was conducted to understand the type of resistance and to select the most resistant lines.

Materials and Methods

Nine *Capsicum* lines previously found resistant to CVMV (VC 16, 17, 33, 34, 35, 36, 37, 40, 41) and one with reported resistance to CMV (MC 5) were studied. Lines Passion and VC 10a served as controls.

The viruses (CVMV, CMV, PVY and ToMV), most commonly encountered on peppers in Southeast Asia were used to inoculate the plants and test their resistance. Plants were twice inoculated mechanically (by Q-tip) at the first true-leaf stage and at the second true leaf stage. A DAS ELISA test was conducted at the second, sixth and eighth leaf above the second inoculated leaf when it was fully expanded using a homogenate of two pooled leaf disks of 1 cm diameter from each leaf.

Five plants of each line were tested and each plant served as one replicate. Two microtiter wells were filled with a homogenate of each leaf.

The same plants were also inoculated with a mixture of all four viruses. An ELISA test was conducted using the same method described above.

Results

Several types of CVMV reactions were observed.

Reaction type 1 (highly resistant). Very low absorbance values (ranging from 0 to 0.008) were obtained in all leaf positions of C 16, 33, 34, 36, 37 and 41. Plants showed no symptoms.

Reaction type 2 (moderately susceptible). Low absorbance values of 0.033 and 0.024 were obtained in the second and sixth leaves in MC 5. Plants showed mosaic symptoms.

Reaction type 3 (highly susceptible). High absorbance values ranging from 0.293 to 0.593 were obtained in Passion and VC 10 in all leaf positions tested, with plants showing mosaic symptoms. Lines 17 and 40 were not evaluated because they were segregated for susceptibility and resistance.

For CMV, different types of reactions were noted. However, these could not be readily distinguished from one another.

CMV reactions:

Reaction type 1 (resistant). Low absorbance values (from 0.002 in the top leaves to 0.047 in the sixth leaf) were found in all leaves of VC 41. Plants showed very mild symptoms.

Reaction type 2 (moderately resistant). Plants of VC 33a and 37a showed mild symptoms in the leaves with absorbance values slightly higher than Reaction type 1. Absorbance values ranged from 0.097 to 0.005.

Reaction type 3 (moderately resistant). A high absorbance value (0.189) in the second leaf above the inoculated leaf and low values (0.032-0.054) in the second leaf were obtained in VC 16. The plants showed mild symptoms.

Reaction type 4 (moderately susceptible). High absorbance values (from 0.093 to 0.115) in the second and sixth leaves above the inoculated leaf and low absorbance values (0.044-0.085) in the leaves above the sixth leaf were obtained in VC 34, 35 and 36. The plants showed some symptoms.

Reaction type 5 (highly susceptible). Very high ELISA values in all leaf positions tested were obtained in VC 10 with plants showing very severe symptoms.

There were several reaction types not clearly distinguishable among types 3, 4 and 5 for VC 16 and 17.

Line MC 5 which was reported to carry resistance to CMV was found susceptible. However, the plants showed some degree of tolerance with intermediate absorbance values (0.096) in the second leaf and high values (0.167-0.345) only in the sixth, eighth and top leaves.

For PVY, two reaction types were observed, namely:

Type 1 (resistant). Very low absorbance values ranging from 0. to 0.004 were observed in all leaf positions of VC 16, 17, 40, Passion and MC 5.

Type 2 (susceptible). High absorbance values (0.218-1.075) were obtained in all leaves of VC 10.

All lines were found susceptible to TMV with high absorbance values in the second leaf and very high absorbance values (>1) in the leaves above. When pooled inoculum was used, TMV infection was clearly detected. With all other viruses, results were obtained which generally did not correspond with the values obtained for singly-inoculated plants.

Conclusion

Good sources of resistance to CVMV, PVY and CMV are available in the lines tested but none to ToMV. Line VC 41 seems best for use in virus resistance breeding programs because of its resistance to both CVMV and CMV.

To find all lines susceptible to ToMV, the most commonly encountered tobamovirus on peppers, was unexpected. In the future, sources of resistance to this virus need to be identified.

Pooled inoculum was found unsuitable for identifying resistance and distinguishing among different types of resistance.

Survey on Pepper Viruses in the Philippines

Summary

Fifty-nine samples were collected from the major pepper production areas in Luzon island in the Philippines. Alfalfa mosaic virus, tomato mosaic virus, cucumber mosaic virus, chili veinal mottle virus and tomato spotted wilt virus were found. Two samples reacted with antiserum to virus isolate 697, previously isolated from tomato in Taiwan and characterized as tobacco vein banding mosaic virus.

Introduction

Surveys were conducted in 1987 and 1988 to gain more information about the viruses present in Thailand, Taiwan, Korea and Indonesia for use in the AVRDC pepper virus resistance breeding program.

Materials and Methods

Fifty-nine samples showing virus-like symptoms were collected from both hot and sweet pepper grown in the Los Baños and Baguio areas. Samples were dehydrated over calcium chloride before they were brought to AVRDC for testing by DAS ELISA for the presence of 12 viruses that infect peppers.

Results

Only 10 of the 59 samples were found to be virus-infected. Three of the 10 plants were infected with AMV, ToMV and CMV and CVMV. Four samples contained TSWV. Two samples reacted with antiserum to virus isolate 697, previously isolated from tomato in Taiwan and characterized as tobacco vein banding mosaic virus.

Virus Purification and Antiserum Production

Summary

Cooperators of the ADB germplasm improvement subnetwork of the collaborative vegetable research program were provided with antisera of CMV, CVMV and ToMV. Virus purification methods used were those previously described.

Introduction

Cooperators of the ADB germplasm improvement subnetwork of the collaborative vegetable research program requested antisera to the most important pepper viruses in the conduct of pepper virus surveys and resistance screening. Sufficient antisera to PeMV and TEV were available from previous virus purifications performed. However, antisera to ToMV, CVMV and CMV had to be made.

Materials and Methods

CVMV and CMV were purified. Three isolates of CMV were used: Peet, P 522 (isolated from pepper) and NT 9. Tomato mosaic virus was purified according to the method described by Wetter et al. (1984).

Antiserum was produced in rabbits as follows: For ToMV, four weekly intramuscular injections were given using 1 ml antigen solution (containing 2 mg ToMV); for CVMV, five weekly intramuscular injections with 0.75-0.9 mg/ml antigen and for CMV, six weekly 2-3 mg/ml antigen.

For the first injections the antigen was emulsified with an equal volume of complete adjuvant; consecutive injections were made using the complete adjuvant. The rabbit was first bled one week after the last injection.

Results

The following virus yields were obtained.
For CMV:
Peet : 18.1 mg/100 g infected leaf tissue
P 522 : 13.2-24.9 mg/100 g infected leaf tissue
NT 9 : 36 mg/100 g infected leaf tissue

Using an extinction coefficient of E 0.1%/10 mm at 260 nm = 5.0, the virus concentration was calculated to be 12.6, 9-30.6, 21.6 mg/ml for CMV Peet, P 522 and NT 9, respectively.

For CVMV: 0.8-2.5 mg/100 g infected leaf tissue

Using an extinction coefficient of 2.4, the virus concentration was calculated to be 0.75-2.75 mg/ml.

For ToMV: 182.8 mg/100 g infected leaf tissue

Using an extinction coefficient of E 0.1% 10 mm at 260 nm = 3.18, the virus concentration was calculated to be 237.74 mg/ml.

Immunoglobulins and enzyme conjugate were prepared as described previously. In DAS ELISA, ToMV, IgG and enzyme conjugate of 1/2000 were distinguished healthy from infected tissue. Similarly, for CMV and CVMV, IgG and enzyme conjugate at 1:1000 dilution were distinguished healthy from infected tissue.

Pepper Physiology

Growth and Partitioning of Dry Matter

Summary

Hot and sweet pepper varieties were grown in hot and cool seasons to evaluate the effect of spacings on growth and yield. Total dry matter production, marketable fruit yield and fruit size of sweet pepper were significantly higher in the cool season than in the wet-hot season. Sweet pepper diverted more dry matter to the fruits during the cool season than in hot season. The number of flowers and fruits of sweet pepper in both seasons were comparable. Yield differences of sweet pepper in both seasons could be attributed to differences in the production and translocation efficiency of dry matter. Total dry matter production and marketable fruit yields of hot pepper were not different in both seasons. However, hot pepper produced more but smaller fruits in the hot season than in the cool season. Apparently, hot pepper set more fruits in the hot than in cool season. Close intrarow spacing at 30 cm appeared most suitable for fruit yields of hot and sweet peppers in both seasons.

Introduction

To attain maximum harvest in *Capsicum* plants, important consideration is given to maximum dry matter production and desirable balance between supply and use of assimilates. Maximum dry matter production, however, depends on photosynthetic potential, environmental conditions and canopy structures conducive to the process. Generation of desirable balance between supply and use of assimilates requires the reduced competition for assimilates by other plant parts and/or the increased sink strength of fruit for assimilates.

The study addressed the maximum dry matter production and the balance of dry matter distribution during the vegetative and generative development of hot and sweet peppers grown in the hot and cool seasons. Investigations of the physiological aspects of root-top interactions under high temperature condition and source-sink relationships between vegetative and generative parts in *Capsicum* plants could give information on how source-sink relationship under stressed conditions can be manipulated for high yields.

Materials and Methods

Seeds of sweet pepper, Blue Star and hot pepper, Passion were sown in seedling flats on 20 May and 1 Sept. 1988, respectively. Seedlings were later transplanted to the field on 17 June and 5 October 1988, respectively. Mean maximum and minimum temperatures for plantings in June and October were 31.1°C and 24.2°C, and 24.8 and 15.6°C, respectively. Cultural management practices employed in the hot and cool seasons were the same.

Plots of 1.5 × 6.0 m^2 were arranged in a randomized complete block design with four replications. Interrow spacing was 50 cm, and intrarow 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. 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. Leaf chlorophyll and NPK content in the petiole were analyzed. Data on light penetration by the canopy were recorded every two weeks. Flowers

and fruits were counted twice weekly. 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

Hot pepper produced comparable fruit yield under hot and cool seasons, in spite of heavy rainfall during the hot season (Table 1). Every plant grown during the hot season tended to have more but smaller fruits than planted in cool season. Plants in dense spacings produced larger fruits but lesser fruits than those in sparse spacing. Yield on unit area basis increased as planting density increased.

However, sweet pepper grown in the cool season produced more fruits than those grown in the hot season (Table 1). Plants spaced at 30 cm had higher yields than the other two spacings. Reduction in yield during the hot season was mainly due to a decrease in fruit size.

Hot pepper produced comparable number of flowers in both seasons of the same spacing, except that plants in the hot season had more flowers in 60 cm intrarow spacing (Table 2). Hot pepper had higher fruit-set percentage and more fruits in the hot season than that of the cool season due to small fruits in hot season. Low fruit-set percentage of hot pepper in the cool season could be due to larger fruits which retarded the development of late flowers. Furthermore, the reduction in the number of fruits in the cool season was compensated by the increase in fruit size. Thus, the overall yield of hot pepper was not different in these two seasons.

Sweet pepper also produced comparable number of flowers and fruits in both seasons (Table 2). However, fruit size of sweet pepper in cool season was four to six times bigger than in hot season. Hot pepper had more flowers and fruits and higher fruit set rate than sweet pepper at 15 weeks after transplanting.

The number of seeds per fruit in both peppers was not influenced by spacing, but high temperature during hot season substantially reduced it particularly in sweet pepper. Reduced pollination and fertilization under high temperature condition made the fruits smaller.

Table 1. Yield components of hot and sweet peppers grown in hot and cool seasons.

Season	Hill space (cm)		Fruit yield (t/ha)		No. of fruits/ plant		Fruit size (g/fruit)	
	Hot	Sweet	Hot	Sweet	Hot	Sweet	Hot	Sweet
Hot	30	30	34.9 a[z]	13.0	107 b	10	11.3	57.9
	45	45	29.8 ab	7.8	139 ab	8	11.4	49.4
	60	60	22.6 b	5.3	148 a	5	9.8	52.9
Cool	30	30	31.4 a	28.1 a[z]	40.9 b	8.3	19.3 a	84.6
	45	45	25.8 ab	18.2 b	62.0 a	8.4	15.6 b	81.4
	60	60	21.4 b	13.6 b	70.1 a	8.6	14.5 b	75.8

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

Table 2. Characteristics of reproductive development of hot and sweet peppers grown in hot and cool seasons.

Season	Hill Space (cm)		No. of Flowers/ plant		Fruit set (%)		No. of seeds/fruit	
	Hot	Sweet	Hot	Sweet	Hot	Sweet	Hot	Sweet
Hot	30	30	112.1	49.0	73.4	57.4	82.7	66.6
	45	45	157.8	68.0	75.9	37.9	81.3	65.9
	60	60	207.8	59.3	75.0	36.3	81.8	52.8
Cool	30	30	124.9	49.6	45.1	31.8	127.2	303.2
	45	45	146.4	47.5	49.2	34.8	124.6	292.2
	60	60	144.8	56.1	42.9	29.3	126.9	279.8

Regardless of planting season at 45 and 60 cm intrarow spacing, hot pepper accumulated more dry matter than in 30 cm intrarow spacing (Fig. 1). Plants in sparse spacing tended to have more branches and dry matter in the stem. A significant amount of dry matter accumulation of more than 40% was accounted for at 15 weeks after transplanting (Fig. 1). Hot pepper of same spacing accumulated more or less comparable dry matter in two seasons; they thrived under hot-wet conditions.

Sweet pepper, regardless of intrarow spacings, in the cool season accumulated more dry matter than in the hot season (Fig. 2). There was an inefficient dry matter translocation to the developing fruit in the hot season than in cool season. About 20-30% of dry matter in the hot-wet season was noted 15 weeks after transplanting.

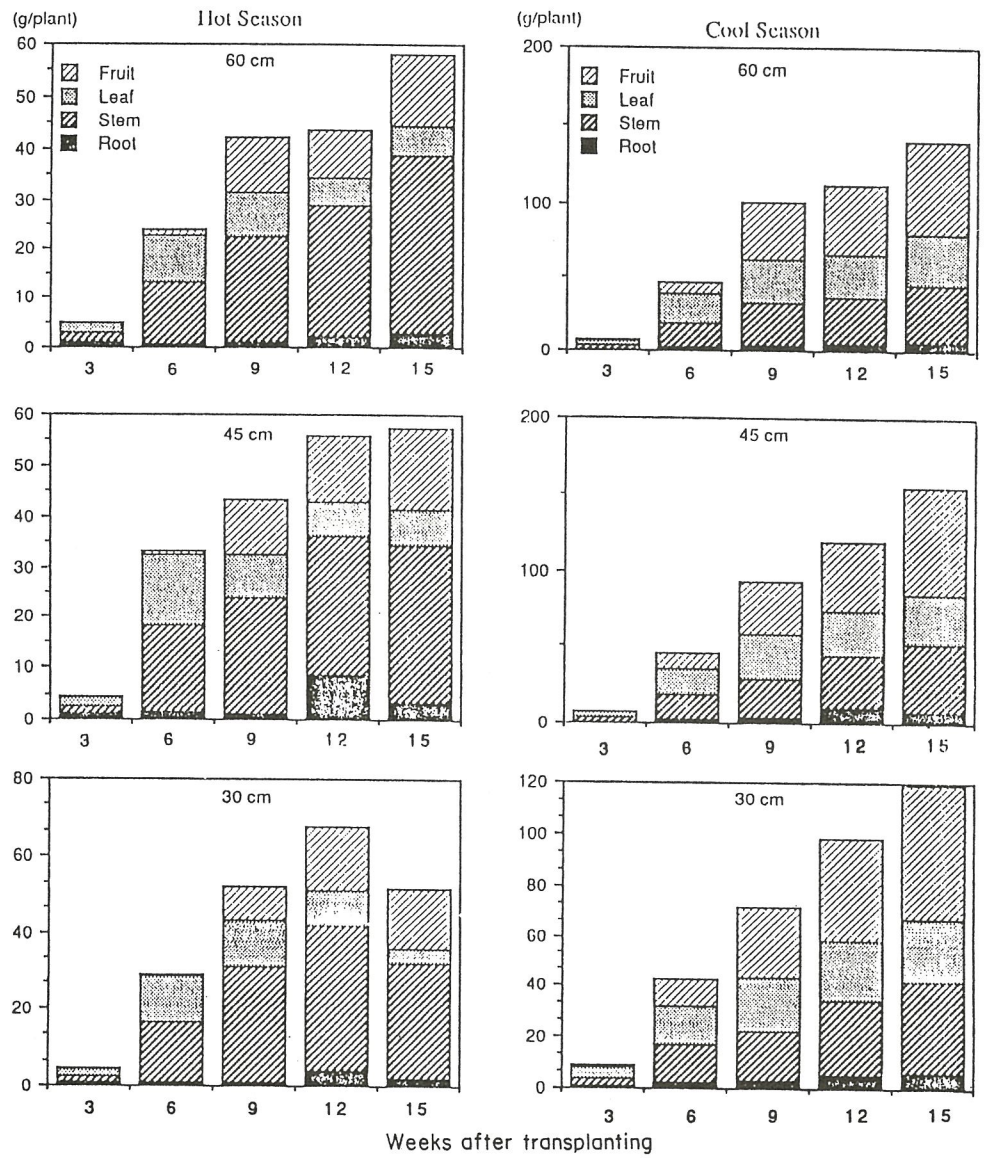

Fig. 1. Accumulation and distribution of dry matter in hot pepper grown under three spacings in hot and cool seasons.

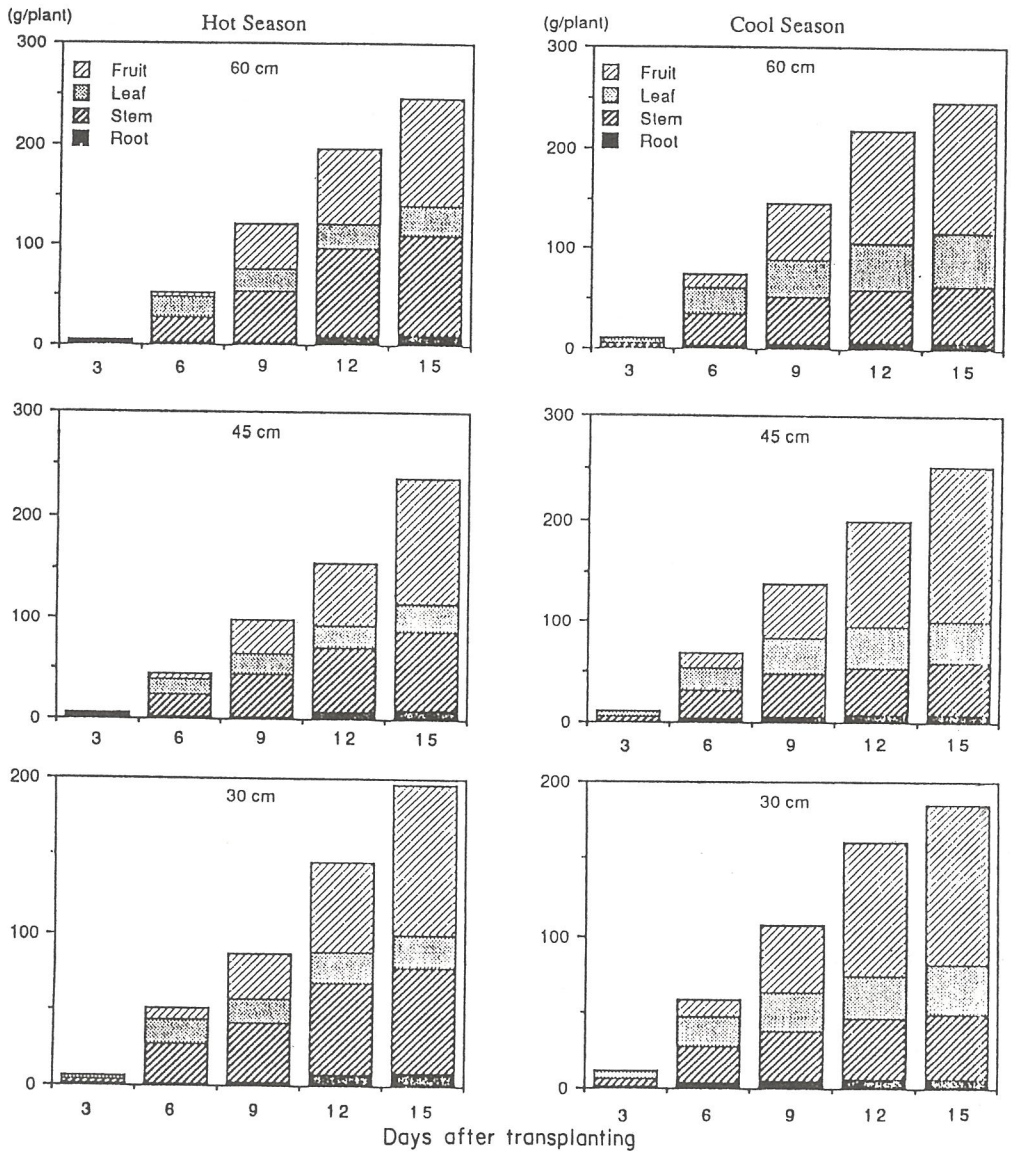

Fig. 2. Accumulation and distribution of dry matter in sweet pepper grown under three spacings in hot and cool seasons.

On community basis, hot pepper in both seasons at 30 and 45 cm intrarow spacings had higher CGR than at 60 cm intrarow spacing (Fig. 3) because of high LAI in dense population (Fig. 4). Hot pepper in the hot season had smaller LAI at early growth stage than that in the cool season. Hot pepper produced few but bigger leaves. Although there was no apparent difference in NAR, i.e. photosynthetic potential of the same season among different intrarow spacings, hot pepper in the hot season tended to have high NAR. Since CGR is the product of LAI × NAR, the compensatory effect of LAI and NAR contributed to the comparable dry matter production of hot pepper grown in two seasons.

CGR of sweet pepper in the cool season was higher than in the hot season (Fig. 3) because of high LAI (Fig. 4). CGR of sweet pepper grown in the hot season declined six weeks after transplanting because of heavy rainfall (418 mm) in August. Survival rate of sweet pepper after flooding in the hot season was generally lower than that of hot pepper, more than 90% of hot pepper plant versus

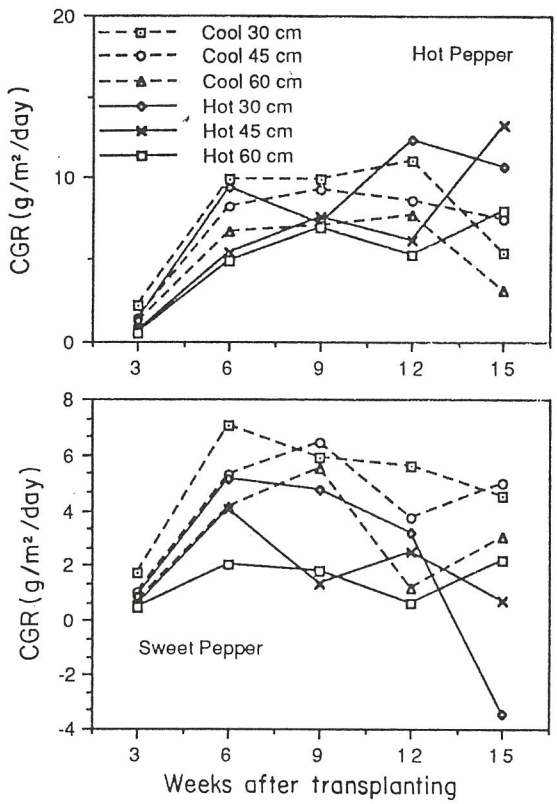

Fig. 3. Crop growth rate (g/m^2/day) of hot and sweet pepper grown three spacings in hot and cool season.

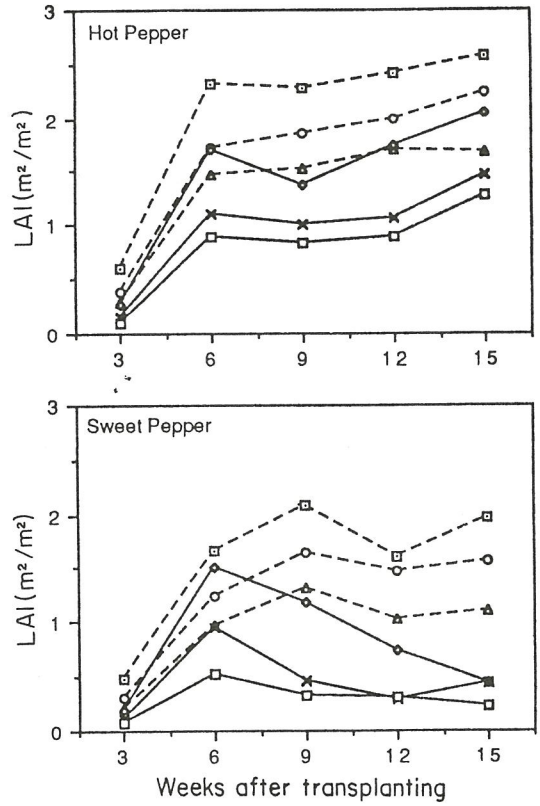

Fig. 4. Leaf area index of hot and sweet sweet peppers grown under three spacings in hot and cool seasons.

42-74% of sweet pepper among three spacings. At 60 cm intrarow spacing, both peppers had lower survival rates than in close spacing due to high soil temperature right after flooding resulting from ready exposure of soil surface to solar radiation.

The accumulated dry matter and CGR of sweet pepper were substantially lower than that of hot pepper (Figs. 1, 2 and 3) because of low LAI in sweet pepper (Fig. 4). High shoot/root ratio nine weeks after transplanting in the hot season clearly indicated that the root system was damaged by flooding in both peppers. However, hot pepper readily recovered from flooding.

On NPK content in the petiole, N in both pepper varieties slightly decreased as plants grew in both planting seasons. Phosphorus, on the other hand, greatly increased as growth advanced in both peppers nine weeks after transplanting in the hot season but not in the cool season (Fig. 5). because of heavy rainfall.

Potassium content in both peppers in the hot season decreased as growth advanced at six weeks after transplanting, however, the decrease was drastic in the cool season (Fig. 6). This may be an indication of the leakage of soil potassium due to heavy rainfall in the hot season. Relatively high potassium level in the cool season may promote the translocation of assimilate from leaves to the developing fruit. No great difference of NPK content was observed in the petiole among three intrarow spacings.

There was a potential difference of dry matter production between hot and sweet peppers under high temperature conditions. Close intrarow spacing at 30 cm produced more dry matter and fruit per unit land area. More dry matter was diverted to the developing fruit of hot pepper particularly in the cool season. How an underlying control of dry matter partition could be exerted is not yet known. Enhanced pollination and fertilization under low temperature conditions may have increased seed formation thereby hormonal level to strengthen sink activities in the developing fruit.

Potassium may have also facilitated the translocation of assimilates. Regarding plant survival under heavy rainfall, the root system of both peppers was sensitive to flooding but hot pepper readily recovered after flooding.

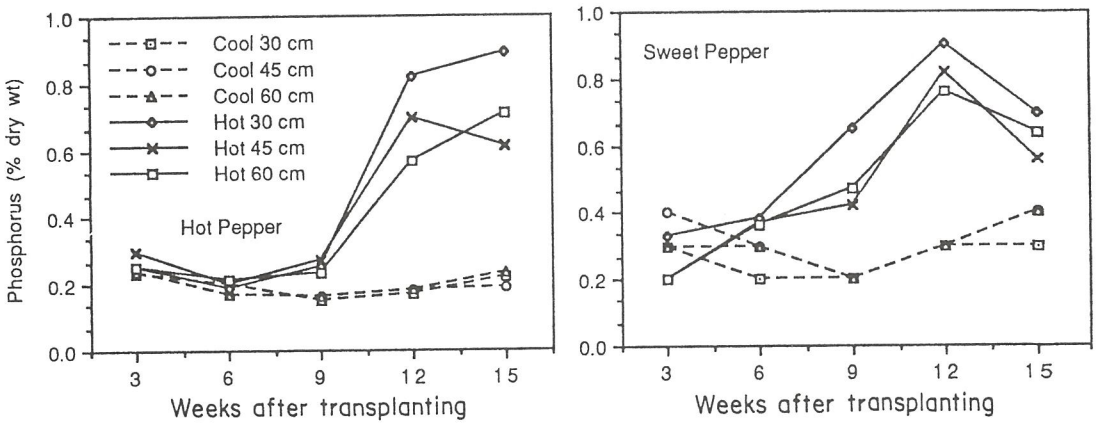

Fig. 5. Phosphorus content in the petioles of hot and sweet peppers grown under three spacings in the hot and cool seasons.

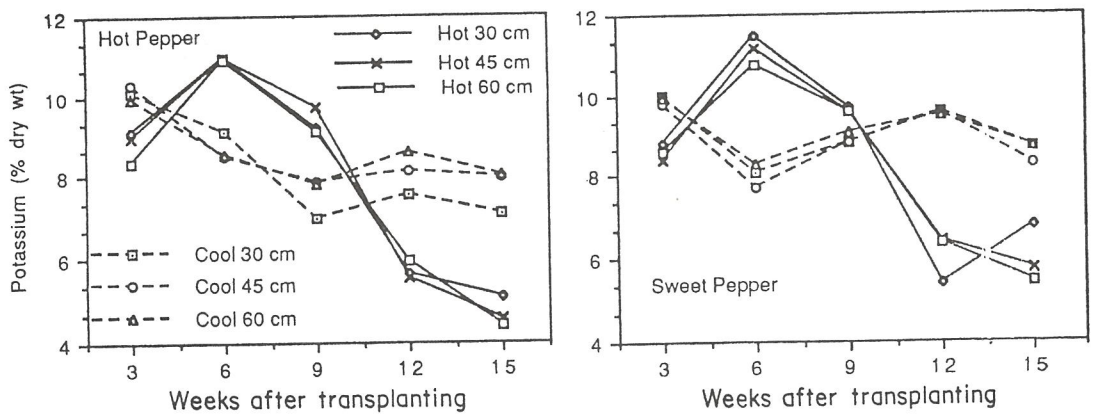

Fig. 6. Potassium content in the petioles of hot and sweet peppers grown under three spacings in the hot and cool seasons.

Generative and Growth Characteristics of *Capsicum*

Summary

Twenty sweet and 28 hot pepper varieties were investigated for growth and generative characteristics in three distinct seasons to relate these characteristics to the yield formation in both peppers from a wide range of genetic background. Results refute the contention that most *Capsicum* plants are sensitive to high temperatures in terms of fruit-set. On the contrary, the number of fruits in both peppers tended to increase at high temperatures without heavy rainfall. However, the ovary and fruit size of both peppers were significantly reduced at high temperatures. Fruit size was positively related to ovary size. There was a negative correlation between the number of fruits and fruit size. Overall fruit yields were higher in the hot than in the cool season. The number of seeds per fruit was lesser in fruits obtained in the hot than in the cool season. It is possible that seed formation is related to fruit development. Fruits in the hot season contained high sugar content. Overall growth of both *Capsicum* plants was 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 shedding may be great in the hot season such that the yield is seriously reduced. The cause of this shedding in *Capsicum* plants under high temperature conditions is not well understood. This study investigated the generative characteristics of hot and sweet pepper as related to yield and yield components from a wide range of generic background. These *Capsicum* plants were grown in three distinct seasons.

Materials and Methods

Seeds of 20 hot and 28 sweet pepper varieties were sown on 25 April (the first planting) and 20 September 1988 (the second planting), and 13 April 1989 (the third planting), respectively. Later these seedlings were transplanted to the field on 3 June and 3 November 1988, and 24 May 1989, respectively.

Plots were arranged in a randomized complete block design with three replicates. Each plot was composed of 30 plants. Every plant from each replicate was randomly tagged and flowers and fruits were counted twice weekly. At four and eight weeks after transplanting, 20 newly open flowers of each replicate were randomly sampled and investigated for number of corolla lobe, percentage of style exsertion, length of exserted style, and fresh and dry weights of ovary. Percentage of fruit-set was evaluated from three randomly selected plants. Mature fruits of each replicate were investigated for number of fruits per plant, average fruit size, number of seeds per fruit, and fresh and dry weights of fruits. Four randomly selected plants per replicate were harvested and dry weights of different plant parts were determined. Yield and its components and other growth and quality characteristics were also investigated.

Mean maximum and minimum temperatures were 31 and 24°C for the first planting, 23 and 13°C for the second planting and 31 and 24°C for the third planting, respectively.

Results and Discussion

Among plantings, the first and the third fell in the hot season and one in the cool season. The first planting experienced heavy rainfall. It was also damaged by an increased soil temperature due to typhoon. The second and third plantings served the purpose of comparing the effects of temperatures.

Among entries, hot pepper produced more flowers and fruits (both total and marketable) due to an increase in fruit-set in the hot than in the cool season (Table 3). Hot pepper grown in the hot season produced substantially higher yield (seven-fold) and fruit dry weight (three-fold) than in the cool season. Hot pepper produced smaller fruits with fewer seeds in the hot than in the cool season because of an increased stigma exsertion in the hot season. However, fruit-set was not dependent upon pollination and fertilization because hot pepper set more fruits in the hot season despite increased stigma exsertion.

Table 3. Means and ranges of generative characteristics and total dry weight of 20 hot and 28 sweet pepper varieties grown in three seasons.

	June 88		Nov 88		May 89	
	Hot	Sweet	Hot	Sweet	Hot	Sweet
No. of flowers/plant	143	45	114	32	236	58
Total no. of fruits/plant	63	14	52	12	113	24
No. of marketable fruits/plant	18	11	18	5	89	21
Total fruit dry wt (g/plant)	32	23	26	9	93	57
Market. yield (g/plant)	87	256	64	370	449	414
Fruit set (%)	66	47	48	40	92	41
Mean fruit size (g)	5	28	14	106	6	40
Exsertion rate (%)	91	76	75	15	82	97
No. of seeds/fruit	25	45	101	162	52	41
Total dry wt (g/plant)	–	–	72	49	193	156

Hot pepper also produced more dry matter in the hot than in the cool season. In brief, high temperatures seemed favorable to hot pepper production.

Sweet pepper produced more flowers and fruits despite the increased stigma exsertion in the hot than in the cool season (Table 3). Sweet pepper also produced higher yield and fruit dry weight in the hot than in the cool season. However, the increase under hot conditions is less than that of hot pepper. There were comparable fruit-set percentages between two seasons. Akin to hot pepper, sweet pepper produced smaller fruits and lesser seeds in the hot than in the cool season. Sweet pepper also produced more dry matter during hot season than in cool season. In brief, sweet pepper thrives in high temperatures but produces large fruits under low temperatures. Hot pepper produced more flowers and set more fruits than sweet pepper.

Between plantings in November 1988 and May 1989, negative correlations were observed between the number of fruits per plant and average fruit size in both hot and sweet peppers (Fig. 7). Results suggested that there was a competition for assimilates between fruit-set and increment. It is interesting to note that there were also negative correlations between fruit size and sweetness in both peppers (Fig. 8). Fruit size in both peppers, on the other hand, was positively correlated to ovary size (Fig. 9). Ovary size of sweet pepper was significantly larger than that of hot pepper. Fruit size was apparently predetermined by ovary size around the anthesis in both peppers. It would be interesting to study further whether manipulation of environmental conditions during anthesis would foster fruit increment.

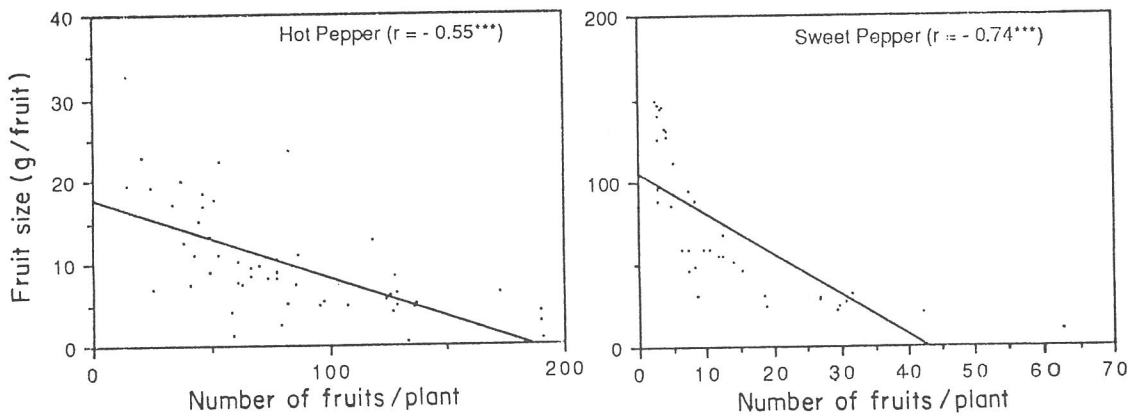

Fig. 7. Correlations of number of fruits and fruit size of hot and sweet peppers planted in November 1988 and May 1989.

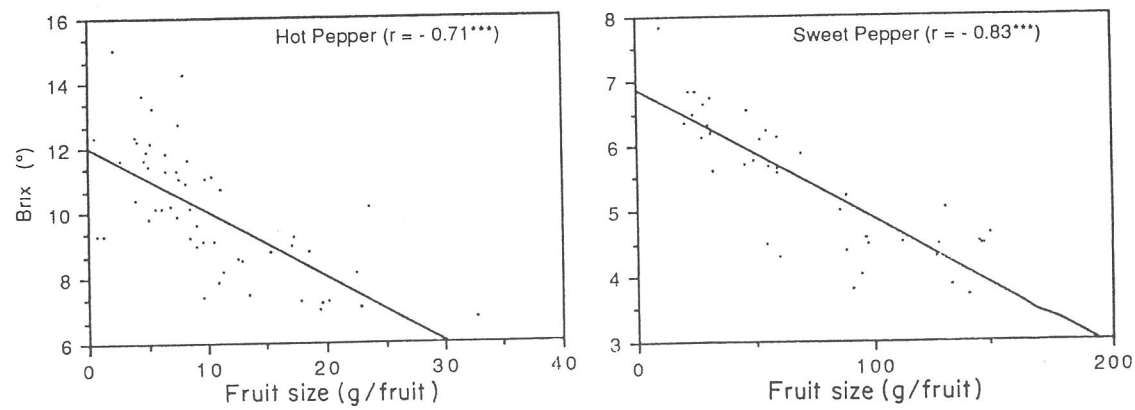

Fig. 8. Correlations of fruit sweetness and size of hot and sweet peppers planted in November 1988 and May 1989.

Since fruit size in both peppers was positively correlated to number of seeds per fruit (Fig. 9), more seeds in the fruit of sweet pepper (Table 3) could be ascribed to its fruit size. Results suggested that potential ovary size around anthesis of *Capsicum* plants may also depend on the scope of ovules fertilized. Some peppers among three plantings exserted relatively short styles. The longest was not more than 4 mm from anther to the base of stigma. In contrast to tomato, the style of *Capsicum* plant barely exserts at high temperatures. Thus, the style of *Capsicum* plant is considered relatively heat tolerant. This could be one of the factors accounting for the heat tolerance of *Capsicum* plants. Furthermore, fruits of both peppers produced seeds under hot conditions (Tables 5 and 6). This suggested that *Capsicum* plants, in contrast to tomato, produce viable pollens and ovule at high temperatures.

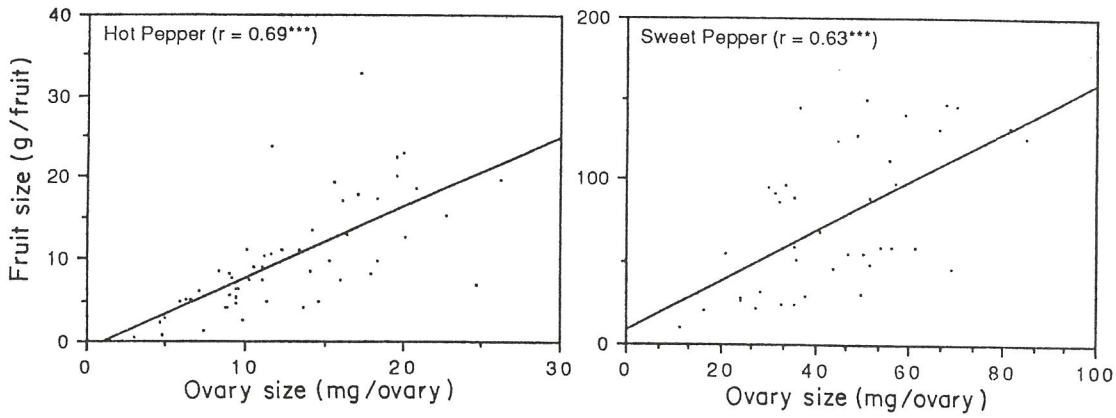

Fig. 9. Correlations of ovary and fruit size of hot and sweet peppers planted in November 1988 and May 1989.

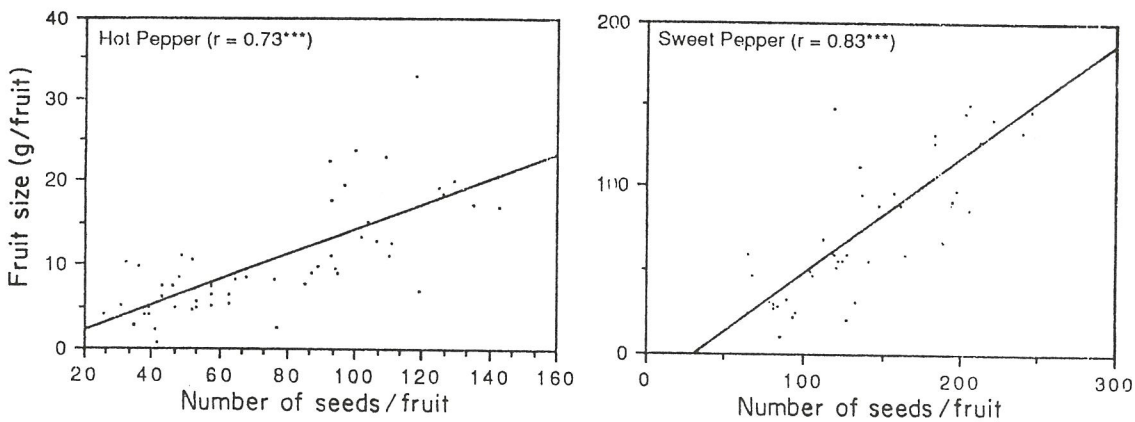

Fig. 10. Correlations of number of seeds and fruit size of hot and sweet peppers in November 1988 and May 1989.

Effects of Row Directions on Growth

Summary

Mulching with silver-colored polyethylene film increased soil temperatures of east-side and west-side rows at 3 and 2 °C, respectively, of the NS-oriented row bed, and south-side and north-side rows at 2 and 1 °C, respectively, of the EW- oriented row bed with sweet pepper, Blue Star, transplanted

in June 1989. There were no differences in soil temperatures between rows and bed directions of the NS- or EW-oriented row bed without mulching. Sweet pepper plants of the EW-oriented bed without mulching produced more dry matter than those of the NS-oriented bed. Under PE mulching, plants in the east side produced lesser dry matter than those of the west side of the NS-oriented bed. Those in the south side had lesser dry matter than the north side of the EW- oriented bed.

Introduction

In summer 1988, great differences in growth of pepper plants were observed between east and west rows of the conventional, NS-oriented row bed mulched with silver-colored polyethylene film overlaid with rice straw. This study ascertained the cause of the differences.

Material and Method

Seeds of sweet pepper, Blue Star were sown on 23 May 1989 and transplanted to the row bed on 27 June 1989. The row bed was 6.0 m × 1.5 m in size, with plants spaced 45 × 50 cm, and 25 cm in height. Four treatments were employed, namely: 1) NS-oriented row-bed without mulching; 2) NS-oriented row-bed with PE mulching; 3) EW- oriented row-bed without mulching; and 4) EW-oriented row-bed with PE mulching. A split-plot design with four replicates was employed.

Soil temperatures at 10-cm depth of both sides of the row bed were monitored for 24 h weekly. The experiment was terminated 30 days after transplanting. Dry weights of sweet pepper plants were determined.

Results and Discussion

Mulching increased the daily mean soil temperature up to 3, 2, 2, 1°C for east- and west-side of the NS-oriented row bed, and south and north side of the EW-oriented row bed, respectively (Table 4). There were no differences in soil temperatures among rows and bed directions of the row bed without mulching. For the row bed with PE mulching, east-side was 1°C higher than west-side in the NS-oriented bed, whereas south-side was 1°C higher than north side in the EW-oriented bed.

Table 4. Mean soil temperatures (°C) at 10 cm depth on bed sides of the row bed with sweet pepper running either north-south or east-west direction.

Days after Transplanting		NS-oriented		EW-oriented	
		East	West	South	North
0-15	Control	29	28	28	28
	Mulching	29	29	29	29
16-30	Control	28	28	28	28
	Mulching	31	30	30	29

Without PE mulching, plants of the EW-oriented row bed seemed to produce higher dry matter than the NS-oriented row bed (Table 5). Total dry matter was lower in east side of the row bed with PE mulching than the west-side of the NS-oriented bed, and the south-side was lower than north-side of the EW-oriented bed. Mulching also reduced root dry weight, especially in east side of NS-oriented bed and south side of the EW-oriented bed. Similar experiments were also conducted later. PE mulching raised soil temperatures about 2°C; however, no differences in soil temperatures in four bed sides were observed.

Results clearly indicated that the east slopes on the row bed running north-south and south slopes on row bed running east-west received more radiation during the day. Under mulching conditions, this would increase soil temperatures up to a detrimental level to sweet pepper growth under hot summer conditions.

Table 5. Mean dry weights (g/plant) of sweet pepper grown on bed sides of the row bed running either north-south or east-west.

Treatment	Bed-side	Top	Root	Total
Control	East	10.2	1.2	11.4
	West	10.3	1.0	11.4
	North	11.2	1.4	12.7
	South	11.7	1.1	12.8
Mulching	East	10.9	1.0	12.0
	West	12.2	0.9	13.1
	North	11.3	1.3	12.7
	South	10.1	1.0	11.1

Bacterial Leaf Spot Resistance Expressed in Tissue Culture

Summary

The interaction of race 1 of *Xanthomonas campestris* pv. *vesicatoria* and three cultivars of its host sweet pepper, resistant Early Calwonder-30R (ECW-30R), partially resistant PBC163 (Redland Sweet Sue) and susceptible Early Calwonder was evaluated in a tissue culture system. Results indicated that resistance to the pathogen can be expressed under *in vitro* conditions. By inoculation with bacterial cells at 10^5 cfu/ml and 10^3 cfu/ml of race 1 on the callus, resistance and partial-resistance reactions could be detected.

Introduction

Resistance to race 1, but not to race 2 and 3, of *Xanthomonas campestris* pv. *vesicatoria* (Xcv), the causal agent of leaf spot disease in pepper is controlled in some cultivars by a single dominant gene (Bs_3). This resistance factor was obtained from PI271322. Sometimes it is difficult to obtain consistent results due to environmental variations.

A tissue culture system for studying the interaction of this bacterium and its host may lessen the problems of physiological and morphological complexity of intact plants and their interactions with environmental conditions. Pepper tissue cultures can be grown in a defined medium. The availability of resistant cultivar (Early Calwonder-30R, ECW-30R) to race 1, partial resistant cultivar (PBC163, Redland Sweet Sue) and susceptible early Calwonder enables the feasibility of exploring the genetic resistance in callus tissues.

Materials and Methods

Seeds of ECW-30R (with BS_3 gene), Redlands Sweet Sue (PBC163, with partial resistance) and Early Calwonder (ECW, susceptible) were first sterilized with 70% ethyl alcohol for 2 min and then 1.2% sodium hypochlorite for 20 min before rinsing four times with sterilized distilled water. These were then sown aseptically on agar slants.

Cotyledon and hypocotyl explants were cut from 12-day-old germinated seedlings and cultured in a modified Murashige and Skoog's basal medium supplemented with indoleacetic acid 1 mg/l and benzyladenine 2 mg/l (Alka and Rao 1978). The pH of the medium was adjusted to 5.8. All cultures were incubated for 12 h at 25 $\pm$ 3°C.

Eight-week-old calli were inoculated with Xcv16 (race1), the isolate from infected pepper in Taiwan by spraying 20 ul of bacterial solution on the surface calli with a syringe. Bacterial cells of inocula were 10^1 cfu/ml, 10^3 cfu/ml, 10^5 cfu/ml and 10^8 cfu/ml. At seven days after inoculation calli were removed and ground. Callus suspensions were then plated in the agar slant. Colonies were counted after two days of culture at 32°C.

Results and Discussion

There were no distinct color differences on the callus inoculated with various bacterial populations which could be due to a change in color before inoculation. However, there were more bacterial colonies developed around the callus of ECW than that of ECW-30R and PBC163.

More bacterial colonies were developed after plating the liquid obtained from callus of ECW inoculated with bacterial cells at 10^3 and 10^5 cfu/ml than those of PBC163 and ECW-30R (Fig. 11). The difference at 10^5 cfu/ml was greater than that at 10^3 cfu/ml. No distinct difference was observed in the number of bacterial colony among three cultivars after plating the liquid isolated from calli inoculated with bacterial cells at 10^8/ml. When the callus was inoculated with bacterial cells at 10^1 cfu/ml, the number of PBC163 colony became similar to that of ECW-30R. It seems important to find a suitable concentration to identify the resistant reactions toward *Xanthomonas campestris* pv. *vesicatoria*.

These results demonstrated that resistance to race 1 of *Xanthomonas campestris* pv. *vesicatoria* can be expressed under *in vitro* conditions. A resistance gene could have been linked to an undesirable horticultural trait. Thus, new sources are desired. Possible approaches to these areas would involve the transfer of resistance genes from a resistant to a susceptible host with desirable horticultural traits, and somaclonal selection in the presence of pathogen and/or pathogen metabolites. Investigation of resistance of pathogen-host interactions involving other races and resistant genes is ongoing.

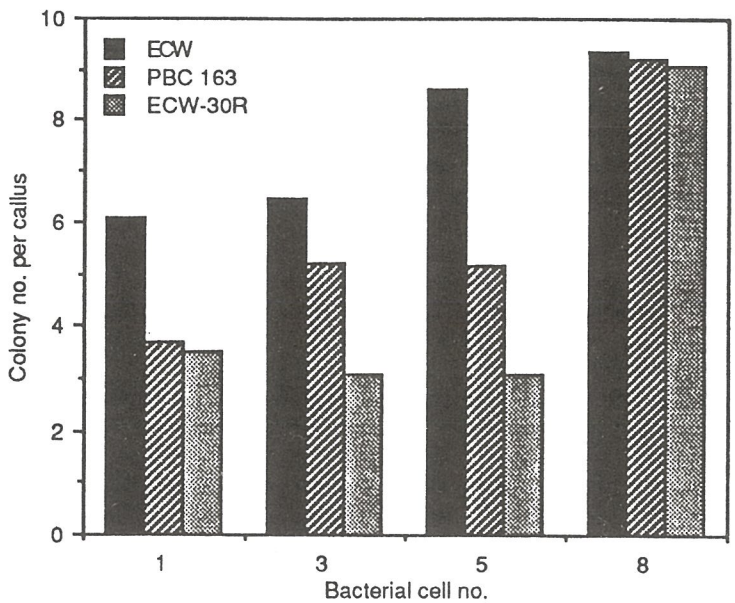

Fig. 11.
Number of bacterial colon on agar slant after plating the extract of calli inoculated with race 1 of *Xanthomonas campestris* pv. *vesicatoria*. Both x-axis and y-axis are in $\log_{10}$.

Electrolyte Leakage Changes

Summary

Conductance measurements indicated an increase in electrolytes leakage of leaves of a sweet pepper cultivar inoculated with a race of *Xanthomonas campestris* pv *vesicatoria* to which it is susceptible, whereas leakage remained low after inoculation with a race to which it is resistant. Results suggested that increased cell permeability is associated with host response to the pathogen and the magnitude of increase is less in hypersensitive host-pathogen combinations.

Introduction

Hypersensitive reaction (HR) may be induced by *Xanthomonas campestris* pv *vesicatoria* in pepper. HR is considered as a resistance mechanism. HR ranges from a pinpoint necrosis to larger necrotic lesions. Pinpoint necrosis occur two to three days after inoculation while large necrotic lesions are visible seven to 12 days after inoculation. These symptoms of HR suggest that a change in permeability of host cell membranes is induced by an infected bacteria. Modification or disruption of host cell membranes may be important in pathogenesis.

Three dominant genes, designated Bs_1, Bs_2 and Bs_3 are responsible for HRs to race 2, races 1, 2 and 3, and race 1 of *Xanthomonas campestris* pv. *vesicatoria* on the leaf tissue. Conductometric measurements of leaf tissue leakage of various pepper cultivars contain different resistant genes were carried out to assessthe degree to which permeability on infected tissues is changed by the pathogen.

Materials and Methods

Seeds of Early Calwonder-10R (with Bs_1 gene), Line 3-25-27 (with Bs_2 gene), Early Calwonder-30R (with Bs_3 gene), Redlands Sweet Sue (PBC 163) and PBC164 (both partially resistant type) and Early Calwonder (susceptible) to race 1, 2 and 3 of *Xanthomonas campestris* pv. *vesicatoria* were sown in October 1988.

Xcv16 (race1), Xcv3 (race2), and Xcv14 (race3) which are isolates from infected pepper in Taiwan were used. Inocula were cultured on 523 slant media in test tubes for 24 h at 32°C. Bacterial cell suspension at 10^8 cfu/ml was first set with OD value of 0.137 by a spectrophotometer at 600 nm. Concentrations at 10^3 cfu/ml and 10^5 cfu/ml were diluted from the stock solution.

At 40-50 days after sowing, plants in vinyl pot (ID 9 cm) at one plant per pot were sprayed with pathogens at the pressure of 1.5 kg/cm^2. Inoculated plants were kept in plastic tunnel for a week. Ten plants per row were transplanted to the field except PBC163 and PBC164 with five and seven plants per row, respectively because of seed shortage. A randomized complete block design was employed. Plants were covered with transparent plastic film to increase temperature and humidity. Soil was mulched with a black plastic film.

The number of young, mature, and fallen leaves of a randomly selected plant and infected area in each of three leaves and diameter of three lesions in each of three leaves in six labelled plants were investigated at one week interval ten days after inoculation. Leaf area of remaining and fallen leaves and dry weights of remaining leaves, stem and roots of randomly selected six plants were measured at 30 and 40 days after inoculation.

Leaf discs were obtained from three labelled plants at 9, 16, and 23 days after inoculation. Before making leaf discs, leaves were rinsed with deionized water. Electrolytes conductivities from four 1-cm^2 disks per leaf were measured. Leaf disks were placed in the test tubes containing 10 ml deionized water at 25°C for 30 min to determine the conductivity. These were later boiled at 100°C for 30 min and then allowed to cool at 25°C for 20 min before measuring the conductivities again.

Results and Discussion

Leaves of ECW-30R (Bs_3) inoculated with Xcv race 1 had the lowest electrolyte leakage at 16 days after inoculation, PBC163, PBC164 and line 3-25-27 the intermediate level, and ECW and ECW-10R, the highest. At 23 days after inoculation, difference between cultivars was lesser than those at 16 days after inoculation (Table 6) because the bacteria were suppressed by low humidity and temperatures.

Leaves of PBC164, PBC163, and line 3-25-27 inoculated with race 2 had lower electrolyte leakages than those of other varieties at 16 days after inoculation. Electrolyte leakage in all varieties at 23 days after inoculation was higher than at 16 days. No difference between varieties was observed.

Leaves of lines 3-25-27, PBC163, and PBC164 inoculated with race 3 had lower electrolyte leakage than other varieties at 16 days after inoculation.

Leaves of line 3-25-27 inoculated with mixture of races 1, 2 and 3 had the lowest electrolyte leakage 16 days after inoculation, but those of PBC163 and PBC164 were similar to those of

susceptible varieties. Therefore, reaction of partially resistant cultivars, PBC163 and PBC164, could not be distinguished from susceptible or resistant ones in any of the three races.

In general, the resistant reactions coincided with the lesser leakage observed in leaf tissues. Apparent correlation between susceptibility and tissue leakiness could be attributed to stimulatory effects on growth of the bacterium. Membranes of susceptible cells may be more readily disrupted by the pathogen and less capable of self-repair than those of the resistant cells. Being unstable, the membrane could partly account for the association between tissue leakiness and disease susceptibility.

Table 6. Electrolyte leakages (%) of sweet pepper leaves infected with races 1, 2 and/or 3 of *Xanthomonas campestris* pv. *vesicatoria* at 10^5 cfu/ml.

Cultivar	Race 1		Race 2		Race 3		Mixture	
	Day 9	Day 16	Day 9	Day 16	Day 9	Day 16	Day 9	Day 16
ECW-10R	10.6	30.9	17.2	12.4	24.9	26.7	18.0	23.4
Line 3-25-27	11.0	25.0	19.4	8.3	10.7	21.1	11.7	18.7
ECW-30R	10.1	18.5	20.1	13.6	14.9	24.6	14.7	23.2
PBC 163	12.0	25.3	19.3	9.6	11.5	20.2	18.9	23.7
PBC 164	8.8	24.8	20.7	8.8	12.0	19.6	16.8	21.9
ECW	11.9	27.7	20.1	14.3	13.5	25.5	18.6	25.0

Soybean Breeding

Hybridization

Summary

Modified backcrossing was carried out to develop productive and quality vegetable soybean utilizing some promising newly introduced vegetable soybean from Japan. Specific crosses were made to combine multiple disease resistance in a promising Thailand variety, Nakhon Sawan 1 and improve the seed size of two Indian varieties, Co 1 and Monetta. A total of 77 crosses (consisting of 48 vegetable and 29 grain soybean) were made.

Introduction

The AVRDC hybridization program aimed to develop tropical vegetable soybean with high quality pod and seed yield and other desirable horticultural characteristics. The grain soybean crossing program focused on combining multiple disease resistance, high yield and quality seed.

Materials and Methods

From the observation trial of introduced vegetable soybean from Japan, Blue slide Kahori, Shirofumi and Tanbaguro were found quality varieties. However, these have low yield and therefore, were used as parent for modified backcrossing. The F_1s between Ryokkoh and Mikawashima, Tzurunoko and Mikawashima, PI 157424 and Ryokkoh and PI 157424 and Tzurunoko were used in modified backrosses.

To incorporate downy mildew (DM) resistance to Nakhon Sawan 1 (OCB) it was crossed with lines 269 and SRE-D-14A. CO 1 and Monetta (small seeded) were crossed with Nakhon Sawan (large seeded) to improve the seed size of the former and combine high yield.

The F_1s of 26 vegetable and 10 grain soybean crosses were planted in the field on 10 October 1989 along with their parents.

Results and Discussion

A total of 77 crosses were made. Thirty-six were modified backcrosses aimed at developing high yielding quality vegetable soybean. One or two additional backcrosses might be required depending upon the performance of the backcross inbred progenies.

A trainee from Thailand made 12 crosses specifically for vegetable soybean and she brought them to Thailand for inbreeding, backcrossing and selection under Thailand conditions.

Twenty-nine crosses were made to incorporate multiple disease resistance to one Thailand variety, Nakhon Sawan 1 (OCB) and to CO 1 and Monetta. Early generation materials from the crosses will be evaluated in Thailand and India by cooperators for further selection.

Seeds from the F_1 plants will be harvested and the F_2 will be planted in spring 1990; selections will also be made for vegetable type and downy mildew F_2 resistance in vegetable and grain soybean, respectively.

Yield Trials

Summary

Results of spring, summer and autumn 1988 AYT were analyzed. Genotypic variation accounted for more than 80% of the total sum of squares for 100-seed weight. However, variations in yield were attributed to season. Genotypes GC 81090-48 and Nakhon Sawan 1 (OCB) appeared adaptable to all seasons. The yield potential of soybean has been improved to more than 5 t/ha. Moreover, such lines carry resistance to both bacterial pustule (BP) and downy mildew (DM). Yield during summer was drastically reduced by typhoon and continuous rain. However, BP-resistant selections with yields equal to or better than KS 10 had been identified.

Introduction

Breeding lines selected for disease resistance and other simply inherited traits in early generations are included when they reach the advanced generation in different stages of yield trials. In the past pedigree yield trial, preliminary yield trial (PYT), intermediate yield trial (IYT) and advanced yield trial (AYT) were conducted. Since many national programs have revised their policy, and, to minimize yield testing at AVRDC and increase yield testing in the national programs, IYT and AYT were conducted at AVRDC in 1989; PYT was eliminated. Both IYT and AYT were conducted in spring, summer and autumn. Spring and autumn AYT will be discussed under soybean rust section. Vegetable soybean yield trial will be discussed under vegetable soybean. This section discusses the spring and summer IYT and summer AYT.

Materials and Methods

Experimental details of the trials are given in Table 1. Entries that were included in AYT-1 and AYT-2 along with their parentage are given in Tables 2 and 3. Plot size for IYT was 3 × 2 m; for AYT it was 6 × 3 m. The harvest plot size for IYT and AYT were 6 m^2 and 10 m^2, respectively. Data on yield, other agronomic characters and disease ratings were collected and analyzed. Selection of genotypes for the next stage of the trial was based on multiple criteria. Adaptation to multiple seasons and specific seasons was also evaluated by pooled analysis of the data. Suggested AVRDC cultural practices were used.

Table 1. Planting dates and experimental designs for AYT and IYT in 1989.

Experiment	No. of entries plus (checks)	Design (replications)	Planting dates
1988			
AYT-1	11 (3)	Split plot (4)	9 February 1988
AYT-2	12 (2)	Split plot (4)	9 February 1988
AYT-1	11 (2)	RCBD (4)	12 July 1988
AYT-2	12 (2)	RCBD (4)	26 July 1988
AYT-1	11 (2)	Split plot (4)	13 September 1988
AYT-2	12 (2)	Split plot (4)	13 September 1988
1989			
AYT-1	10 (2)	Split plot (4)	14 February 1989
AYT-2	11 (2)	Split plot (4)	14 February 1989
AYT-1	10 (2)	RCBD (4)	12 July 1989
AYT-2	11 (2)	RCBD (4)	12 July 1989
IYT-1	33 (3)	RCBD (2)	21 February 1989
IYT-2	18 (3)	RCBD (2)	21 February 1989
IYT-1	33 (3)	RCBD (2)	13 July 1989
IYT-2	18 (3)	RCBD (2)	12 July 1989

Table 2. Selections and their parentage included in AYT-1 1989.

Cross designation	Parents or name
G 10959[z]	PI 399044
G 12179[y]	Hovte fees
G 12501[z]	D 64-8707
GC 82345-20-2	KS 1034 × (SRF 400 × PI 297550)
GC 82347-60-1	KS 1034 × (Clark 63 × 64-4)
GC 82355-36-3	(PI 194647 × TN 3) × T 17
GC 81027-16-1	H 15 × (SRF 400 × PI 297550)
GC 81118-8-4	(Forest × Shih Shih) × (Clark 63 × Shih Shih)
–[y]	74 Phyto-2-2
–[x]	69-8-1-4Pc
AGS 129 (ck)	Shih Shih × SRF 400
AGS 302 (ck)	Shinsei × PI 248407

[z]New breeding lines received from U.S.D.A. [y]New breeding lines received from South Asia. [x]New breeding lines selected from Land O'Lake population.

Table 3. Selections and their parentage included in AYT-2 1989.

Cross designation	Parents or name
GC 82334-29-5	(PI 89170 x PI 230971) x (Shih Shih x SRF 400)
GC 82335-35-3	(PI 89170 x PI 230971) x (Clark 63 x 64-4)
GC 82341-14-2	PI 171445 x (Shih Shih x SRF 400)
GC 82341-7-2	
GC 82344-50-2	Lee × (Shih Shih × SRF 400)
GC 82349-6-1	(R-10 × Lee) × (Shih Shih × SRF 400)
GC 82355-8-3	(PI 194647 × TN 3) × T 17
GC 82362-47-1	Tanbaguro × H 15
GC 83011-18-1	Vesoy 4 × KS 8
G 12128	Welkom (from South Africa)
G 12504	D 74-9820 (from USDA)
AGS 129 (ck)	Shih Shih × SRF 400
AGS 302 (ck)	Shinsei × PI 248407

Results and Discussion

Pooled analysis of data for yield and 100-seed weight in the AYT-1 and AYT-2 showed that variations in yield were largely due to seasons and genotype variations and G × S interactions were low. However, analysis of yield data from two seasons suggested that variations attributed to seasons were greater between summer and autumn but not in spring and summer. More variations were due to either genotypes or G × S interactions.

For 100-seed weight, variations due to genotypes were predominant, while variations due to seasons and G × S were negligible. Therefore, 100-seed weight was more genotype-specific and less influenced by either season or G × S.

Data on days to flowering and maturity nodes, branches and pods per plant, 100-seed weight and yield in AYT-1 and AYT-2 showed that yield in summer was significantly higher than in spring and autumn. These appeared to be due to more nodes, branches and pods per plant as well as longer period to flowering and maturity.

Based on either significant differences in yield or maturity between one check variety, genotypes with adaptability to more than one season were selected and are presented in Table 4. Some were deficient of the required disease resistance while others such as KS 10 and AGS 302 were used as checks.

IYT Spring 1989. In IYT-1 during spring 21 out of 36 entries produced more than 4 t/ha. Three of them significantly outyielded KS 10, the check variety most susceptible to downy mildew. Some new breeding lines had similar yield to that of KS 10 but were resistant to both DM and BP.

Sixty-eight percent of the entries were resistant to BP while 58% did not show any symptoms of DM infection.

One third of the entries in IYT-2 gave more than 4 t/ha. Some promising lines selected had similar yield potential to the check varieties AGS 302, CNS and G 8190 and they carried resistance to BP and DM. Of the 21 entries evaluated, 12 and 11 did not have DM and BP symptoms, respectively.

IYT Summer 1989. Yield in summer was generally low due to a typhoon which hit the crop at R_6 growth stage (12-13 September 1989). Thereafter, there was continuous rain for about 10 days which drastically affected the yield. GC 81027-6-10NL and -6-15-1NL gave the highest yield of 2.0 t/ha and 1.9 t/ha in 93 days and 88 days, respectively. Both had moderate levels of BP resistance.

In 1986 specific crosses were made to combine BP pustule resistance to some of the promising selections (AGS entries). Resistant pedigrees derived from the crosses were entered in IYT-2. Sixteen of the 18 selections were BP resistant.

AYT-1 and AYT-2 Summer 1989. The promising selections from summer AYT-1 and AYT-2 are given in Table 5.

Table 4. Promising selections from the combined analysis of AYT-1 and AYT-2 in spring, summer and autumn, 1988.

Adaptation to seasons	Yield (t/ha)	Days to maturity	100-seed wt. (g)	Disease reaction		
				DM	BP	Rust percent[z]
Spring, summer and autumn						
GC 81090-48	2.9 a	104 a	19 c	R	HR	10
OCB	2.4 a	88 f	21 bc	MS	R	22
Summer and autumn						
GC 81090-48	2.7 a	98 a	18 de	R	HR	21
GC 00062-107-6	2.7 a	98 a	17 fg	R	HR	15
Spring and autumn						
SRE-D-14B	2.1 a	97 d	24 a	HR	MR	28
KS 10	2.0 ab	98 d	15 h	HS	R	28
AGS 302	2.0 ab	100 c	21 c	R	MS	26
GC 81090-48	2.3 a	102 a	17 cd	R	HR	24
GC 00062-107-6	2.3 a	102 a	16 de	R	HR	21
Spring and summer						
GC 00062-107-6	3.2 a	110 a	17 e	R	HR	27
269	3.1 a	96 bc	19 def	R	R	45

[z]Lowest and highest rating among all lines were 8% and 48%, respectively.

Table 5. Promising selections from AYT-1 and AYT-2 in summer 1989.[z]

Entry no.	Names or pedigree	Yield (t/ha)	Days to maturity	100-seed wt. (g)	BP rating
AYT-1					
G 12501	D64-8707	2.2 a	92 c	12.3 fg	MR
	74 Phyto-2-2	1.9 abc	83 g	12.1 fg	MR+
GC 81027-16-1	H15 × (SRF 400 × PI 297550)	1.7 bc	93 c	13.0 ef	HR
AGS 129 (ck)		1.1 d	93 c	14.7 cd	HR−
AGS 302 (ck)		1.0 d	100 a	21.0 a	HS
Means of 12 entries		1.6	90	14.1	
CV.		13.0	0.83	4.34	
AYT-2					
GC 82341-14-2	PI 171445 × (Shih Shih × SRF 400)	1.6 b	96 b	12.7 hi	MR
GC 82349-6-1	(R-10 × Lee) × (Shih Shih x SRF 400)	1.6 bc	94 e	16.8 d	MR−
GC 82335-35-3	(PI 89170 × PI 230971) x (Clark 63 × 64-4)	1.6 bc	99 a	13.9 fg	MR−
AGS 129 (ck)		1.20 de	89 f	13.7 gh	HR−
AGS 302 (ck)		1.3 cde	100 a	18.7 c	HS
Means of 13 entries		1.4	96	16.6	
CV		12.2	1.39	4.74	

[z]Mean separation by DMRT at 5% probability level.

Breeding of Vegetable Soybean

Summary

Many tropical and subtropical countries are interested in producing vegetable soybean either for domestic consumption or for export. However, suitable varieties are not yet available. Last year the yield potential of graded pod was 5.9 and 5.5 t/ha in spring and autumn, respectively. In the advanced yield trial in 1989 yield potential was 9.5 and 7.8 t/ha for spring and autumn, respectively. Of the nine vegetable soybean varieties newly introduced from Japan, Blue Side, Shirofumi and Kahori appeared promising. Four selections each from PYT and IYT had excellent yield potential (standard pod yield) and good horticultural characteristics. Consumer acceptance of some promising vegetable soybean varieties will be evaluated in 1990. Depending upon the season and genotype the harvest index for total pod yield varied from 30 to 65% and that for standard pod yield, from 26 to 50%. On a fresh-weight basis, selection GC 84136-P-4-1-8 gave a biological yield of 33.2 t/ha.

Introduction

The potential of vegetable soybean either for export or domestic consumption is gaining popularity among countries in Asia and the Pacific. However, suitable varieties either for whole pod use or for shelled beans are unavailable for cultivation in the tropics and subtropics. AVRDC's vegetable soybean breeding program specifically for the tropics and subtropics focuses on production and quality. Quality includes pod and seed appearance, flavor, texture, taste, number of seeds per pod and size of pod and seed. The breeding program aims to increase the percent of marketable pods and minimize culls.

A number of yield trials, pedigree evaluations and field observations of introduced vegetable soybean were conducted.

Materials and Methods

Generation Advance. Crosses GC 87008, GC 87009, GC 87010, GC 86056, GC 86057 and GC 86058 were advanced from F_4 to F_5 during September 1988. Seven 1987 crosses were advanced from F_3 to F_4 also in September.

On 22 and 23 February 1989, five BC_1F_5 populations were planted in the field in a 3-m long rows with 50 cm between-row and spaced 10 cm within rows. Mean yield of standard pods per plant and 100-seed weight were determined to make selections. Selection differential was calculated.

In spring 1989, crosses with a total population of 299 were advanced to the F_4 generation.

Yield Trials. Forty-seven breeding lines were included in an IYT with Tzurunoko and KS 1 as checks. Nine introductions from Japan and one breeding line were included in an AYT, with KS 1 and Ryokkoh as checks. Observations on days to maturity, biological yield, standard pod yield, total pod yield and 100-seed weight were made. Harvest index was calculated.

Results and Discussions

Generation Advance. The number of lines advanced through visual observation from F_3 to F_4 and F_4 to F_5 varied with crosses. Seed size was one of the most important characters and therefore 100-seed weight of each plant in each population was examined.

The selection differential for 100-seed weight was highest in crosses GC 86056 and GC 86057 for which the initial F_4 population was the lowest. The backcross inbred progenies (BC_1F_5) had more desirable selections compared to the single cross hybrid derivatives. Therefore, the need for backcrossing was clear. The yield of standard pods per plant was also recorded for selected individuals. The selection differential was rather low with the exception of cross GC 86057. The backcross inbred progenies had higher mean yield than single cross hybrids. These selections will be further evaluated in autumn 1989 and the promising ones will be included in the IYT in 1990.

Preliminary yield trial. Four out of 49 entries gave significantly higher standard pod yield than the improved local checks KS 1. A total of 12 entries significantly outyielded both Tzurunoko and Ryokkoh. The harvest index varied from 30% to 54%. Harvest index for standard pod varied from 26 to 50%. Those with high standard pod harvest index selections were those which had AGS 129 as one of the parents crossed with KS 1 and backcrossed to KS 1. The mean 100-seed weight of green seed was 61.5 g while the highest was 80.6 g. Promising entries from PYT will be included in AYT in 1990.

Intermediate yield trial. Four out of 46 breeding lines evaluated produced significantly higher standard pod yield compared to Tzurunoko. Almost all selections were from single cross progenies. GC 84128-9-2-1 had a 100-seed weight of 85.8 g with 37% standard pod harvest index.

Advanced yield trial. GC 84136-P-4-1-8, a cross between Ryokkoh and Mikawashima gave a yield of 33.2 t/ha on a fresh weight basis. However, the harvest index for total pod yield was 39% (12.9 t/ha) and that for standard pod is only 27% (8.8 t/ha). Data were on fresh weight basis. On the other hand, Blue Side, an introduction from Japan with 27 t/ha biological yield gave 52% (14 t/ha) and 36% (9.5 t/ha) for total and standard pod yield harvest indices, respectively. In addition Kahori, an introduction from Japan has a very large seed size, 81.8 g compared to 55.6 g for KS 1 and 68.5 g for Ryokkoh. Kahori has been selected for use in the breeding program.

In autumn 1989, the best yielders in the spring trial produced a standard pod yield similar to that of KS 1 and Ryokkoh. However, Shironomai and Tzurunoko Daizu significantly yielded higher than the two checks. Biological yield during autumn was only one third that of spring. But the harvest index for total pod yield during autumn went up to 64% and the standard pod yield harvest index was 44%. Shorter photoperiod and cooler temperature resulted in lower biological yield.

Analysis of data in spring and autumn showed that except for 100-seed weight, all other characters were significantly influenced by season. Planting in spring was definitely better than in autumn. Shironomai appeared to have the best standard pod yields with an average of 8.0 t/ha in spring as well as in autumn with an average of 8.0 t/ha.

Breeding for Soybean Rust Tolerance

Summary

An analysis of the AYT data from spring and autumn 1987 and 1988 suggested that of the total variations, 49% was attributable to fungicide treatment. It showed that soybean rust was dominant in determining yield compared to genotype or season. Similarly the percent of rust infection was also influenced by fungicide treatment (45% of the total variations due to treatment). Variations due to genotype were dominant for 100-seed weight but treatment had also some effects.

In 1989 yield trials, new genotypes such as GC 81118-8-4, GC 82345-20 and GC 82349-6-1 had combined high rust tolerance indices and their yields were similar to or higher than the checks.

From 268 pedigrees evaluated four had very low percent of rust infection. Five percent of the entries were selected for further evaluation.

Introduction

Yield loss due to soybean rust could be as high as 90% in the tropics and subtropics. Incorporation of soybean rust tolerance in breeding lines has been chosen as a strategy to control the disease.

Materials and Methods

Analysis of 1987-88 AYT. In spring and autumn 1987 and 1988, 12 genotypes were evaluated with and without fungicide. Plots with fungicide were not inoculated, whereas those without fungicide were artifically inoculated with soybean rust to induce the infection. Data on percent of rust infection, yield and 100-seed weight were collected. Data in four seasons were analyzed.

Yield trials in 1988 and 1989. During spring 1988, 11 and 12 breeding lines, and three and two checks were used in AYT-1 and AYT-2, respectively. Observations on days to maturity, yield, 100-seed weight and percent rust infection were made. Rust tolerance indices and yield losses due to rust were also calculated.

During spring 1989, 10 test genotypes and two checks were compared for soybean rust tolerance in AYT-1. In AYT-2, 11 test genotypes were compared with two check varieties for soybean rust tolerance and high yield potential. The entries included in AYT-1 and AYT-2 are given in Tables 2 and 3.

Days to maturity, yield, percent of rust infection and 100-seed weight were measured as in the past. The fungicide-untreated plots were inoculated to induce rust infection.

Pedigree observation yield trial. Out of 275 pedigrees selected last year for further evaluation, 268 were planted along with five checks in a randomized complete block design with two replications. The trial were planted on 13 March 1989 in 2-m long rows with two rows per plot. Observations on days to flowering and maturity, 100-seed weight, percent of rust infection and yields were recorded.

Results and Discussion

Analysis of 1987-88 AYT. An analysis of data in four seasons suggested that nearly 49% of the total variations was attributable to treatments with and without fungicide or rust infection. Therefore, rust infection and the extent of infection determined yield. Of the total variations 45% were due to fungicide treatment for rust infection. Variations in 100-seed weight due to genotype accounted for 56%. It was likely that yield reduction was due to reduction in the number of pods and seeds per pod and empty pods. Soybean rust infection reduces seed size but seed size is more genotype dependent.

Among entries evaluated, GC 00002-100 had the highest yields of 2.45 t/ha (fungicide treated) and 1.8 t/ha (without fungicide). However, yields were similar to KS 10 and AGS 302 in the nonfungicide-treated plot.

Some rust-tolerant accessions in AYT-1 and AYT-2 are given in Tables 6 and 7. In AYT-1 yield loss due to rust was lowest; yields of GC 00138-29 were high. Entries SRE-B-15C and SRE-C-56A were highly tolerant but their yields were low. In AYT-2, GC 00062-107-6 had almost no yield reduction despite rust infection. Compared to SRE lines significant progress has been achieved in combining rust tolerance with high yields.

Yield trials 1989. In AYT-1 spring, GC 81118-8-4 had similar yield as AGS 129 in the fungicide-untreated plots but the yields in fungicide-treated plots were higher. The rust-tolerance index for yield was 74.0 (Table 8). GC 82345-20-2 was significantly higher yielding (3.6 t/ha) than the two check varieties under the fungicide-treated plot. In some entries such as GC 81118-8-4, rust infection was low even without fungicide protection. With fungicide the percent of rust infection in AGS 129 was quite high, whereas in GC 82347-60-1 the percent of rust infection declined to as low as 0.2% (Table 9).

Table 6. High yielding lines selected from AYT-1, autumn 1988.

Entry	Yield (t/ha)		DM[z]		HDSW[y] (g)		Rust lesion (%)	
	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide
GC 00002-100	2.5 a	1.8 ab	93 c	92 abc	20.8 c	17.3 d	4 a	44 a
GC 00138-29	2.3 ab	1.9 a	93 c	92 abc	16.6 f	15.4 e	5 a	35 ab
SRE-D-14B	2.1 bc	1.8 abc	94 bc	93 ab	25.9 a	24.2 a	3 a	32 ab
PI 3796	2.1 bc	1.6 a-d	96 a	93 ab	14.5 g	11.9 g	4 a	38 ab
GC 60020-8-7-7-18	2.0 bc	1.7 abc	87 de	87 d	19.6 d	17.4 d	3 a	42 ab
GC 82146-43-9-9	2.0 bc	1.6 abc	89 d	87 d	17.5 e	15.3 e	3 a	44 a
SRE-B-15C	1.6 ef	1.5 cde	86 e	87 d	18.1 e	17.7 d	2 a	25 bc
SRE-C-56A	1.7 c-f	1.7 abc	93 c	92 bc	21.5 bc	20.3 c	2 a	14 c
AGS 302 (ck)	1.9 cd	1.6 abc	94 bc	93 ab	22.2 b	20.0 c	3 a	31 abc
AGS 129 (ck)	1.9 cd	1.6 abc	88 d	86 d	16.0 f	14.5 e	3 a	37 ab
OCB (ck)	1.6 def	1.2 f	84 f	83 e	20.9 c	18.0 d	2 a	29 abc
Mean of 14 entries	1.9	1.6	90.7	89.6	19.5	17.4	3	50.9
C.V.	11.5	12.3	1.3	1.3	3.2	4.6	70.1	18.5

[z]DM = days to maturity. [y]HDSW = 100-seed weight. Mean separation by DMRT at 5% probability level.

Table 7. High yielding lines selected from AYT-2, autumn 1988.

Entry	Yield (t/ha)		DM[z]		HDSW[y] (g)		Rust lesion (%)	
	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide
GC 81090-48	2.3 a	1.9 a	93 a	93 a	17.9 cd	16.3 b	5 cde	37 cde
GC 81075-72	2.2 ab	1.5 b	93 ab	92 a	15.6 gh	14.2 de	4 de	45 a-d
GC 81083-42	2.1 abc	1.6 b	93 ab	93 a	17.3 de	14.5 cde	8 a-d	38 b-e
GC 00062-107-6	2.1 a-d	2.0 a	93 ab	93 a	16.8 ef	16.1 bc	1 e	29 c
GC 81079-12	2.0 bcd	1.3 c	93 ab	92 a	19.4 b	15.1 b-e	7 a-e	45 a-d
GC 81075-10	2.0 b-e	1.7 b	93 ab	93 a	16.0 fg	14.0 e	3 de	34 de
GC 00062-31	2.0 b-e	1.2 c	92 ab	89 cd	18.8 bc	14.9 b-e	12 a	53 a
GC 00097-56-6	2.0 b-e	1.3 c	92 b	90 bc	19.8 b	15.8 bcd	10 abc	49 ab
GC 81090-72-7	1.9 cde	1.4 c	93 ab	89 cd	21.2 a	16.4 b	6 b-e	37 b-e
AGS 129	1.9 cde	1.6 b	89 c	90 bc	16.5 efg	15.2 b-e	5 cde	33 de
AGS 302	1.8 de	1.7 b	93 ab	93 a	22.1 a	20.9 a	5 cde	26 e
Mean of 14 entries	1.9	1.5	92.4	91.1	18.1	15.5	6.3	40.1
C.V.	9.6	8.5	1.1	1.5	3.7	6.9	55.4	19.1

[z]DM = days to maturity. [y]HDSW = 100-seed weight. Mean separation by DMRT at 5% probability level.

Table 8. Soybean rust-tolerance index (RTI) using100-seed weight and yield, AYT-1, spring 1989.

Entry	RTI (yield)	RTI (100-seed weight)
G 10959	49.3	62.8
G 12179	29.1	62.6
G 12501	62.0	78.3
GC 82345-20-2	51.9	64.2
GC 82347-60-1	53.0	61.7
GC 82355-36-3	44.8	66.1
GC 81027-16-1	46.5	66.9
GC 81118-8-4	74.0	78.5
74 Phyto-2-2	73.7	79.4
69-8-1-4Pc	83.4	89.3
AGS 129	80.5	77.1
AGS 302	71.8	76.8

Table 9. Differences in yields and other traits of selected entries, AYT-2, spring 1989.[z]

Entry	Yield (t/ha)		HSDW (g)		Rust lesion %	
	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide
G 82345-20-y	3.6 a	1.9 cd	19.3 a	12.4 e	3 b	63 bc
G 12179	3.5 ab	1.0 g	17.1 cde	10.7 f	3 b	88 a
GC 81118-8-4	3.3 ab	2.5 a	17.7 cd	13.9 cd	1 b	12 f
G 10959	3.2 b	1.6 e	16.4 ef	10.3 f	4 b	76 ab
GC 82347-60-1	3.1 bc	1.7 de	23.0 a	14.2 c	0.2 b	59 bc
AGS 129 (ck)	3.1 bcd	2.5 a	17.9 c	13.8 cd	20 a	53 cd
AGS 302 (ck)	3.1 bcd	2.2 ab	22.4 a	17.2 a	1 b	40 de
Mean of 12 entries	3.0	1.8	18.0	12.9	5.9	54.5
C.V.	7.5	10.0	3.3	4.3	106.5	20.5

[z]Mean separation by DMRT at 5% probability level.

GC 82349-1 had similar rust-tolerance index and yield potential as AGS 129 and AGS 302 (Table 10). Differences in percent of rust lesion and other traits of treatments with and without fungicide are given in Table 11. The trend was similar to AYT-1. However, in fungicide treated plots, the percent of rust infection for AGS 129 in AYT-2 was much lower than in AYT-1. It appeared that there were micro-environment differences between trials for percent of rust infection which need further investigation.

An analysis of spring and autumn trials and the genotype × environment interactions will be presented in the 1990 Progress Report.

Pedigree observation yield trial. The top 5% of the genotypes from 268 selections were chosen for further evaluation. The mean percent of rust infection for 268 genotypes was 69.6%. Two percent of the entries had 50% rust infection and 6.7% had 51 to 60% rust infection. The remaining 92% had more than 61% rust infection.

Table 10. Soybean rust-tolerance index using 100-seed weight and yield in AYT-2, spring 1989.

Entry	RTI (yield)	RTI (100-seed weight)
GC 82334-29-5	72.5	85.8
GC 82335-35-3	65.1	76.6
GC 82341-14-2	64.6	86.3
GC 82341-7-2	47.3	68.3
GC 82344-50-2	49.8	62.7
GC 82349-6-1	74.8	79.9
GC 82355-8-3	43.7	68.7
GC 82362-47-1	41.9	60.6
GC 83011-18-1	41.1	61.8
G 12128	68.4	80.3
G 12504	70.1	77.0
AGS 129	84.4	82.5
AGS 302	71.5	80.5

Table 11. Differences in yields and other traits between genotypes with and without fungicides, AYT-2 spring 1989.

Entry	Yield (t/ha)		DM[z]		HDSW[y] (g)		Rust lesion %	
	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide	with fungicide	without fungicide
GC 82355-8-3	3.3 a	1.4 de	115 a	110 a	20.1 e	13.8 c	1 c	80 a
GC 82341-14-2	3.2 abc	2.1 a-d	105 d	103 bc	13.1 h	11.3 e	4 c	32 bcd
GC 82349-6-1	3.1 abc	2.3 ab	114 a	109 a	19.9 e	15.9 b	1 c	24 cd
GC 82344-50-2	3.1 abc	1.5 cde	111 c	100 e	22.8 d	14.3 c	16 a	79 a
GC 83011-18-1	3.0 abc	1.2 e	114 a	104 b	25.9 a	16.0 b	5 c	77 a
GC 82334-29-5	3.0 abc	2.2 abc	113 ab	109 a	13.4 h	11.5 e	1 c	20 d
GC 82335-35-3	2.9 abc	1.9 bcd	114 a	109 a	14.1 h	10.8 e	2 c	21 d
AGS 302 (ck)	3.2 ab	2.3 ab	104 d	101 de	23.1 cd	18.6 a	0.1 c	40 bc
AGS 129 (ck)	3.1 abc	2.6 a	106 d	103 bc	17.7 f	14.6 c	3 c	28 bcd
Mean of 13 entries	2.9	1.8	108.9	102.6	19.3	14.1	5.2	48.9
C.V.	8.5	23.0	1.5	1.0	3.7	4.2	84.8	24.8

[z]DM = days to maturity. [y]HDSW = 100-seed weight. Mean separation by DMRT at 5% probability level.

Breeding for Bacterial Pustule Resistance

Summary

Of the IYT and AYT entries evaluated, 48% were either highly or moderately resistant to bacterial pustule. Among 121 breeding lines evaluated, 97% were either highly or moderately resistant, indicating that the selection pressure exerted in the past season was quite efficient. Yields during summer were low due to continuous rain during harvest.

Introduction

During summer, the rainy season bacterial pustule (BP) caused by *Xanthomonas phaseoli* var. *sojensis* is a serious disease. Bacterial pustule causes yield reductions up to 50%. Resistance to BP is governed by a recessive gene r_{xp}. As a routine procedure, all yield trial entries were artificially inoculated with BP to determine their reaction to the disease. A number of high yielding AGS lines were deficient of BP resistance. They were therefore crossed with BP-resistant breeding lines. Advanced

generation lines were evaluated to select BP-resistant high yielding lines. In addition to BP, downy mildew resistance was also simultaneously incorporated.

Materials and Methods

Seventy-seven genotypes that were included in the IYT and AYT were planted on 14 July 1989 in 2-m long rows set 50 cm apart. Each entry was planted in two rows with two replications in a randomized complete block design. The field was inoculated with a bacterial suspension on 23 August 1989 when plants were in R_2 growth stage. The first BP reading was taken on 13 September 1989. The mean of two replications was used as the BP final reading.

In another trial, 121 potentially BP-resistant breeding lines were evaluated for yield as well as BP. The trial was planted on 27 March 1989 in 3-m long plots with two rows per plot and 50-cm spacing between rows. On 4 May 1989 the plants were inoculated with BP. In addition to BP rating, yield, days to flowering, days to maturity and 100-seed weight were also recorded.

Results and Discussion

Most of the IYT and AYT entries had significantly higher yields than the susceptible checks. Of the 77 entries 43% were either highly or moderately resistant. The promising entries that yielded similarly to AGS 129 are listed in Table 12.

Among breeding lines evaluated, 57% were rated highly resistant or resistant and 40% were moderately resistant while very few were highly susceptible. Selection during this summer was extremely efficient in discarding the susceptibles.

Unlike in the past, the BP screening materials were planted this year in late March and inoculated in May when it was hot. Such screening worked very well. Selected high yielding entries which are highly resistant to BP are listed in Table 13.

International Cooperation

Summary

Eight AVRDC Soybean Evaluation Trials (ASET) and 1471 seed packets of grain soybean were distributed to 74 cooperators in 35 countries. In addition 167 seed packets of vegetable soybean were

Table 12. High yielding and bacterial pustule-lines selected from BPR trial, spring 1989.

Entry	Yield (t/ha)	Days to maturity	100 seed weight (g)	Bacterial pustule
GC 86025-10	1.8	112	13.4	HR
GC 86027-59	1.6	101	12.3	HR
GC 86039-32	1.5	112	15.4	HR
GC 86031-26	1.5	112	13.5	HR
GC 86021-4	1.4	90	11.6	HR
GC 86029-19	1.4	101	13.2	HR
GC 86035-14	1.4	90	13.9	HR
GC 86029-28	1.4	101	13.1	HR
GC 86031-6	1.4	112	12.7	HR
GC 86023-26	1.4	101	11.9	HR
AGS 129 (ck)	1.1	92	12.6	HR
CNS (ck)	0.5	104	8.5	MR
AGS 302 (ck)	0.8	96	16.3	HS
G 8190 (ck)	0.6	112	11.8	HS
G 38 (ck)	0.72	92	11.0	HS
Mean of 12 entries	1.0	106.7	13.1	
CV	24.5	6.3	7.8	
LSD (0.05)	0.5	13.3	2.0	

Table 13. Yields and other characteristics of selections highly resistant to bacterial pustule, summer 1989.

Variety	Yield (t/ha)	Days to maturity	100 seed weight (g)	Seed quality	Bacterial pustule
G 12501	2.4 a	91 cde	12.9 a-z	2 d	MR
GC 82341-14-2	2.3 ab	90 cde	12.1 a-z	2 d	MR
GC 86029-28NL	2.2 abc	94 abc	16.2 c-q	3 cd	MR
GC 81027-16-1	2.1 a-d	90 cde	13.3 a-z	3 cd	HR
GC 82341-7-2	2.0 a-f	94 abc	15.9 c-s	3 cd	MR
GC 81027-6-10NL	2.0 a-g	88 def	13.8 l-x	2 d	MR
GC 86032-17	2.0 a-g	98 a	17.8 c-j	4 abc	MR
AGS 129 (ck)	2.0 a-h	90 cde	14.9 f-w	3 cd	HR
CNS (ck)	1.5 c-s	90 cde	13.2 a-z	2 d	MR
G 8190 (ck)	1.1 l-u	81 hi	12.8 a-z	3 bcd	HR
TK 5 (ck)	0.9 o-u	94 abc	13.8 l-y	3 bcd	HS
Shih Shih (ck)	0.8 q-u	80 i	10.8 a-z	3 cd	HS
Means of 77 entries	1.3	91.5	14.9	2.8	
CV	23.5	2.6	9.7	15.3	

distributed to 41 cooperators in 22 countries. Results showed that AGS 268, AGS 269 and AGS 129 appeared promising. In 1989 about 70% of the total vegetable acreage was covered by KS 1 (AGS 292). A total of 400 kg seeds of three genotypes were supplied to a cooperator in Pakistan. Korean breeding lines were successfully advanced and 16 kg seeds were shipped to Korea.

Introduction

Interested national programs request AVRDC's improved genetic materials for evaluation and use by their farmers. The national program scientists provide AVRDC feedback regarding the performance of the improved materials and problems that remain to be resolved. Such feedback assists AVRDC in finetuning its research program to complement those of the national programs.

Distribution of Germplasm, Elite Lines and AVRDC Soybean Evaluation Trial

Scientists from seven countries requested eight ASETs. Seventy cooperators from 32 countries around the world requested and received from AVRDC 506 AVRDC Glycine Selections (AGS), 467 Glycine cross pedigrees (GC series), 104 enhanced germplasm, 389 other entries and five new accessions for their evaluation and selection or for use in their breeding programs (Table 14). There has been a continuing interest in AVRDC soybean from a number of countries, even from the temperate zone, although AVRDC's breeding efforts are focused primarily on the tropics and subtropics. Three promising entries, AGS 129, OCB and GC 60058-12-6-6-1-55 were requested from Pakistan. A total of 400 kg seeds of all entries were distributed to cooperators.

As in the past, generation advancement for Korea was successfully conducted; 16 kg seeds of 36 populations were sent on time to Korea. The generation advancement and seed multiplication of Korean breeding lines will be continued.

Interest in growing vegetable soybean has gained popularity and the momentum generated by the release of Kaohsiung No. 1 vegetable soybean (AGS 292) persisted in 1989. From 22 countries 41 cooperators requested and received from AVRDC the following vegetable soybean varieties: 107 AGS lines, 5 GC pedigrees and 55 accessions.

ASET Results

Results of 1987 ASETs were received from six cooperators in five countries. In Ecuador, the Philippines and Saudi Arabia, AGS 269 (a pure line selection from PK 7386) significantly outyielded the local checks, 2.9 t/ha, 1.5 t/ha and 2.5 t/ha vs 0.5 t/ha, 0.9 t/ha, 1.0 t/ha respectively. In Pakistan AGS 147 yielded 3.4 t/ha in 135 days. AGS 268 was also one of the best yielders in the Philippines and Saudi Arabia (Table 15).

Reports from other Countries

In Thailand, Dr. Sadao Hatta reported that due to delay in receiving the seeds, germination was very poor.

In Iraq, AGS 269 had similar yield as that of Lee (local check) but the variety attained maturity in 175 days.

In Taiwan, KS 1 vegetable soybean occupies nearly 70% of the total area planted with vegetable soybean in 1989.

Table 14. Distribution of AVRDC Soybean Evaluation Trial and other enhanced germplasm to national programs in different countries.

Country	No. of cooperators	ASET	Type of seed sent				
			AGS lines	GC pedigree	Accession	Other	New Accession
Australia	2		6	2	7	4	1
Bangladesh	1		16	4	2		
Belize	1		1	8	3	8	
Bhutan	1		10		2	2	
Brazzaville	1		1		2		
Denmark	1		1				
England	1				2		
France	1		12	5	1		
Honduras	1		10				
India	6		291	64	20	9	4
Indonesia	2		1	25			
Iraq	1	1					
Japan	1		3	6		1	
Korea	2		21		3	42	
Malaysia	1		4			1	
Mexico	1			5	3	20	
Niger	1		2				
Nigeria	1		3				
Pakistan	3		14	41			
Peru	1	1					
Philippines	7	2	5	85	13	14	
Saudi Arabia	1		12	1		2	
Singapore	1			7	9	4	
Solomon Islands	1		10				
Sri Lanka	1		3				
Surinam	1			24	1	6	
Taiwan	18		51	52	13	11	
Tanzania	1		12		1	2	
Thailand	5	1	9	49	20	1	
Trinidad	1	1					
U.S.A.	3		3	61	2	261	
Mali	1		1	3		1	
Vientiane	1		4				
Vietnam	1	1		25			
Yemen	1	1					
Total	74	8	506	467	104	389	5

Table 15. Summary of findings from national cooperators.

Country Location Cooperator	Entry	Yield (t/ha)	DM	100-seed weight (g)	SQ	No. of plants harvested
Ecuador						
Lat. 05S	AGS 269	2.9 a	98 c	18.7 cd	2 a	235 bc
73m	AGS 129	2.8 ab	98 bc	18.8 c	2 b	281 a
Programa de Oleaginosas	AGS 208	2.7 ab	89 e	21.8 b	2 a	236 bc
de Ciclo Corto	AGS 147	2.6 ab	94 d	18.4 cd	1 c	257 b
	AGS 299	2.6 abc	88 e	17.5 de	1 c	229 c

Table 15. Continued.

Country Location Cooperator	Entry	Yield (t/ha)	DM	100 seed weight (g)	SQ	No. of plants harvested
Date planted:	AGS 268	2.5 abcd	101 ab	18.6 cd	2 b	256 b
10 June 1988	GC 60058-12-6-6-1-55	2.4 abcd	88 e	14.0 h	1 c	245 bc
T: 12						
R: 4	Local check	2.3 bcd	101 a	15.5 g	1 c	257 b
	Local check	2.1 cd	102 a	16.0 fg	1 bc	231 c
Mexico						
Lat. 24°48'N	Tamazula	2.7 a	105 f	17.8 b	3 cd	230 abc
38.54m	S-80 (ck)					
Dr. Pedro Manjarrez-Sandoval	Bragg (ck)	2.3 b	127 b	14.7 e	2 de	195 bc
	AGS 208	2.1 b	103 g	16.1 cd	3 cd	216 bc
Date planted: 15 June 1988						
T:12, R:4, Spring-summer						
Pakistan						
Lat. 34°46°15"N	AGS 147	3.4 a	135 c	20.5 e	4 a	96 ab
2950 ft.	Swat-84 (ck)	3.0 b	143 b	21.3 d	1 e	73 ef
DrU Mohammad RahiU l Amjad Khan	AG 12	3.0 a	14Y a	18.R l	Y l	8- bcd
	GC 60058-12-6-6-1-55	2.5 c	109 f	13.9 i	4 a	80 cde
Date Planted:	Bragg (ck)	2.5 c	105 f	22.0 c	1 de	104 a
3 June 1988						
T:12, R: 3, Summer						
Philippines						
Lat. 16°14.3'N	AGS 268	1.3 a	119	14.9 a	1	74 a
64m	AGS 208	0.8 ab	99	13.8 a	3	59 ab
Mr. Andres C. Pascua	Local check	0.7 ab	88	14.9 a	3	48 bc
	OCB	0.8 ab	76	15.0 a	2	68 ab
Date planted:	AGS 85	0.7 ab	111	14.3 a	2	59 ab
1 June 1988	AGS 269	0.6 ab	95	14.0 a	1	60 ab
T: 12	GC 60058-12-6-6-1-55	0.6 ab	99	12.2 a	2	66 ab
R: 4						
Wet season	AGS 129	0.6 ab	111	14.9 a	3	63 ab
	AGS 299	0.5 b	119	13.0 a	2	67 ab
	AGS 304	0.6 b	99	16.2 a	1	45 bc
	Local check	0.5 b	119	14.7 a	2	45 bc
	AGS 147	0.3 b	111	13.8 a	3	29 c
Lat. 7°5636"N	AGS 269	1.5 a	87 bc	15.2 bc	3 ab	371 a
302m	AGS 304	1.4 a	81 d	5.1 g	2 b	368 a
Dr. Nonito S. Franje	AGS 147	1.3 a	86 bc	14.0 cd	2 b	393 a
	AGS 268	1.2 ab	97 a	16.6 b	3 ab	388 a
Date planted:	AGS 129	1.2 ab	86 bc	15.8 bc	3 ab	388 a
17 July 1988	AGS 299	1.2 ab	86 bc	14.3 cd	3 ab	355 a
T: 12	OCB	1.2 ab	84 bcd	20.3 a	2 ab	347 a
R: 4	AGS 85	1.1 ab	87 bc	14.1 cd	4 a	374 a
Wet season	GC 60058-12-6-6-1-55	1.1 ab	84 bcd	9.8 f	2 b	384 a
	AGS 208	1.1 ab	83 cd	19.0 a	3 ab	348 a
	Local check	0.9 b	88 b	11.8 e	2 ab	228 b
	Local check	0.9 b	88 b	12.7 de	2 ab	149 b
Saudi Arabia						
Lat. 28°22N	AGS 268	2.6 a	125 a	16.7 cd	1	39 c
777m	AGS 269	2.5 ab	115 c	15.8 d	1	67 ab
Mr. Ahmed Al Ajaji	AGS 147	2.4 abc	108 de	14.5 e	1	79 a
Mr. Abdel Salam	AGS 129	2.0 a-d	106 e	15.7 d	1	63 ab
	AGS 299	1.9 a-d	116 c	18.0 bc	1	61 ab

Table 15. Continued.

Country Location Cooperator	Entry	Yield (t/ha)	DM	100 seed weight (g)	SQ	No. of plants harvested
Date planted: 31 July 1988	GC 60058-12--6-6-1-55	1.9 bcd	108 de	14.5 e	1	56 bc
T: 12	AGS 85	1.8 cde	109 d	16.9 cd	1	77 ab
R: 4	OCB	1.7 de	90 h	17.5 bc	1	63 ab
Summer	AGS 208	1.6 def	103 f	18.2 b	1	69 ab
	AGS 304	1.2 ef	95 g	7.1 f	1	61 ab
	Davis (ck)	1.0 fg	122 ab	19.5 a	1	16 d
	Jamer (ck)	0.6 g	120 b	20.6 a	1	12 d

Mean separation by DMRT.

Soybean Entomology

Beanfly Control

Summary

An insecticide screening was conducted to control beanflies: *Ophiomyia phaseoli* (Tryon), *O. centrosematis* (de Meijere) and *Melanagromyza sojae* (Zehntner) on soybean, mungbean and snap bean. Pyrazophos, BAS 15246 and omethoate and dimethoate were tested for the control of mainly *M. sojae* on soybean. The chemicals were sprayed at 3, 7, 10, 14, 21, 28 and 36 days after emergence (DAE) and their efficacy evaluated at 21 and 35 DAE. Pyrazophos at 0.4 and 0.5 kg AI/ha gave the best control of agromyzids on soybean. There was a significant negative correlation between the dosages of pyrazophos from 0.1 to 0.5 kg AI/ha and the number of beanfly larvae found in soybean or percentage of soybean plants damaged by the pest. Pyrazophos gave better pest control than omethoate, the standard insecticide. This fungicide also provided excellent control over agromyzid in mungbean which harbors all beanfly species and in snap bean where *O. phaseoli* is a major pest.

Introduction

Agromyzid flies, *Ophiomyia phaseoli*, *O. centrosematis*, and *Melanagromyza sojae* are destructive pests of economically important legumes such as soybean, mungbean, snap bean and cowpea in tropical to subtropical Asia, Africa and Oceana. The adults lay eggs in the plant soon after germination. The larvae feed inside the stem, weakening the plant; eventually, the plants die. At present farmers rely only on chemical insecticides to control the pest. Three insecticides, namely, dimethoate, monocrotophos and omethoate have been found effective so far. However, in recent months dimethoate and monocrotophos have shown lesser effectiveness in controlling these pests. This indicates that beanflies have developed resistance to these chemicals. Since the three chemicals are structurally similar, there is a possibility that omethoate will become ineffective. While research on alternative control measures is ongoing, there is a need to search for more effective chemicals to control these pests.

Pyrazophos is an organophosphorus fungicide used normally to control plant diseases. It was accidentally found effective in controlling Drosophila which feeds on rotten plant parts. Since Drosophila beanflies are also Diptera, a preliminary test was conducted in summer 1988 to test the efficacy of pyrazophos in controlling beanflies. Results showed that pyrazophos effectively controls beanflies. In late 1988 and early 1989, field trials on the control of beanflies on soybean, mungbean, and snap bean were conducted.

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 × 3 m plots. Seeds of soybean breeding line AGS 66 were sown in two parallel rows set 40 cm apart in each bed. Within each row, a distance of 10 cm was maintained between two adjacent planting spots (hill). Standard cultural practices such as weeding, irrigation, fertilizer application and disease control were observed.

Three legume species, namely, soybean, mungbean and snap bean were utilized. For soybean, there were 10 treatments including a control, each replicated four times and arranged in a randomized complete block design. For mungbean and snap bean, only six treatments including control were used. 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). A 0.5-liter spray volume (50% of the designated quantity of the active ingredient) was applied to each plot during the first four applications and 1 liter per plot (1000 liters/ha) in the succeeding three applications. Each sprayer was individually calibrated with a stopwatch and specific volumes of spray solution were accurately and uniformly applied to each plot to ensure that a specified amount of AI was applied. Cone type nozzles were used. Spraying was done at 3, 7, 10, 14, 21, 28 and 36 days after emergence (DAE).

Effectiveness of insecticide was evaluated 21 and 35 DAE. Thirty plants were randomly uprooted from each plot. Each plant was cut 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 protected against other pests by occasional sprays of fenvalerate. At harvest, seed yield from each plot was recorded. Data were subjected to analysis of variance (ANOVA) and means were compared by DMRT.

Results and Discussion

Results of the evaluation of the effectiveness of various chemicals in the control of *M. sojae* in soybean are summarized in Table 1. Pyrazophos 30EC used at 0.4 or 0.5 kg AI/ha gave the best agromyzid control. Insect control in these two treatments was better than in omethoate, the standard effective chemical. There was a strong dose-dependent relationship between concentration of pyrazophos and number of beanfly larvae+pupae per plant and percentage of beanfly damaged plants. A significant negative correlation was observed between the concentration of pyrazophos and the number of beanflies per plant (r = -0.779* and -0.774* for first and second observations, respectively) and percentage of damaged plants at both observation intervals (r = -0.898** and -0.883**, respectively).

The insect growth regulator, BAS 15246, was found ineffective. Dimethoate failed to provide any control. Beanfly appears to have developed resistance to this insecticide. Omethoate, an oxygen analog of dimethoate, gave satisfactory control over the pest. The insecticide treatments that provided adequate control over beanflies gave significantly greater yields than the control.

Results of evaluation of the effectiveness of pyrazophos in controlling agromyzid beanflies in mungbean are summarized in Table 2. As in soybean, there was a significant negative correlation between the concentration of pyrazophos and the number of beanfly larvae+pupae per plant (r = -0.766* and -0.799* for the first and the second observations, respectively) and percentage damaged plants of both observation intervals (r = -0.846* and -0.831*, respectively). Mungbean was damaged by all agromyzid species. However, the severity of infestation by these pests was less in mungbean than in soybean.

Table 1. Evaluation of insecticides for the control of beanflies on soybean.[z-u]

Insecticides	Rate kg AI/ha	No. of beanfly larvae + pupae/30 plants		Damaged plants %		Yield t/ha
		11/22	11/29	11/22	11/29	
Pyrazophos 30EC	0.1	8.0 d	9.8 c	40.9 c	45.0 b	0.8 a
Pyrazophos 30EC	0.2	4.8 d	3.3 c	27.5 d	18.4 c	0.8 ab
Pyrazophos 30EC	0.3	1.0 e	2.0 c	7.5 e	15.0 c	0.8 ab
Pyrazophos 30EC	0.4	0.5 f	0.3 e	3.3 e	4.2 c	0.7 ab
Pyrazophos 30EC	0.5	0.0 g	0.0 f	0.8 f	3.3 c	0.8 a
BAS 15246 15EC	0.2	21.5 c	31.8 b	89.2 ab	97.5 a	0.6 bc
BAS 15246 15EC	0.3	22.0 c	27.0 b	83.3 b	85.0 a	0.6 c
Dimethoate 44EC	0.3	32.8 b	40.3 a	92.5 ab	95.9 a	0.7 abc
Omethoate 50EC	0.5	3.3 d	0.8 d	13.3 e	10.9 c	0.7 ab
Control		40.8 a	47.0 a	96.7 a	98.4 a	0.7 abc

[z]Cultivar: KS9. [y]Planting date: 10/21/88. [x]Insecticides sprayed: 10/27/88, 11/1/88, 11/4/88, 11/8/88, 11/15/88, 11/22/88, 11/29/88. [w]Harvest date: 89/1/30. Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different by DMRT at 5% probability level. [v]Plot size: 10 m^2. [u]Design: RCBD.

Results of evaluation of the effectiveness of pyrazophos in controlling beanflies on snap bean are summarized in Table 3. In four dosages, pyrazophos gave excellent beanfly control. Snap bean was most susceptible to *O. phaseoli* damage and pyrazophos seemed to be specifically highly active against this species. There was a strong negative relationship between the dosages of pyrazophos and the number of beanfly larvae and pupae found in plants and percentage of damaged plants. However, this relationship was statistically significant only for percentage of plants damaged five weeks after germination (r = -0.794*).

Table 2. Effects of pyrazophos on mungbean infested by beanflies.[z]

Fungicide	Rate kg AI/ha	No. of beanfly larvae + pupae/30 plants		Damaged plants %	
		10/27	11/10	10/27	11/10
Pyrazophos 30EC	0.1	2.0 b	0.3 b	20.9 b	24.2 b
Pyrazophos 30EC	0.2	0.3 bc	0.3 b	14.2 bc	26.7 b
Pyrazophos 30EC	0.3	0.0 c	0.0 b	4.0 c	27.5 b
Pyrazophos 30EC	0.4	0.5 bc	0.0 b	5.9 c	17.5 b
Pyrazophos 30EC	0.5	0.5 bc	0.0 b	8.0 c	14.2 b
Control		4.8 a	1.3 a	41.7 a	53.4 a

[z]Cultivar: Tainan No. 3. [y]Planting date: 9/19/88. Insecticides sprayed: 9/26/88, 9/30, 10/3, 10/7, 10/14, 10/21, 10/28, 11/2. Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different by DMRT at 5% probability level. Plot size: 10 m^2. Design: RCBD.

Table 3. Effects of pyrazophos on infestation of snap bean by beanflies.[a-f]

Fungicide	Rate kg AI/ha	No. of beanfly larvae + pupae/30 plants		Damaged plants %	
		11/4	11/11	11/4	11/11
Pyrazophos 30EC	0.1	0.5 b	0.5 b	13.2 b	18.3 b
Pyrazophos 30EC	0.2	0.3 b	0.3 b	8.2 b	14.3 b
Pyrazophos 30EC	0.3	0.3 b	0.0 b	6.5 b	11.7 b
Pyrazophos 30EC	0.4	0.0 b	0.0 b	4.0 b	10.0 bc
Pyrazophos 30EC	0.5	0.0 b	0.0 b	2.3 b	4.2 c
Control		12.0 a	5.0 a	74.2 a	65.8 a

[z]Cultivar: local variety. Planting date: 10/4/88. Insecticides sprayed: 10/11/88, 10/15, 10/18, 10/21, 10/28, 11/4, 11/11. Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different by DMRT at 5% probability level. Plot size: 10 m^2. Design: RCBD.

Conclusions

Pyrazophos, an organophosphorus fungicide gives good control over *Ophiomyia phaseoli*, *O. centrosematis*, and *Melanagromyza sojae*. The efficacy of the chemical was similar in three host plants: soybean, mungbean and snap bean. A concentration of 0.4 to 0.5 kg AI/ha is optimum to attain effective control.

Limabean Podborer Resistance

Summary

Soybean germplasm selections were screened in three different tests in the field for resistance to limabean podborer, *Etiella zinckenella* (Trietsche). The germplasm was planted in the field in July, August and September and exposed to the ambient population of the pest supplemented by the occasional release of laboratory-reared insects. At harvest, insect-damaged and healthy pods were recorded and percentage of pods damaged was statistically analyzed to determine their resistance level. In the preliminary single replicate screening of 815 accessions, 11 were classified as highly resistant. The average pod damage in these accessions was 0.7% against 13% for three highly susceptible checks. In the second test, accessions least damaged in 1987 (G 6359, G 7180, G 6497) were significantly

less damaged in each of the three plantings. Similarly in the advanced test, in three plantings, all accessions (G 3469, G 3543, G 3574) which were least damaged in two previous tests in 1986 and 1987, were also significantly less damaged in this test. All six resistant accessions included in the latter two tests have smaller pods and seeds. In past evaluations, smaller seeded accessions were invariably less damaged than the large-seeded ones. The utility of these accessions in breeding podborer-resistant cultivars is, therefore, limited.

Introduction

In tropical to subtropical Asia, limabean podborer, *Etiella zinckenella*, is a serious pest of soybean. It attacks other economically important legumes such as cowpea, mungbean and lentil. The adult lays eggs mainly on the developing pods and larvae bore inside and feed on developing seeds. This mode of feeding reduces soybean yields. Screening of soybean germplasm for resistance to the podborer is ongoing at AVRDC. In past screenings, a significant positive correlation between pod size and podborer damage to the pod was observed. The resistance is attributed to the small and inadequate mass of seed to support the growth of one insect per seed. Such resistance appears mechanical rather than genetic. Screening of soybean germplasm to find genetic sources of resistance is also ongoing. In 1988-89, AVRDC screened selected soybean germplasm for resistance to limabean podborer.

Materials and Methods

Preliminary screening. A 0.8-ha parcel of land, away from a frequently insecticide-sprayed area was rototilled. After application of basal fertilizers, the land was worked into 0.75 m-wide raised beds. These beds were further divided into 5-m long plots. Seeds of each of 100 soybean accessions were planted as a single row on top of individual beds. The crop was raised following AVRDC standard cultural practices including irrigation, weeding, fertilizer application and disease control to achieve high yields. At pod formation of the earliest pod-setting accession, laboratory-reared *E. zinckenella* were released at intervals to initiate infestation. At harvest, 25 plants from each accession were uprooted and the podborer-damaged and healthy pods were recorded. The percentage of damaged pods was calculated. Data on pod damage were statistically analyzed based on mean ($\times$) of percentage pod damage and standard deviation (SD). The accessions that had percentage of pod damage less than $\times - 2$ SD were considered highly resistant (HR), between $\times - 2$ SD and $\times - 1$ SD, moderately resistant (MR); between $\times - 1$ SD and $\times$, as having low resistance (LR); between $\times$ and $\times - 2$ SD, susceptible (S); and more than $\times + 2$ SD, highly susceptible (HS).

Second screening. Three least damaged accessions in two identical single-replicate plantings (one each in September and October 1987) were included in this test. Seeds of three apparently resistant G 6359, G 6497, G 7160 and one susceptible accession, G 3266, were planted in a single row in each of the three randomly selected 5-m long and 0.75-m wide plots, three times, each in July, August and September 1988. Soon after flowering of the earliest flowering accessions, laboratory-reared *E. zinckenella* were released in the field to initiate podborer infestation. At harvest, 25 plants were uprooted and the number of podborer-damaged and healthy pods was recorded and the percentage of damaged plants was computed. The data on each planting were analyzed by ANOVA and means were separated by DMRT.

Advanced screening. Soybean accessions, G 3469, G 3543, and G 3574, included in this test were least damaged by podborer in the preliminary single-replicate test planted twice in 1986-1987 and second multireplicate test planted thrice in 1987-88. Seeds of each of three resistant and one susceptible accession, G 3266, were in a single row in each of three randomly selected 5-m long and 0.75-m wide plots, three times, once each in July, August and September 1988. Soon after flowering of the earliest flowering accession, a large number of laboratory-reared *E. zinckenella* were released to initiate podborer infestation. At harvest, 25 plants were uprooted from each plot and podborer-damaged and healthy pods were recorded. The percentage of pods damaged from monthly plantings was analyzed by ANOVA and means were separated by DMRT.

Results and Discussion

Preliminary screening. Among the 1000 accessions planted in September 1988, only 815 had been evaluated for podborer infestation. Others had poor germination. Of the 815 that were evaluated, 11 were ranked HR; 93, MR; 324, LR; 266, S, and 121, HS (Fig. 1). The 11 HR accessions had an average pod damage of 0.7% against 13% for three highly susceptible checks. These accessions will be studied further in 1989-1990 to confirm their resistance.

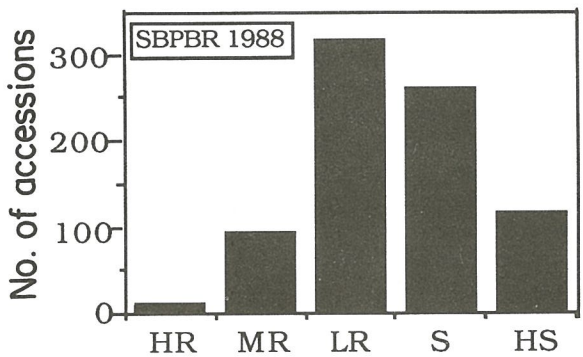

Fig. 1.
Distribution of soybean accessions in various podborer resistance categories: HR = highly resistant. MR = moderately resistant, LR = low resistance, S = susceptible, HS = highly susceptible.

Second screening. The results of the second screening are summarized in Table 4. All resistant accessions had lesser damage than the susceptible check in each of the three plantings. This confirms the findings of the preliminary screening.

Advanced screening. The results of the advanced screening are summarized in Table 5. All resistant accessions had significantly less damage than the susceptible check entries. These accessions showed moderate to high levels of resistance to *E. zinckenella* in each of the three tests.

The resistant accessions of both second and advanced screenings had smaller pods compared with the susceptible entry. In all past studies, accessions with small pods and seeds showed less podborer damage and in all tests, podborer damage had negative correlation with pod size. The use of these accessions in breeding podborer-resistant soybean cultivar is limited since small-seeded cultivars tend to give low yields.

Table 4. Infestation of various soybean accessions by limabean podborer.[z]

Acc.	Damaged pods (%) at various plantings		
	July	August	September
G 3266	11.0 a	13.6 a	10.4 a
G 6359	3.0 b	2.1 b	3.7 a
G 7180	2.8 b	4.1 b	4.6 a
G 6497	2.3 b	4.4 b	4.2 a

[z]Planting dates: 12 July 1988 29 August 1988, and 16 September 1988. Plot size: 5 × 0.75 m. Replicates: 3. Design: RCBD. Mean separation within columns by DMRT at 5% probability level.

Table 5. Infestation of various soybean accessions by limabean podborer.[z]

Acc.	Damaged pods (%) at various plantings		
	July	August	September
G3266	14.2 a	13.1 a	9.7 a
G3469	5.2 b	3.2 b	1.6 c
G3543	3.4 b	3.5 b	2.9 b
G3574	3.1 b	4.7 b	2.9 b

[z]Planting dates: 12 July 1988, 29 August 1988, and 16 September 1988. Plot size: 5 × 0.75 m. Replicates: 3. Design: RCBD. Mean separation within columns by DMRT at 5% probability level.

Soybean Pathology

Evaluation for Bacterial Pustule Resistance

Summary

Twelve of the 116 soybean breeding lines evaluated were confirmed as highly resistant to bacterial pustule (BP) under field conditions. Most of the 116 lines were resistant to moderately resistant with only one line classified as moderately susceptible. Of the 12 highly resistant lines, 10 had AGS 269 and two had AGS 129 as one of the parents.

Introduction

Bacterial pustule of soybean occurs most frequently under warm and moist conditions. The most effective method to control this disease is by developing and planting resistant lines. This experiment aimed to confirm bacterial pustule resistance in soybean breeding lines.

Material and Methods

The number of entries, plot size, plant density, inoculum preparation and isolate were the same as reported in the 1988 Progress Report. Seeds were sown on 27 March and the plants were inoculated at R_3-R_4 growth stage on 4 and 11 May. The plants were assessed on 1 and 12 June. The rating system used was as follows: highly resistant (HR) = less severity than AGS 129; resistant (HR-) = similar severity to AGS 129; moderately resistant (MR) = similar severity to G 2034 (CNS); moderately susceptible (MS) = severity levels between G 2034 and G 38; and highly susceptible (HS) = severity greater than G 38.

Results and Discussion

Twelve of the 116 lines evaluated were rated as highly resistant, 55 lines as HR-, 48 as MR, and one line MS. Ten of the highly resistant lines had AGS 269 as the male parent (Table 1). When

Table 1. Soybean breeding lines highly resistant to bacterial pustule.[z]

Line no.	Pedigree
GC 86021	AGS 8 × AGS 129
GC 86022-12	AGS 8 × AGS 269
CG 86022-17	AGS 8 × AGS 269
GC 86024-3	AGS 17 × AGS 269
CG 86025-9	AGS 29 × AGS 129
GC 86026-38	AGS 29 × AGS 269
GC 86026-48	AGS 29 × AGS 269
GC 86026-51	AGS 29 × AGS 269
GC 86030-5	AGS 85 × AGS 269
GC 86030-7	AGS 85 × AGS 269
GC 86032-17	AGS 95 × AGS 269
GC 86032-18	AGS 95 × AGS 269

AGS 269 was used as one of the parents, 24% of the progenies were HR, 41% HR-, and 35% were MR. Of the 66 lines identified as HR or HR in 1988, 45 were HR or HR and 21 were rated as MR, even under severe infection.

Incidence of Pathogens on Stems

Summary

There were more pathogens on stems of soybean in the AYT-1 than AYT-2. Plots treated with a fungicide consistently had less fungi on stems compared to untreated plots (57%). *Macrophomina phaseolina* occurred on 70% of stems examined in the AYT-1 fungicide-untreated plots.

Introduction

There are few reports on soybean resistance to anthracnose (*Colletotrichum* spp.) and charcoal rot (*Macrophomina phaseolina*). Both diseases are important in Southeast Asia although there is no documentation on yield reduction attributed to these diseases. Other stem pathogens on soybean that are important in some locations are *Phomopsis* spp., *Cercospora* spp. and *Sclerotium rolfsii*.

This study aimed to determine the differences in the incidence of *Colletotrichum* spp., *Macrophomina phaseolina* and other stem-borne pathogens on soybean lines in the Advanced Yield Trials (AYT)-1 and -2.

Materials and Methods

Twenty stems per plot were visually rated for pathogens at R_8 growth stage in AYT-1 and -2, spring 1989. Data were converted to percentage. Both trials were split-plots in a randomized complete block design with four replications. The plants in the main plot were fungicide-treated (bayleton) and untreated. There were 12 breeding lines in AYT-1 and 13 in AYT-2.

Results and Discussion

Of the stem pathogens, *Cercospora* spp. had the highest incidence (60%), followed by *Macrophomina phaseolina* (59%) and *Colletotrichum* spp. (38%) (Table 2). The occurrence of both *Phomopsis* spp. and *Sclerotium rolfsii* was less than 1%. No lines had consistently lower levels of pathogens compared to the average incidence of pathogens in all lines. Although these results were preliminary, this technique of evaluating the resistance of soybean lines to stem pathogens at R_8 growth stage poses some potential. It has been used by other researchers evaluating soybean diseases.

The incidence of seedborne pathogens in each line in these two trials was investigated to establish the relationships between pathogens on the stem and on the seed. Data from AYT-1 and AYT-2 planted in summer and fall are under investigation. Therefore, future experiments will be planned to determine the importance of stem pathogens in relation to yield and seed infection, and to determine if differences in the levels of infection are related to soybean genotypes.

Table 2. Mean percentage incidence of three pathogens on soybean stems from fungicide-treated and fungicide-untreated plots, AYT-1 and -2, spring 1989.[z]

Treatment	*Cercospora* spp.		*Colletotrichum* spp.		*Macrophomina phaseolina*	
	AYT-1	AYT-2	AYT-1	AYT-2	AYT-1	AYT-2
Fungicide	59	48	43	26	54	56
No fungicide	67	64	50	34	70	55

[z]Mean percentages are from 20 samples in each of four replications of 12 and 13 entries in AYT-1 and AYT-2, respectively.

Sweet Potato Breeding

Hybridization

Summary

In the 1988-89 hybridization program, four polycrosses and two series of handcrosses were conducted. Priority was given to the improvement of dry matter, eating quality, resistance to leaf scab and vine borer, and root performance of sweet potato under hot humid conditions.

Introduction

In the cool season of 1988-89, four polycrosses and two series of handcrosses were conducted.

Materials and Methods

Polycross nurseries were set up each for: 1) orange-fleshed food type, aimed at improving the dry matter yield; 2) yellow-fleshed food type, for combining good eating quality and scab resistance; 3) another yellow-fleshed food type, for improving the yield under hot humid conditions; and 4) high-starch type, for improving the starch content and scab resistance. The handcrosses focused on the improvement of resistance to leaf scab and vine borer.

Results and Discussion

A total of 59,184 seeds obtained from the crosses provided the materials for the seedling screening in 1989.

Yield Performance of the Advanced Clones in Spring and Summer

Summary

The selection of clones adapted to a range of environments in the lowland tropics was continued. Croppings under different environments in spring and summer have been carried out as a routine procedure of the screening. This study investigated the genotype × season interactions on yield and chemical components to confirm the clones' responses to different seasons.

Significant genotype × season interactions were observed for marketable yield and its components. Of the clones evaluated, CN 1489-89 had stable yield and Tainung 66, one of the best yielders under favorable conditions, appeared most sensitive to hot-humid conditions. Results indicated different genotypes with contrasting responses to environmental changes in the hot-humid season can be identified under the spring and summer conditions.

Introduction

The AVRDC sweet potato breeding program aims to develop sweet potato varieties that are well adapted to the lowland tropics. Repeated trials have been made in different months during the year to evaluate the clones adapted to a wider range of environments.

Based on the results of the 1987 yield trials at AVRDC, the planting months and durations of the main yield trials were redefined as follows:

Season	Planting months	Planting durations
Spring	April	120 days
Summer	June	120 days
Fall	September	150 days

Trials in the spring and summer under similar temperatures as in the tropical lowland areas in Asia are given emphasis in the program. All breeding lines in the preliminary and advanced yield trials are evaluated in the two croppings during the hot-humid season at AVRDC. Advanced clones are also evaluated in fall for cool-dry conditions (Fig. 1).

Results of trials showed that yield in summer is very low compared to croppings in spring and fall. It has been considered that high soil temperatures, intensive rainfall due to tropical depression/typhoon in summer, followed by waterlogging in the fields seriously affect yields.

Although summer cropping generally resulted in poor yield, varietal differences have also caused severe yield reduction. As reported last year, the continuous evaluation in spring and summer enabled the breeders to identify the clones more adapted to a range of environments, both favorable and marginal to the root formation of sweet potato in the hot season.

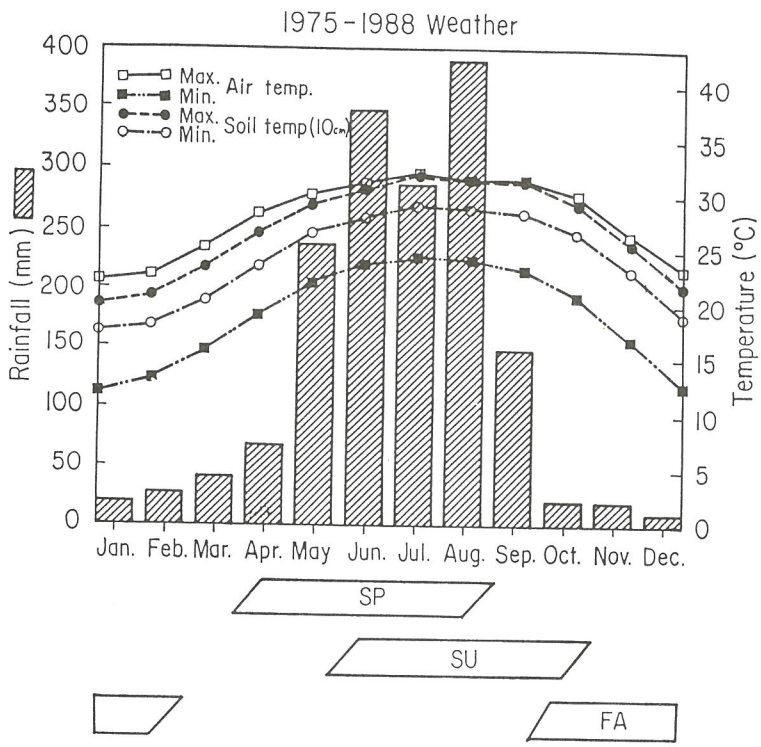

Fig. 1. Mean temperature, rainfall (1975-1988) and duration of sweet potato yield trials, AVRDC.

This study aimed to investigate the nature of genotype × season interactions on yield and chemical components in view of improving the adaptability of sweet potato clones to a range of hot tropical environments and to confirm the clones with different responses to summer conditions.

Materials and Methods

The data from the advanced yield trials in the spring and summer of 1987 to 1989 were used in this study. A total of 11 advanced clones and Tainung 66 were included in the trials. Tainung 66 is one of the leading varieties in Taiwan with high and stable yield in fall and spring but very sensitive to adverse conditions in summer. At harvest, samples of roots were taken and sent to the chemistry laboratory for dry matter, starch, protein, sugar, fiber and β-carotene analyses.

Results and Discussion

Results of a combined analysis of variance are summarized in Table 1. The seasonal means were averaged over entries and years. It was noted that all characters except β-carotene content were depressed in summer.

Table 1. Significant effects of treatment on marketable yields and other characters in the advanced yield trials, 1987-1989.

Character	Mean of 12 entries over three years		Season	Entry	Season × entry
	spring	summer			
Marketable root yield (t/ha)	24.1	11.0	***	***	***
No. of marketable root (×1000/ha)	126.0	79.0	***	***	***
Marketable rate[z](%)	91.0	73.0	***	***	***
Average MKT root size (g)	190.0	135.0	***	NS	***
Top weight (t/ha)	38.5	35.6	NS	*	NS
Dry matter (%)	31.6	28.1	***	***	NS
Starch (% FWB)	22.1	19.8	***	***	NS
Sugar (% DWB)	13.1	12.9	NS	***	NS
Protein (% DWB)	4.5	3.8	***	***	NS
Fiber (% DWB)	2.7	2.5	**	***	NS
Carotene (mg/100 g FW)	4.1	4.1	NS	***	NS

*Significant at 5% level. **Significant at 1% level. ***Significant at 0.1% level. NS = Not significant. [z]Marketable rate = marketable yield/total yield.

The interactions between season and entry were highly significant in marketable root yield, number of marketable roots, marketable rate (marketable yield/total yield) and average marketable root size.

Although genotype variations exist in the dry matter, starch, protein and fiber contents, characters of all entries are similarly influenced by season. Top weight (fresh vine and leaf weight) and sugar and β-carotene contents were not affected by season while genotypic variations were present.

Figure 2 shows the nature of season × genotype interactions for marketable yield. In summer, marketable root yields, number of marketable roots, and average marketable root size were reduced in all entries. However, CN 1489-89, the best yielder in summer, showed least reduction in all characters. Tainung 66 was one of the highest yielders in spring but had the lowest yield in summer. Yield of this variety in summer was very poor because of severe reduction in the number of marketable roots. CN 1510-25 with high yield equivalent to Tainung 66 in spring showed reduced number of marketable roots in summer. The reduction of average root size resulted in a quite lower marketable rate.

The relative environment sensitivity (b:regression coefficient) of marketable yield is presented in Table 2. Most entries had b-values around 1.0 (1.0 ± 0.23) which indicated an average sensitivity to environments.

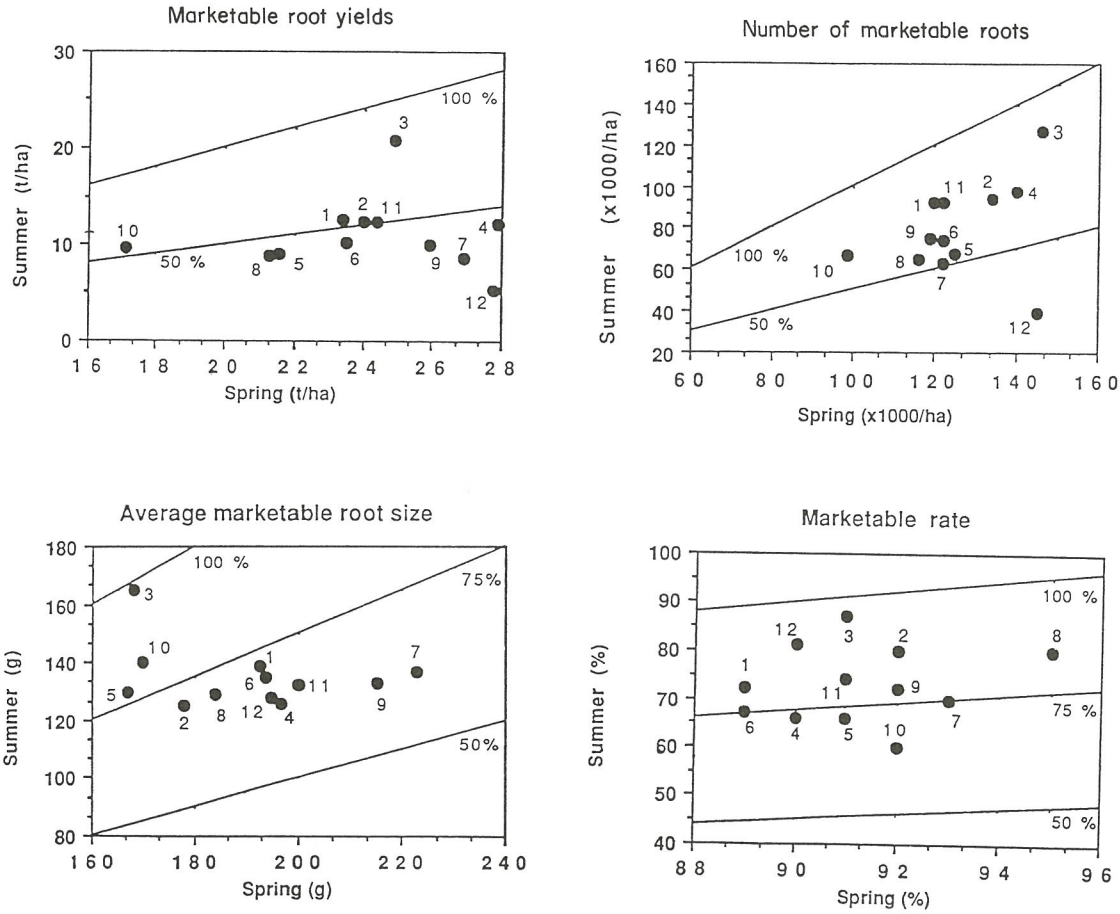

Fig. 2. Yield components of the advanced clones in different seasons, AVRDC, 1987-1989. 1 = CN 1108-13, 2 = CN 1232-9, 3 = CN 1489-89, 4 = CN 1510-25, 5 = CN 1525-11, 6 = CN 1618-461, 7 = CN 1656-101, 8 = CN 1656-37, 9 = CN 1656-97, 10 = CN 1661-15, 11 = CN 1688-116, 12 = TN 66. The lines in the figures show percentage of summer vs spring.

Table 2. Mean and environmental sensitivity for marketable yields of advanced sweet potato clones, 1987-89.

Code no.	Clone no.	Mean marketable yield (t/ha)			b^z	R^2
		spring	summer	overall		
1	CN 1108-13	23.4	12.5	17.9	0.91	92.8
2	CN 1232-9	24.0	12.3	18.1	0.97	78.8
3	CN 1489-89	24.9	20.8	22.8	0.56	58.8
4	CN 1510-25	27.9	12.2	20.1	1.19	96.7
5	CN 1525-11	21.6	9.1	15.3	1.13	88.6
6	CN 1618-461	23.5	10.1	16.8	0.96	96.8
7	CN 1656-101	26.9	8.7	17.8	1.22	84.3
8	CN 1656-37	21.3	8.9	15.1	1.04	90.2
9	CN 1656-97	25.9	10.0	17.9	1.21	98.4
10	CN 1661-15	17.1	9.7	13.4	0.68	86.3
11	CN 1688-116	24.4	12.4	18.4	0.91	96.3
12	TN 66	27.8	5.2	16.5	1.39	86.8
	Mean of entries	24.1	11.0	17.5	1.00	100

[z]b:Regression coefficient.

CN 1489-89, with the highest mean yield appeared very stable in different environments. CN 1661-15 was also relatively stable among entries but its yields in both spring and summer were quite low. Tainung 66 was the most sensitive clone to environmental changes although it was one of the highest yielders in spring. CN 1510-25, another high yielding clone in spring was less interactive than Tainung 66.

Figure 3 shows the yields of CN 1489-89 and Tainung 66 under six environments (spring and summer, 1987-1989) with single regression lines. Tainung 66 was very sensitive to the low yielding environments (summer) but responded very well to high yielding environments (spring). These two varieties showed contrasting responses to adverse summer conditions last year. These clones are being utilized as check cultivars in yield trials at AVRDC.

Results suggested that efficient setting of planting time enabled the identification of different genotypes with contrasting responses to a range of tropical environments. In AVRDC screening procedures, spring trials enabled the evaluation of yield under relatively favorable conditions in the tropics. On the other hand, since sweet potato in the tropics is often grown under marginal conditions, the clones identified as adaptable to summer conditions could provide essential information on the crop's potential.

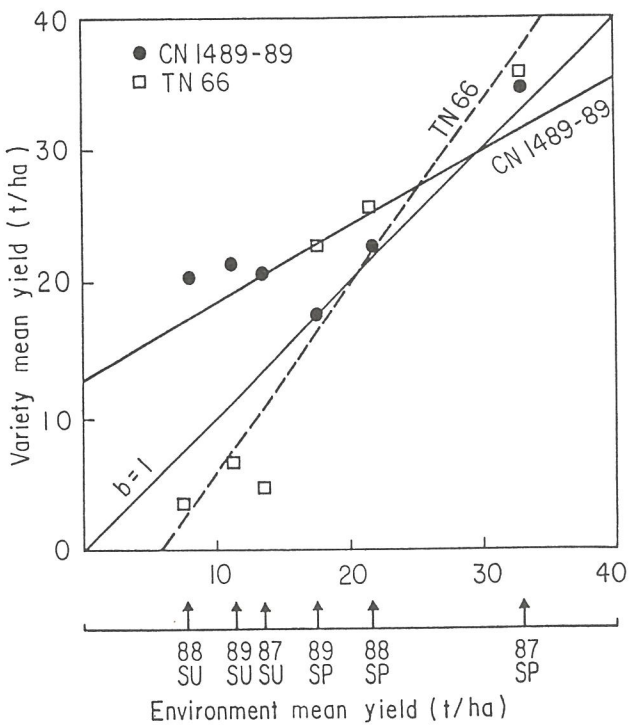

Fig. 3.
Response of Tainung 66 and CN 1489-89 to different environments; AVRDC, 1987-89.
SP = Spring, SU = Summer.

Performance of New Clones in the Advanced Yield Trials

Summary

Through selection at different stages, the final set of promising sweet potato clones are evaluated in the advanced yield trials (AYT). Selections in the AYTs are based on the combined performance over seasons and years. Twelve clones were selected for evaluation next year.

Introduction

After two years of preliminary yield trial (PYT), the promising clones are evaluated based on their combined performance under different environments in the spring, summer and fall to select new

clones for international distribution. This report includes the performance of new entries in the advanced yield trials (AYTs) conducted in the spring and summer of 1989.

Materials and Methods

A total of 32 new clones were evaluated in the spring and summer AYTs in 1989. Based on flesh color the clones were divided into AYT-Group 2, for orange-fleshed clones and AYT-Group 3, for yellow-fleshed clones. The experimental details of the trials are given in Table 3. Tainung 66 and CN 1489-89 were used as common standard cultivars (Fig. 3). Other high yielding clones such as CN 1108-13, CN 1232-9, CN 1510-25 and Tainung 57 were also compared. Root samples were analyzed for their chemical compositions.

Table 3. Sweet potato yield trials conducted in 1989.

Season	Trial	Group	No. of entries	Date of planting	Date of harvesting	Planting duration	Experimental design (Reps.; No. of plant/plot)
1988 Fall	PYT(II)[y]	–	20	16 Sept.	15 Feb.	153	RCBD (2;40)
1989 Spring	AYT[z]	1	14	21 March	19 July	121	RCBD (4; 80)
		2	14	22 March	24 July	125	〃
		3	18	27 March	26 July	122	〃
	PYT(II)	1	26	4 April	31 July	119	RCBD (2; 40)
		2	26	12 April	2 August	113	〃
		3	20	12 April	7 August	118	〃
		4	20	13 April	7 August	117	〃
	PYT(I)[x]	–	52	14 April	9 August	118	RCBD (2; 20)
	EYT[w]	–	35	17 April	14 August	120	〃
Summer	AYT	1	14	23 May	2 October	133*	RCBD (4; 80)
		2	14	24 May	3 October	133*	〃
		3	18	29 May	4 October	129*	〃
	PYT(II)	1	26	5 June	18 October	136*	RCBD (2; 40)
		2	26	26 June	19 October	116	〃
		3	20	7 June	9 October	125	〃
		4	20	9 June	5 October	119	〃
	PYT(I)	–	64	14 June	23 October	132	RCBD (2; 20)
	EYT	–	35	27 June	16 October	112	〃

[z]Advanced yield trial. [y]Preliminary yield trial, 2nd year. [x]Preliminary yield trial, 1st year. [w]Evaluation yield trial. *Harvests of trials were postponed for 5-16 days because of heavy rains and bad field conditions.

Results and Discussion

Supplementary food type (orange-fleshed type). Table 4 shows the yields and other horticultural characteristics of the orange-fleshed selections from AYT 1989.

Compared with CN 1108-13, a light orange-fleshed clone, dry matter content of the selection was improved by more than 5 %. Although the yield is lower than CN 1108-13, CN 1818-17 and CN 1790-42 seemed promising for their improved dry matter content, sufficient β-carotene content, drier texture, red skin, better shape and uniformity. In summer, CN 1818-17 showed better yield than the other selections whereas CN 1489-89 had lower yield than the check.

Supplementary food type (yellow-fleshed clones). Table 5 summarizes the yields and other characteristics of seven yellow-fleshed selections from AYT 1989. Although the breeding program aims for an ideal 30-35% dry matter content for yellow-fleshed type, some clones with lower dry matter content were also selected for combined performance.

Among selections, CN 1821-39 and CN 1821-8 showed good yield suited for feed use because of relatively big and less uniform roots. Regardless of their relatively low yield, uniform roots and red skin, CN 1757-40 and CN 1757-30 were found suitable for fresh market use in summer. CN 1823-77 was outstanding and yielded significantly higher than any other entries in the group.

Yield stability in two seasons. Before the AYT, each selection was evaluated in the PYTs for two years. Yield data from the PYTs and AYT were used to estimate the relative yield stability.

Table 4. Yields and other horticultural characteristics of selections in the AYT-Group 2, 1989.

Clone No.	Spring 1989										Summer 1989
	MKT yield (t/ha)	MKT yield rate (%)	MKT root number (× 1000/ha)	Average MKT root size (g)	Dry matter (%)	β carotene (mg/100g)	Skin[z] color	Flesh[y] color	Root[x] shape	General[w] appearance	MKT yield (t/ha)
CN 1818-117	21.7 b-e	90	151 a-c	147 c-f	29.8 d	4.3 bc	R_3	O_3	S,O_V	F-G	13.7 bc
CN 1790-42	21.6 b-e	90	105 c	207 ab	32.8 a-c	4.1 bc	R_7	O_3Y_5	O_V, RS	F-G	2.9 e
CN 1831-57	20.8 b-c	86	178 ab	116 f	32.0 b-d	1.3 e	R_7	Y_3O_3	O_V	F-G	9.1 c-e
CN 1517-142	20.4 c-e	92	106 c	193 a-c	33.0 ab	3.1 cd	O_3	O_3Y_5	S	F-G	8.8 c-e
Check lines											
CN 1108-13	28.3 ab	88	190 a	150 c-f	24.8 e	5.2 b	O_3	O_3	O_VS	F	10.2 cd
CN 1510-25	28.0 a-c	90	174 ab	163 b-e	31.4 b-d	0.2 e	R_3	Y_1	O_V	F	10.3 cd
CN 1489-89	21.8 b-c	87	169 ab	130 ef	35.0 a	0.9 e	Y_1	Y_1	S	F	18.0 ab
TN 66	27.5 a-d	86	156 a-c	176 a-e	23.1 ef	8.3 a	R_5	O_5	S,LO_V	G	4.3 de
Mean of 14 entries	11.9	89	145	163	29.9	3.6					10.4
Range	17.6-30.3	84-95	101-190	116-209	21.7-35.0	0.2-8.3					2.9-23.4
CV (%)	15.2	4.8	17.4	12.9	4.5	23.3					29.6

[z]Skin color; R = Red, O = Orange, P = Purple, Y = Yellow, B = Brown, increasing color intensity indicated by numbers (1 = light to 7 = very intense). [y]Flesh color; W = White, Y = Yellow, O = Orange, increasing color intensity indicated by numbers (1 = light to 7 = very intense). [x]Root shape; R = Round, S = Spindle, RS = Round spindle, LS = Long spindle, O_V = Ovate, RO_V = Round ovate, LO_V = Long ovate, O_b = Obovate, I = Irregular. [w]General appearance; P = Poor, F = Fair, G = Good. Means with different letters are significantly different at 1% probability level by DMRT.

Table 5. Yields and other horticultural characteristics of selections in the AYT-Group 3, 1989.

Clone no.	Spring 1989									Summer 1989
	MKT yield (t/ha)	MKT yield rate (%)	MKT root (× 1000/ha)	Average MKT root size (g)	Dry matter (%)	Skin color	Flesh color	Root shape	General appearance	MKT yield (t/ha)
CN 1821-39	31.6 ab	93	150 b-d	211 a-d	27.6 d	Y_1	Y_1	RS,O_V	F	12.7 c-f
CN 1821-8	30.4 bc	91	139 c-e	220 ab	29.4 c	Y_1R_1	Y_3	Ov,S	F	14.0 b-c
CN 1823-77	28.3 b-e	93	143 b-e	201 b-e	31.7 ab	Y_1	W	S	F-G	21.1 a
CN 1836-163	27.6 b-f	94	109 ef	255 a	30.7 bc	Y_1	Y_1	LS,S	F	14.9 b-d
CN 1757-40	24.6 e-f	92	154 b-d	160 ef	24.6 e	R_5	Y_1	S	F-G	10.2 d-g
CN 1836-188	24.5 e-f	86	195 a	126 f	30.0 bc	R_1	Y_1	RS,O_b	F	8.7 f-h
CN 1757-30	23.5 ef	89	147 b-d	164 d-f	32.6 a	R_7	Y_1	S,O_V	F-G	6.3 g-i
Check lines										
CN 1232-9	27.4 b-f	94	158 bc	179 b-e	26.5 d	Y1	Y1	S,RS	F	10.3 d-g
CN 1510-25	30.1 b-d	94	167 a-c	180 b-e	29.5 c	R5	Y3	Ov,S	F	9.5 e-g
TN 57	27.8 b-f	90	170 a-c	164 e-f	21.9 f	B3	Y3	S,Ov	F	4.6 hi
CN 1489-89	24.9 d-f	90	148 b-d	171 c-f	31.2 a-c	Y1	Y1	S	F	15.8 bc
TN 66	35.9 a	94	177 ab	203 b-e	22.3 f	R_5	O_5	O_V,LS	G	4.0 hi
Mean of 18 entries	26.2	92	143	187	27.6					10.6
Range	16.6-35.9	86-95	97-195	126-255	21.6-33.0					
CV (%)	9.4	2.9	11.8	12.1	3.3					23.1

For footnotes, please see Table 4.

Figure 4 presents the relationships between mean yield over environments and stability among selections. Two lines had outstanding mean yields and relative stability. CN 1823-77 with a mean yield over environments of 23.8 t/ha, was the most stable clone among entries. CN 1821-8 showed the highest mean marketable yield over environments and on the average, it was sensitive with the regression coefficient (b), 0.95. A promising orange-fleshed clone, CN 1790-42, was classified similar to Tainung 66, being sensitive to the adverse summer environment.

Scab resistance of the selections. In the screening for leaf scab resistance the following selections were found resistant: CN 1790-42 (for Group 2), CN 1821-8, CN 1823-77, CN 1836-163 and CN 1836-188 (for Group 3). CN 1823-77 and CN 1836-188 showed higher resistance than the well-known resistant cultivar Hawaii from Tonga. Further evaluations will be conducted to confirm their level of resistance.

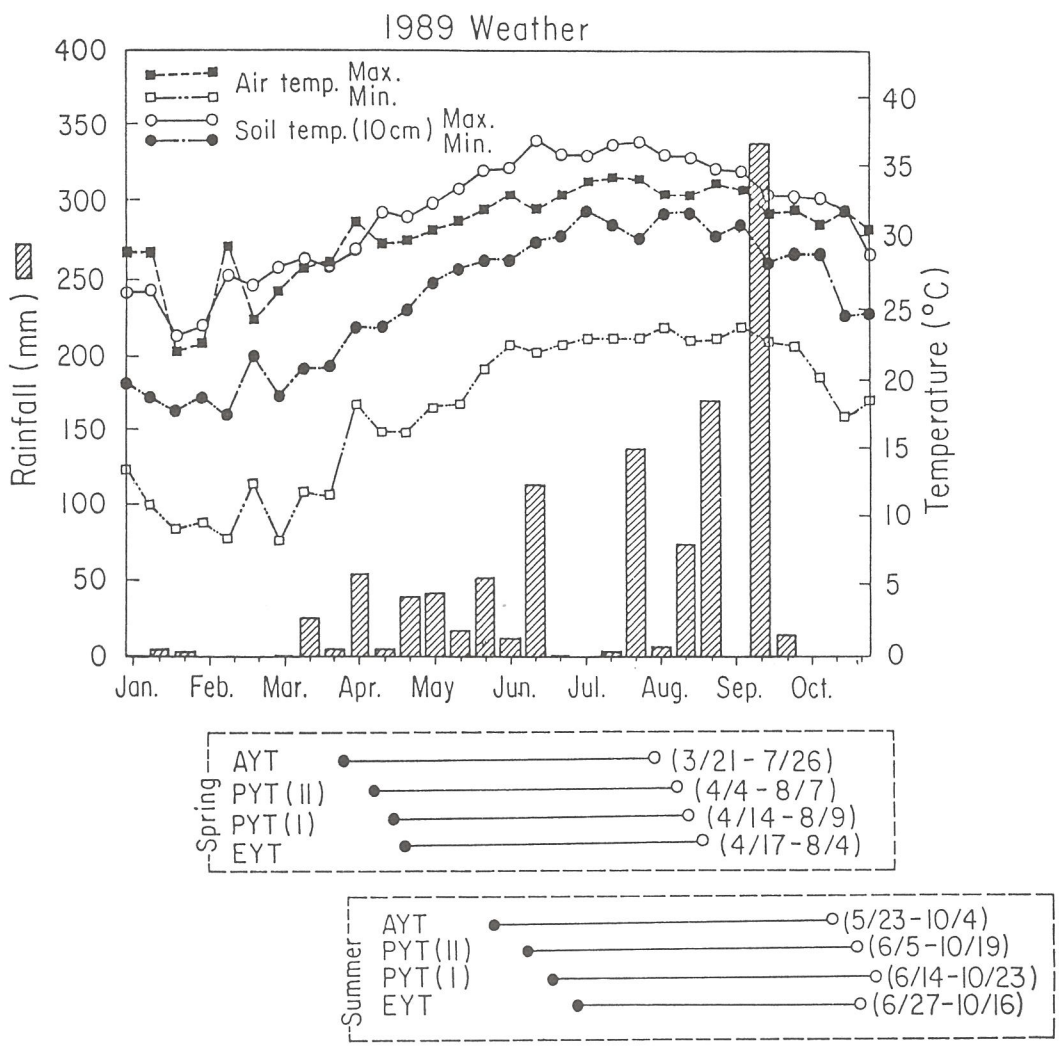

Fig. 4. Temperature and rainfall during the sweet potato yield trials, AVRDC, 1989. Because of the intensive rainfall on July 26, August 28 and September 12, the trials fields were under water-lodged conditions for a few days each time.

Selection of Promising Clones in the Preliminary Yield Trials

Summary

Thousands of new genotypes underwent rigorous selection in the seedling screening and observation yield trials. Only a limited number of clones were entered into the preliminary yield trials to evaluate their yield, adaptability to a wider range of environments and overall performance including morphological and chemical factors. A total of 20 clones were selected from the PYT2 and 18 from the PYT1 for further evaluation next year.

Introduction

Through rigorous selections of general morphological characters and dry matter content in the observation yield trial, only a limited number of clones were selected for evaluation in the preliminary yield trials (PYTs).

In the PYT1 (first year) a relatively small plot size (20 plants/plot, 2 replications) was used to evaluate more clones. Selection from the first year has been continued in the PYT2 (second year) with the plot size increasing to 40 plants/plot, (2 replications). Both trials were evaluated in spring and summer.

Materials and Methods

In 1989, 72 entries were evaluated in PYT1 and 64 clones in PYT2. The entries in PYT2 were divided into: Group 1, orange fleshed-food type; Group 2, yellow-fleshed type; Group 3, high starch type; and Group 4, for the interspecific hybrids. Group 4 will be reported in the next section.

The experimental details are given in Table 3 and the weather during the trials is summarized in Figure 5. Tainung 66 and CN 1489-89 were used as the common standard clones and other high yielding clones/varieties were compared based on the purpose of each group. Root samples of PYT1 were subjected to chemical analysis and the dry chip weight of the PYT1 entries was measured.

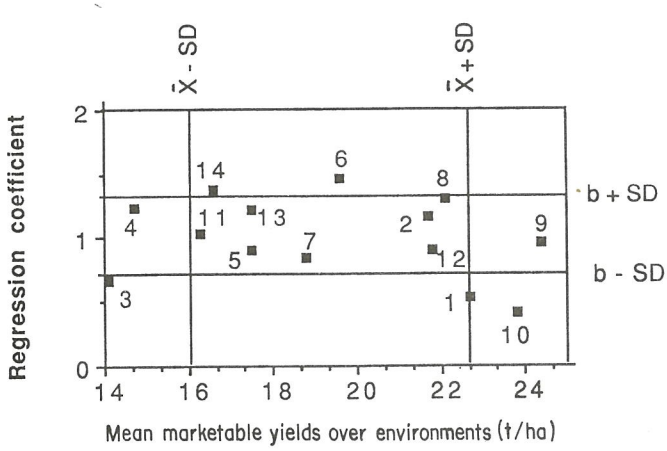

Fig. 5.
Relationship between marketable yield and environmental sensitivity of the new advanced clones, AVRDC, 1987-1989.
1 = CN 1489-89, 2 = CN 1510-25, 3 = CN 1517-142, 4 = CN 1757-30, 5 = 1757-40, 6 = 1790-42, 7 = CN 1818-117, 8 = CN 1821-39, 9 = CN 1821-8, 10 = CN 1823-77, 11 = CN 1831-57, 12 = CN 1830-163, 13 = CN 1836-188, 14 = TN 66.

Results and Discussion

Preliminary yield trials, 2nd year

Orange-fleshed clones (Group 1). The yields and other characteristics of the selections from Group 1 in PYT2 are summarized in Table 6. Ten clones with yield equivalent to Tainung 66 were selected. CN 1840-284 was promising for the fresh market because of its uniform roots, better spindle shape and sufficient β-carotene content. Although CN 1842-169, CN 1842-195 and CN 1841-197,

Table 6. Yields and other horticultural characteristics of the clones in the PYT2-Group 1, 1989.

Clone no.	Spring 1989										Summer 1989
	MKT yield (t/ha)	MKT yield rate (%)	MKT root No. (× 1000/ha)	Average MKT root size (g)	Dry matter (%)	β-carotene (mg/100 g)	Skin color	Flesh color	Root shape	General appearance	MKT yield (t/ha)
CN 1842-169	21.9 a-c	85	112 bc	198	23.3	4.9	R_3	O_3Y_1	RO_vO_v	F	11.2 a-d
CN 1842-195	21.2 a-d	84	154 ab	138	22.2	8.3	R_3	O_5	S,O_v	F-G	8.7 a-e
CN 1841-197	21.1 a-d	88	186 a	114	20.9	7.0	O_3	O_3	S,RS	F	7.4 a-e
CN 1841-225	20.9 a-d	93	93 bc	226	24.0	7.1	O_3	O_3	ROV	F	5.7 b-c
CN 1840-253	20.0 a-d	90	93 bc	213	26.3	4.3	O_3	O_3	S,O_v	F-G	2.6 de
CN 1840-284	19.5 a-d	81	156 ab	125	25.4	6.2	O_3	O_1	S	F-G	8.9 a-e
CN 1844-341	18.6 a-d	77	134 a-c	139	23.5	5.0	P_5	O_3	S,O_v	F	15.4 a
CN 1842-78	17.0 a-d	91	93 bc	182	28.5	6.7	R2	O_3Y_5	RO_v,R	F	3.3 c-e
CN 1842-199	16.6 a-d	72	133 a-	126	25.7	4.3	R_1	O_3	S,O_v	F	13.6 ab
CN 1843-303	16.0 a-d	87	116 a-c	138	28.4	6.9	R_7	O_5Y_5	S,O_v	F	12.5 a-c
Check lines:											
AIS 0122-2	13.9 a-d	84	96 bc	144	20.2	6.1	R_7	O_5	S	F	0.6 e
CN 1108-13	22.5 a-c	88	127 a-c	182	26.2	6.8	O_3	O_3	O_v,S	F	4.9 c-e
CN 1489-89	19.5 a-d	88	135 a-c	145	32.5	2.1	Y_1	Y_1	S	F	5.9 c-e
CN 1510-25	12.3 cd	70	79 c	154	27.2	2.5	R_3	Y_1	O_v,S	F	4.1 c-e
Tainung 66	18.4 a-d	77	127 a-c	144	23.1	8.7	R_7	O_5	LS,O_v	F	1.5 e
Mean of 26 entries	18.0	81	119	155	24.6	5.7					5.8
Range	11.0-23.6	60-93	79-186	97-226	20.1-32.5	2.1-8.7					0.6-15.4
CV (%)	17.3	6.3	18.5	11.1	3.2	11.5					48.9

For footnotes, please see Table 4.

CN 1844-341 had relatively low dry matter, the lines were selected for further evaluation mainly because of the uniformity of roots and acceptable skin and flesh color. Summer yield was low with the check CN 1489-89 yielding 5.9 t/ha. However, the yields of CN 1842-169, CN 1844-341, CN 1842-199 and CN 1843-303 reached over 10 t/ha.

Yellow-fleshed clones (Group 2). Table 7 shows the results of PYT2 for the yellow-fleshed clones. CN 1821-39, CN 1841-266, CN 1848-9 and CN 1842-107 were selected for relatively higher dry matter content; CN 1843-341, promising for fresh market as well as a material for processed food, was selected for its high dry matter, acceptable skin / flesh color, uniform root shape and excellent dry fine texture; CN 1840-322, CN 1848-236 and CN 1847-9 for skin/flesh color and uniformity of roots. The yield in summer was also low and the coefficient of variation was very high compared with the AYTs. However, CN 1842-107 showed relatively better yield than the other entries.

High starch clones (Group 3). Only the clones with more than 36% dry matter content were entered in this group. Tainan 17, a cultivar suitable for starch extraction was also included as check cultivar. Since summer yield was very low, only the data in spring were reported in Table 8. The starch content of all selections except CN 1732-4 was significantly higher than any check in the trial. However, yields of clones with high starch content tended to be low and, as a result, starch yield was not as high as high yielding clones with medium starch levels such as CN 1510-25. CN 1735-1 and CN 1732-4 were selected for further crossing.

Preliminary yield trials, 1st year. Of the 52 entries, 18 clones were selected. Yields of most selections were statistically comparable to Tainung 66. Dry chip (%) of most selections was more than 30% except CN 1886-9 and CN 1898-50 (Table 9). CN 1899-33 and CN 1899-59 had significantly higher dry matter chip yield than CN 1510-25, the highest dry chip producer among check cultivars. From the performance of the check cultivars in summer, it is possible that environment also severely affected the yields as in PYT2s. However, CN 1899-33, CN 1899-34 and CN 1899-38 significantly outyielded CN 1489-89.

Utilization of Interspecific Hybrids

Summary

Since 1985, the possibility of utilizing 5x-hybrids obtained from the cross between 4x *Ipomoea trifida* and sweet potato has been continued. The first backcross was made and selection of these progenies (BCF_1) has been continued to improve the yield of hybrids.

Eleven BCF_1 lines selected in 1989 were entered into PYT2 and evaluated in three seasons. Compared with the 5x-hybrids, the yields of these lines were recovered after the first backcross and found comparable to sweet potato. No special defect was identified in morphological and chemical characters such as dry matter, starch, protein, and sugar content. The lines could be utilized in breeding programs as ordinary sweet potato varieties.

Introduction

Although there are many cases of utilizing wild relatives in plant breeding, few successful ones in sweet potato breeding have been reported so far despite attempts made since 1930's. Much information would be needed to explore the possibilities in this field.

The AVRDC sweet potato breeding program has evaluated 5x-hybrids obtained from the crosses between 4x *Ipomoea trifida* and Japan's sweet potato cultivars since 1985. Only six sweet potato cultivars and four *I. trifida* were utilized. The original population was limited (3,030 seeds). To improve low yield, the first backcrosses of the selected 5x-hybrids were conducted in 1986. The backcross first generation (BCF_1) was evaluated and high yielding clones with better appearance were selected in 1988.

Table 7. Yields and other horticultural characteristics of the selections in PYT2-Group 2; 1989.

Clone no.	Spring 1989										Summer 1989
	MKT yield (t/ha)	MKT yield rate (%)	MKT root No. (× 1000/ha)	Average MKT root size (g)	Dry matter (%)	Dry matter yield (t/ha)	Skin color	Flesh color	Root shape	General appearance	MKT yield (t/ha)
CN 1821-39	23.6 ab	90	115 b-e	205	30.0	7.1 ab	Y_1	Y_1	RO_v	F	6.7 a-d
CN 1841-266	23.2 a-c	90	121 a-d	191	31.6	7.3 a	Y_1	Y_2	S,RO_v	F	3.7 c-g
CN 1842-107	22.3 a-d	90	135 a-c	170	28.7	6.4 a-d	R_7	Y_2	O_v,S	F	9.4 a
CN 1843-341	20.3 b-f	91	106 b-f	192	34.7	7.0 ab	R_7	Y_6	O_v	F	7.4 a-c
CN 1840-322	20.2 b-f	86	114 b-c	178	31.0	6.3 a-d	R_5	Y_5	O_1S,O_v	F	4.0 c-g
CN 1848-9	18.7 b-f	91	102 c-f	184	35.6	6.7 a-c	Y_1	Y_1	RO_v	F	2.6 e-g
CN 1848-236	18.4 b-f	72	155 ab	121	31.3	5.8 a-f	O_5	Y_5	RO_v	F-G	7.1 a-c
CN 1847-9	16.0 c-g	84	120 a-c	134	32.6	5.2 b-f	R_5	Y_1	O_v,RS	F	3.4 c-g
Check lines											
CN 1232-9	23.2 a-c	88	114 b-c	203	29.0	6.7 a-c	Y_1	Y_1	RO_v,RS	F	2.3 c-g
TN 57	20.5 b-e	83	168 a	122	23.7	4.9 c-f	B_3	Y_5O_1	S,RO_v	F	1.6 e-g
CN 1489-89	16.8 c-g	80	122 a-d	138	32.6	5.5 a-f	Y_1	Y_1	S,LO_v	F	4.0 c-g
CN 1510-25	20.5 b-e	80	133 a-c	155	30.4	6.2 a-d	R_3	Y_3	O_v	F	4.3 c-g
TN 66	27.7 a	85	168 a	166	23.9	6.6 a-c	R_7	O_5	RO_v,S	F-G	0.9 e-g
Mean of 26 entries	18.5	83	115	161	31.7	5.7					3.5
Range	7.2-27.7	66-91	60-168	119-205	23.4-38.2	2.8-7.3					0.0-9.4
CV (%)	10.8	6.3	13.4	9.8	2.2	10.6					37.6

For footnotes, please see Table 4.

Table 8. Yields and other horticultural characteristics of the high-starch clones in the PYT2-Group 3, spring 1989.

Clone no.	MKT yield (t/ha)	MKT yield rate (%)	Dry matter (%)	Dry matter yield (t/ha)	Starch	
					content (% FWT)	yield (t/ha)
CN 1735-1	20.8 a-d	86	36.4 a-c	7.6 ab	27.8 a-c	5.8 a
CN 1732-4	20.5 a-e	92	36.4 a-c	7.5 a-c	25.2 cd	5.2 ab
CN 1817-226	15.7 b-f	76	40.0 a	6.3 a-d	29.3 a-c	4.6 a-c
CN 1837-79	15.4 b-f	89	39.6 ab	6.1 a-d	29.1 a-c	4.5 a-c
CN 1747-20	14.2 c-f	85	38.4 ab	5.5 a-e	28.2 a-c	4.0 a-d
CN 1818-120	13.4 c-f	71	39.3 ab	5.2 a-e	29.3 a-c	3.9 a-d
Check lines						
CN 1232-9	22.2 a-c	84	28.9 d-f	6.4 a-d	19.6 ef	4.3 a-d
TN 57	18.6 b-e	81	23.4 f	4.3 b-e	14.0 g	2.6 b-d
Tainan 17	15.0 c-f	62	27.0 ef	4.0 b-e	16.3 fg	2.4 cd
CN 1489-89	17.2 b-e	79	33.7 b-d	5.8 a-e	23.5 d	4.0 a-d
CN 1510-25	26.3 ab	86	31.6 c-e	8.3 a	22.2 de	5.8 a
TN 66	30.1 a	90	24.3 f	7.3 a-c	14.3 g	4.3 a-d
Mean of 17 entries	16.9	80	34.1	5.5	24.0	3.8
Range	6.1-30.1	60-92	23.4-40.7	2.4-8.3	14.0-30.5	1.7-5.8
CV (%)	19.6	12.3	5.5	19.2	5.2	20.4

For footnotes, please see Table 4.

Table 9. Yields and other horticultural characters of the selected clones in the preliminary yield trial(I), 1989.

Clone no.	Spring 1989									Summer 1989
	MKT yield (t/ha)	MKT root no. (x 1000/ha)	Ave. MKT root size (g)	Dry chip (%)	Dry chip yield (t/ha)	Skin color	Flesh color	Root shape	Gen. appearance	MKT yield (t/ha)
CN 1899-33	33.2	120	278	39.0	12.9	Y1	Y3	RS,R	F	13.8
CN 1899-59	28.8	189	164	42.4	12.0	P3	Y1	S	F	2.4
CN 1886-9	28.3	105	269	24.3	6.9	P1	O5	RS,Ob	F	11.4
CN 1898-50	24.7	236	130	28.8	7.1	P3	Y1	S,Ov	F	11.0
CN 1899-34	24.6	130	192	33.5	8.2	R1	Y1	S	F	21.0
CN 1912-200	24.0	132	189	30.0	7.2	P3	Y3O1	S	F	5.8
CN 1888-17	23.5	116	201	30.9	7.2	R3	O5Y3	ROv.RS	F	3.6
CN 1898-200	22.9	133	172	34.7	7.9	P3	Y1	RS,ROv	F	3.8
CN 1905-12	22.2	125	178	37.9	8.4	B3	Y1	S,Ov	P	7.4
CN 1888-3	21.0	228	116	34.1	7.2	R1	W	Ob,S	F	7.6
CN 1899-58	20.6	153	134	36.6	7.6	Y1	Y1	S,Ov	F	9.6
CN 1912-208	19.8	125	151	36.8	7.4	Y1	Y1	LS,Ov	F	1.2
CN 1899-38	19.6	113	173	40.0	7.8	R1	Y1	S	F	13.0
CN 1898-188	18.5	128	144	35.1	6.5	O3	Y1	S	F	10.8
CN 1900-23	17.4	158	113	34.5	6.0	Y1	Y1	SS	F	9.8
CN 1908-15	16.5	126	128	33.8	5.7	R7	Y1	RS,ROv	F	10.8
CN 1897-35	16.3	91	179	37.6	6.1	R3	Y1	LS	F	9.2
CN 1903-32	16.1	126	128	36.4	5.9	R1	Y1	LS	F	11.6
Check lines										
CN 1108-13	25.3	146	174	24.4	6.2	O3	O3Y5	RO1,O1	F	2.0
CN 1232-9	24.8	108	241	26.3	6.5	Y1	Y1	RS	F	0.8
CN 1510-25	23.5	138	170	31.9	7.5	R3	Y3	LS,Ov	F	1.6
CN 1489-89	22.4	137	164	31.8	7.1	Y1	Y1	LS	F	6.2
Tainung 66	26.5	166	166	24.3	6.4	R5	O5	LS,Ov	F	0.0
Mean of 52 entries	17.5	114	157	33.8	5.9					6.4
Range	4.0-33.2		43-236	78-278	24.3-42.6	1.3-12.9				0.0-21.0
LSD (0.01)	9.3	103.4	80.9	3.4	3.4					5.9
CV (%)	19.8	33.8	19.3	4.1	21.6					34.9

For footnotes, please see Table 4.

Materials and Methods

Eleven BCF_1 clones selected based on yields and general appearance from the preliminary yield trial in 1988 were evaluated in the PYT2s in the fall 1988, spring 1989 and summer 1989. Along with the BCF_1 entries the two parental sweet potato lines (CN 1345-8, CN 1405-14) and check lines (CN 1108-13, CN 1489-89, Tainung 66) were entered into the trials. The experimental details are presented in Table 3. For weevil resistance, the BCF_1 including these 11 clones were evaluated by the entomologists.

Results and Discussion

Yields, some horticultural characters and chemical components of the storage roots are summarized in Table 10. The 5x-hybrids lines used as parents for the backcrosses, numbered with WT did not form storage roots in spring and summer, only in the fall. However, even in the fall, the marketable yield, number of roots and average marketable root size were too low to qualify them as sweet potato lines. The BCF_1 lines recovered their root formation and yield and some clones even outyielded their parental lines and check cultivars.

Dry matter of the BC_1 selections of both sweet potato and WT lines was relatively lower than their parental lines. Other chemical compositions of protein, sugar, starch, fiber and β-amylase were generally comparable to the sweet potato parental lines and check lines. β-amylase content of WT 81 was as low as some lines called nonsweet sweet potato. This line could be utilized as a gene source of low β-amylase.

Table 11 shows the yield and other characteristics of the BCF_1 lines compared to the check cultivars in three seasons. In all entries including the check lines, yield in spring was the highest among three seasons. Most of the BC_1 entries showed yields comparable to the superior check line in summer and fall. CN 1871-4 and CN 1868-6 yielded significantly higher than the superior check line in the trial, whereas the yield in summer was poor. Generally, the BCF_1 lines tested in this series of yield trials did not show any special defects and could be utilized as ordinary sweet potato lines.

Table 10. Horticultural characteristics and nutrition components of BCF_1 clones and the parental lines in the preliminary yield trial; fall 1988.

Clone no.	MKT yield (t/ha)	MKT root no. (x 1000/ha)	Average MKT root size (g)	Dry matter (%)	Dry matter yield (t/ha)	Protein (DWB %)	Sugar (DWB %)	Starch (FWB %)	Fiber (DWB%)	β-amalyse[z]
BC_1 Clones (11 clones)										
Mean	13.2	76	175	25.8	3.4	5.0	11.0	18.4	2.8	33.0
Range	8.8-17.2	62-101	145-256	19.2-31.6	4.1-6.7	4.1-7.2	6.0-16.4	10.7-24.7	2.0-4.1	9.4-69.2
Parental lines (5x-hybrids)										
WT 81	6.8	57	120	37.5	2.6	7.2	5.4	29.3	2.6	1.6
WT 260	2.7	29	101	36.9	1.0	4.9	7.3	28.8	2.7	35.6
WT 298	3.7	37	101	36.2	1.3	5.0	6.6	27.7	2.9	9.0
WT 352	2.6	27	96	36.2	0.9	4.8	8.7	27.5	2.2	67.1
(Sweet Potato clones)										
CN 1345-8	14.4	76	189	34.0	4.9	4.4	6.8	26.5	1.8	90.4
CN 1405-14	9.0	53	171	28.9	2.6	5.3	10.2	20.1	2.9	46.4
Check lines										
CN 1108-13	10.2	70	145	26.6	2.7	4.1	9.7	20.2	2.4	19.2
CN 1489-89	16.1	77	214	33.4	5.4	4.2	8.7	25.5	2.2	45.5
TN 66	11.7	82	144	27.3	3.2	6.1	8.4	18.7	2.7	73.0

[z] β-amylase; unit = mg Maltose/min. For footnotes, please see Table 4.

Table 11. Yields of the BCF_1 clones in the preliminary yield trials, 1987-1989.

Clone no.	Pedigree	Marketable yield (t/ha)				Dry matter (%)	Skin color	Flesh color
		88 fa	89 sp	89 su	Mean of 3 seasons	Mean of 3 seasons		
CN 1871-4	CN 1345-8 x WT 352	10.6	27.1	14.2+	17.3	25.8	R_1	Y_1
CN 1872-8	CN 1345-8 x WT 81	17.2	31.2	2.9	17.1	19.4	R_1	Y_1
CN 1867-3	CN 1405-14 x WT 81	17.1	26.0	1.5	14.9	23.8	O_3	Y_3O_1
CN 1868-6	CN 1345-8 x WT 81	10.6	22.9	10.2+	14.6	24.6	R_1	Y_1
CN 1867-5	CN 1405-14 x WT 981	14.9	26.3	1.9	14.4	22.1	O_3	O_1
CN 1868-13	CN 1345-8 x WT 81	13.2	24.9	4.7	14.3	22.6	R_3	Y_1
CN 1868-12	CN 1345-8 x WT 81	12.4	24.4	4.3	13.7	28.8	Y_1	Y_1
CN 1867-11	CN 1405-14 x WT 81	15.7	23.5	1.8	13.7	19.4	O_1	O_5
CN 1869-7	CN 1345-8 x WT 298	13.0	18.9	6.8	12.9	31.8	Y_3	Y_1
CN 1868-3	CN 1345-8 x WT 81	11.8−	18.6−	3.5	11.3	27.7	R_1	Y_3
CN1868-15	CN 1345-8 x WT 81	8.8−	22.1	2.7	11.2	24.5	P_5	Y_1
Check lines								
CN 1345-8		14.4	19.3	4.5	12.7	30.2	Y_1	Y_1
CN 1405-14		9.0	16.2	0.0	8.4	29.3	Y_1	Y_1
CN 1108-13		10.2	25.6	2.9	12.9	22.8	O_3	O_3
CN 1489-89		16.1	20.1	2.2	12.8	30.9	Y_1	Y_1
TN 66		11.7	25.3	1.5	12.8	24.4	R_5	O_5
Mean (16 clones)		12.9	23.3	4.1	13.4	25.4		
LSD (5%)		4.2	6.6	3.5				
CV (%)		15.2	13.3	39.6	18.5	4.7		

For footnotes, please see Table 4. + Significantly higher than the superior check line. − Significantly lower than the superior check line.

Yield Trials for Germplasm Collection

Summary

Germplasm collections from EYT 1988 were evaluated. The 26 entries include 11 AVRDC elite clones, 24 germplasm accessions from 10 countries and Tainung 66 as check. Yields, other horticultural characteristics and dry matter content were evaluated. The promising clones will be further evaluated for other traits such as resistance to leaf scab and vine borer, chemical component, etc.

Introduction

As the designated repository of the International Board for Plant Genetic Resources (IBPGR) for the sweet potato collections in Asia and the Pacific, AVRDC maintains a duplication of the collections in the region. At present, about 1,300 accessions have been characterized and partly evaluated.

In 1988, a total of 215 accessions including 24 AVRDC elite breeding lines were preliminarily evaluated in spring and summer. Of these accessions, 35 promising clones were selected and evaluated in the evaluation yield trial (EYT) in 1989.

Materials and Method

Thirty-five entries were evaluated in the EYT. The experimental design of the trials is shown in Table 3. Root samples were analyzed in the chemistry laboratory. TN 66, CN 1489-89 and CN 1510-25 were included as check lines.

Results and Discussions

Of the 35 entries, 26 had comparable yields as Tainung 66 in spring. Yield and other horticultural characteristics are summarized in Table 12. Since summer yields were very low and the coefficient of variation is high, reliable comparison could not be made.

Table 12. Yields and other horticultural characteristics of the germplasm collections in the evaluation yield trial, 1989.

Clone no.	Country of origin	Spring 1989											Summer 1989
		MKT yield (t/ha)	Total yield (t/ha)	MKT yield rate (%)	MKT root number (x 1000/ ha)	Average MKT root size (g)	Dry matter (%)	Dry matter yield (t/ha)	Skin color	Flesh color	Tuber shape	General Appear-ance	MKT (t/ha)
CN 0942-47	AVRDC	20.6	26.9	77	97	213	25.7	5.3	P_5	O_1O_3	S	F	3.0
CN 1028-15	AVRDC	23.7	28.9	82	123	194	25.6	6.0	P_5	O_3Y_5	R,RO_v	F	6.3
CN 1108-13	AVRDC	23.9	27.9	96	133	180	26.6	6.3	O_3	O_3	I	F	6.4
CN 1232-9	AVRDC	27.6	32.8	84	131	212	29.6	8.2	Y_1	Y_1	S,O_v	F	4.7
CN 1345-8	AVRDC	17.3	26.4	67	82	229	31.5	5.4	Y_1R_1	W	O_v,S	F	6.2
CN 1448-49	AVRDC	15.7	21.3	74	119	134	36.0	5.6	P_5	Y_5O_1	RO_v,R	F	7.9
CN 1489-89	AVRDC	25.4	29.6	86	160	159	34.9	8.8	Y_1	Y_1	S	F-G	8.4
CN 1510-25	AVRDC	20.2	28.2	72	110	189	34.0	6.9	R_3	Y_1	S,O_v	F	3.2
CN 1517-139	AVRDC	16.9	24.3	69	111	157	35.3	6.0	O_2	Y_3	S	F	3.8
I 0100 (PI 318848; Kumala Belep)	New Caledonia	26.7	35.2	76	123	220	29.1	7.8	Y_1	Y_2	S	F	6.1
I 0136 (OK 6-3-106)	U.S.A.	15.8	19.5	81	128	124	34.7	5.5	R_1	O_5Y_5	S,O_v	F	4.2
I 0234 (Norin 4)	Japan	19.3	27.5	69	83	239	31.7	6.1	R_1	Y_1	O_v,S	F	6.2
I 0253 (Norin 23)	Japan	18.2	21.2	86	75	250	32.0	5.8	P_5	Y_1	RO_v,S	F	6.9
I 0381 (Indonesia 321)	Indonesia	25.2	36.2	69	132	162	27.5	7.0	Y_1R_1	O_3Y_3	S,O_v	F	1.7
I 0392 (Pakwana)	Solomon Islands	25.1	26.1	96	87	288	29.1	7.3	Y_1	Y_1P_7	S,O_v	F	7.4
I 0423 (Tainan 17)	Taiwan	16.3	22.5	73	162	101	27.9	4.5	P_1	Y_1	LS	F	1.7
I 0444 (Kinmen)	Taiwan	25.9	31.9	79	156	162	24.0	6.2	R_1	Y_1	S,O_v	F-G	3.9
I 0928 (Koitaki 2)	Papua New Guinea	23.2	28.3	82	106	222	27.6	6.4	R_7	Y_2	S,O_v	F	0.5
I 0932 (Unu 2)	Papua New Guinea	18.6	20.3	91	75	247	34.7	6.4	Y_1	WS	F	0.9	
I 0934 (Ilimo 1)	Papua New Guinea	19.4	20.7	94	96	201	35.9	7.0	B_3	Y_1	S,O_v	F	1.7
I 0938 (K 79)	Papua New Guinea	21.8	24.9	87	97	228	36.3	7.9	B_3	Y_1	S	F	2.3
I 1174 (V2-3)	Philippines	16.0	19.9	80	77	210	34.1	5.5	P_2	Y_5	O_v,S	F	1.9
I 1175 (V2-30)	Philippines	21.8	26.3	83	141	154	28.2	6.1	R_3	O_7P_1	S	F	2.1
I 1185 (Bali)	Indonesia	17.6	24.0	73	82	216	29.6	5.2	R_1	Y_1	LS,O_v	F	5.3
I 1220 (Tainung 67)	Taiwan	15.8	24.2	66	101	158	29.2	4.6	R_7	Y_5O_3	S	F	1.9
Tainung 66	Taiwan	25.5	31.1	82	120	212	24.5	6.2	R_5	O_5	O_v,S	G	6.5
Mean of 35 entries	18.7	24.0	78	102	192	30.6	5.7						3.6
Range	10.8-27.6	13.6-36.2	56-96	39-162	101-288	24.0-37.0	6.0-8.8						0.2-8.4
LSD (1%)	12.5	11.4	0.2*	68.6	94.5	4.1	2.9						8.2
CV (%)	24.5	17.4	12.2	24.7	18.1	4.9	25.2						55.1

*Significant level at 5%. For footnotes, please see Table 4.

Of the 26 lines, only six (including Tainung 66) were orange-fleshed type. Compared with TN 66, the five accessions had higher dry matter content and acceptable yields. However, Tainung 66 had an outstanding uniformity of marketable root size and shape.

As a result of the preliminary evaluation in 1987, dry matter content of the yellow/white-fleshed entries was 30%. CN 1489-89, CN 1232-9, I 938 (K 79, PNG), I 100 (Kumala Belep, New Caledonia), I 381 (Indonesia 321, Indonesia) and I 934 (Ilimo 1, PNG) gave more than 7 t/ha.

These promising germplasm accessions from the trials will be further evaluated for their chemical components and resistance to leaf scab, vine borer, etc. Some accessions have already been utilized as materials in the hybridization program.

International Cooperation

Summary

Since 1988, virus-indexed clonal materials have been distributed in 22 countries. Preliminary observation trials conducted in Vietnam were reported. Apart from the clonal breeding lines, true seed populations were also made available to the international cooperators.

Introduction

To assure the distribution of safe materials to international cooperators, all clonal materials for international distribution from AVRDC are virus-indexed. Since 1988, virus-indemed materials have been distributed to 22 countries (for details, see 1989 GRSU report).

Besides the pathogen-tested clonal materials, true seed populations were also made available to international cooperators. In 1989, a total of 11,000 seeds were distributed to the International Potato Center in Lima, Peru and to Dr. R. Suenarjo, Ministry of Agriculture and Water Development, Zambia.

Feedback from National Cooperators

Since the intensive distribution of the virus-indexed materials resumed in 1988, AVRDC has received limited feedback from cooperators.

Vietnam. Results of a preliminary observation of AVRDC germplasm collections were provided by Dr. Vo-Tong Xuan, Mekong Delta Farming Systems Research and Development Center. The observation trial was conducted without replication since the materials are still under multiplication. The trial was planted on 8 March after rice cropping and harvested on 29 May 1989.

Results revealed that yields of most entries outyielded Duong ngoc, a local check cultivar. AVRDC's CN 1028-15, CN 1108-13, CN 1489-89, Thailand's PC 9 and China's Xu-shu 18 yielded more than 10 t/ha of marketable roots while the local check cultivar had only 5.1 t/ha. CI 608-652 and Xu-shu 18 also showed vigorous vegetative growth with large leaves which the farmers in the region prefer for hog feed. In terms of acceptability in the region, Xu-shu 18 and CI 608-652 were rated good. Further replicated evaluations will be conducted in 1990.

Sweet Potato Entomology

Search for Sweetpotato Weevil Resistance among Interspecific Backcross Progenies

Summary

Seventy-six breeding progenies from a cross between *Ipomoea trifida* × *I. batatas* backcrossed to *I. batatas* were screened for resistance to sweetpotato weevil, *Cylas formicarius*. The test entries were planted between weevil-infested rows of sweet potato to provide uniform infestation. At harvest roots were evaluated for weevil infestation. The two highest yielding entries with moderate damage and five high yielding ones with least damage appeared to be promising and will be investigated in 1990.

Introduction

Sweetpotato weevil (SPW), *Cylas formicarius* (F) (Coleoptera: Curculionidae) is the most destructive pest of sweet potato in tropical to subtropical parts of the world. Because of its concealed feeding habits, this insect is difficult to control by conventional means such as insecticide. AVRDC research therefore is aimed at developing integrated pest management (IPM) techniques based on the development of SPW-resistant cultivars. AVRDC screened its sweet potato germplasm of 1200 accessions but failed to find a reliable source of resistance. In 1985, therefore, crosses were made between sweet potato and *Ipomoea trifida* to incorporate desirable characters including possible SPW resistance in sweet potato. Based on the desirable resistance level and high yields of the progeny, AVRDC crossed the selected progenies with sweet potato to improve the yield and quality. A total of 76 entries were screened for resistance to SPW.

Materials and Methods

Each entry was planted in randomly selected three 5 × 1 m plots in an SPW nursery. Each plot was bordered on one side by a weevil-infested row of sweet potato planted two months earlier and inoculated with laboratory-reared SPW. The crop was raised following the standard cultural practices except that no insecticide was applied. At harvest, root yield was recorded and roots were evaluated by cutting each root and counting the number of larvae, pupae and adults found inside. The weevil-damaged and healthy portions of the root were weighed and the percentage of damaged root was calculated. The insect count data were converted to the number of total insects (larvae + pupae + adults) per kilogram of roots. Data were subjected to analysis of variance and mean differences were compared by DMRT.

Results and Discussion

Yields and weevil infestation of 19 highest yielding entries are summarized in Table 1. In several tests conducted in the past significant positive correlation between yield and number of weevils/kg roots and percentage of damaged roots was found. In this experiment, therefore, entries with higher yields were selected. The entries with low yields tended to have smaller roots which failed to

crack in the soil. Cracking increases access of weevils to the roots. Entries with small roots may not be truly resistant to SPW and therefore were discarded. The SPW infestation (number of weevils/kg roots and percent of damaged roots) varied greatly. Roughly 50% of the entries had an above average damage by weevils per kilogram roots. Seven entries with above average yields and below average SPW infestation were selected for future evaluation and, if necessary, for further backcrossing.

Table 1. Performance of selected sweet potato backcross progeny for resistance to sweetpotato weevil.[z]

Entry	Yield (t/ha)	Damaged roots (%)	No. of weevils/kg root
1. CN1872-9	24.0	9.5	10.3
2. CN1872-8	23.0	10.7	12.0
3. CN1867-5	17.9	11.7	13.1
4. CN1867-27	17.3	16.8	31.4
5. CN1872-6	16.0	2.0	2.5
6. CN1872-2	15.5	9.7	22.4
7. CN1872-5	14.9	7.1	13.1
8. CN1867-17	14.7	15.0	23.7
9. CN1868-12	14.5	11.8	17.9
10. CN1867-11	14.1	14.9	18.9
11. CN1869-13	13.6	2.0	1.7
12. CN1867-15	13.1	5.1	6.2
13. CN1510-25	13.1	2.0	3.4
14. CN1867-8	12.7	9.5	12.8
15. CN1868-13	12.6	7.9	7.2
16. CN1869-6	12.5	1.3	2.3
17. CN1869-5	12.3	14.2	20.0
18. CN1870-8	12.1	6.7	7.1
19. CN1868-3	12.0	15.3	29.5
Mean (76 entries)	9.1	9.8	19.4
Range	(1.8-24.0)	(0-24.6)	(0-167.5)

[z]Data are means of three replicates. Entries Nos. 1, 2, 5, 11, 12, 13, and 16 are selected for further evaluation.

Search for Sweetpotato Resistance in Vines

Summary

One thousand and one hundred eighty-nine sweet potato accessions and 54 elite clones were screened in two batches for resistance in vine to the sweetpotato weevil (*Cylas formicarius*). Accessions were planted in the field and laboratory-bred weevils were released to initiate infestation. Ten weeks after planting each plant was cut to find weevil damage in the crown. Seven accessions in the first batch and 12 in the second had the least weevil infestation. In a second multireplicated test, accessions I 13, I 98 and I 123 which showed varying levels of resistance to weevil in the roots also had the least infested vines. These accessions are being evaluated for their suitability in the sweetpotato weevil breeding program.

Introduction

Sweetpotato weevil (SPW), *Cylas formicarius* (F.) (Coleoptera: Curculionidae) feeds inside the vines and tuber roots, from the time of planting to root enlargement. Although SPW damage in the crown under natural conditions did not seem to affect root yield, the weevils act as source of infestation when storage roots starts to enlarge (Fig. 1). SPW control in this plant part will, therefore, remove the source of initial infestation and thereby reduce damage to roots considerably. This implies that the development of a sweet potato cultivar with genetic resistance to weevil in vines will reduce weevil damage considerably. Therefore, the entire sweet potato germplasm in AVRDC was screened for SPW resistance in vines.

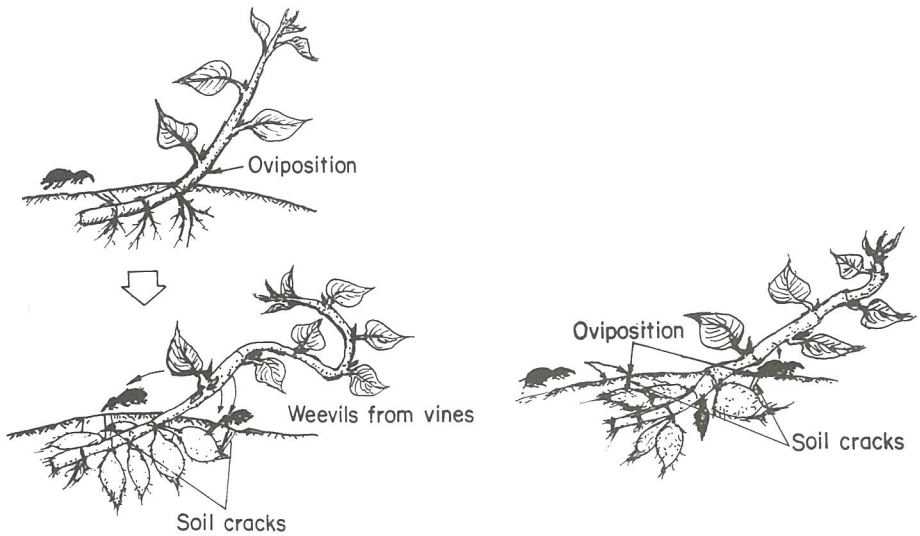

Fig. 1. Possible modes of SPW entry into sweet potato roots. Left, top: Adult weevil emigrates from outside and in the absence of storage roots, oviposits in crown; larvae feed inside.
Left bottom: Adult weevils emerge from larvae, feed in crown and search for soil cracks; lay eggs in the storage roots.
Right: When storage roots are present, adult weevils from outside outside as well as those developed from oviposition and larval feeding inside crown search for soil cracks; lay eggs in developing roots.

Materials and Methods

Carry-over of SPW infestation via cuttings. From a weevil-infested field, 54 accessions were randomly selected to confirm whether SPW infestation is transferred from infested field to a new planting via vine cuttings. Sixty cuttings of normal length from the terminal portion of vines of each accession were planted in individual 5 × 1.5 m plots. The entire area was surrounded by a 5-m wide ditch filled with water to prevent emigration of SPW from the surroundings. The weevils found in cuttings planted in the quarantine area must have come from the same cuttings. Six weeks after planting, all plants were uprooted, cuttings in crown position were cut and the damaged plants and number of weevils (larvae + pupae + adults) found inside each plant were recorded.

Preliminary germplasm screening. The AVRDC germplasm collections of 1189 accessions and 54 elite breeding lines were screened in two preliminary, nonreplicated plantings for SPW resistance. In the first test, cuttings of each of the 492 accessions were planted individually on 13-14 March in 5 × 1 m beds. Six weeks after planting, a large number of laboratory-bred SPW adults was released evenly over the entire planted area. Six weeks after the release, 25 plants from each plot were uprooted and 30 cm portions from the crowns (measured from proximal end) were cut. The number of plants that showed weevil damage and the number of weevils (larvae + pupae + adults) found inside the crowns were noted.

In the second test, 697 accessions and 54 elite cross materials were planted in individual plots on 5-7 July 1989 in a similar manner as the first batch. Three weeks after planting, a large number of laboratory-bred weevils was released evenly over the entire planted area. Six weeks after weevil introduction, 20 plants from each plot were uprooted and the number of plants with visible weevil damage and the number of weevils (larvae + pupae + adults) found inside were recorded.

Second screening. Seven least damaged and four highly damaged accessions from the first preliminary screening were planted for the second time. Each entry was planted in four 5 × 1 m randomly selected plots. Three weeks after planting, a large number of laboratory-bred weevils were released uniformly over the planted area. Six weeks later 20 plants were uprooted from each plot and the number of weevil-damaged and healthy plants and the number of weevils (larvae + pupae + adults) found in the crown were recorded.

Statistical analysis. The number of weevils per plant and percentage of plants damaged by the weevil from the preliminary screening were subjected to a statistical analysis based on mean (X) number of insects per plant or percentage damaged plants and the standard deviation (SD). The accessions found with insects or plant damage < X - 2 SD were considered highly resistant (HR); between X - 2 SD and X - 1 SD, moderately resistant (MR); between X - 1 SD and X, as having low resistance (LR); between X and X + 2 SD, as susceptible (S); and > X + 2 SD, highly susceptible (HS). The number of weevils per plant and percentage of damaged plants from the second screening were analyzed by ANOVA and the means were compared by DMRT.

Results and Discussion

In the study of carry-over of the SPW infestation from old to new infested planting, 51 out of 54 accessions had weevil infestation. This indicated that in all cases, the weevil is transferred from old infested planting material to the new one through vine cuttings used during transplanting.

Results of the preliminary screening of the first batch of 492 accessions are summarized in Figure 2. Based on percentage of damaged plants, 30 were HR; MR, 46; LR, 79; and S, 337. The plants damaged ranged from 17% to 100% with a mean of 90%. Based on the number of weevils found inside the crowns, 61 were MR; LR, 229; S, 128, and HS, 74. The number of weevils (larvae + pupae + adults) per plant ranged from 0 to 9.8 with a mean of 2.7. Seven accessions had less than 40% plants damaged and less than 0.4 insects per plant. These accessions appeared to possess potential resistance, hence, were selected for further screening in a replicated test.

Results of the second preliminary screening are summarized in Figure 3. The number of weevils per 20 plant samples ranged from 0 to 62 with a mean of 13.7, and percent damaged plants from 0 to 100 with a mean of 88.45. Based on the number of insects, 90 accessions were judged as MR; LR, 33; S, 224; and HS, 106. Based on the percentage of plants damaged by the weevil, 33 were classified as HR; MR, 48; LR, 180; and S, 490. The list of accessions that had less than one weevil per 20 plant sample is shown in Table 2. Among the 12 least damaged entries, three WT entries were free of weevils. Accession I 1200 appeared to be as promising as WT entries. All WT entries have narrow vines and woody stems.

Table 2. Infestation of selected sweet potato germplasm by sweetpotato weevil in vines.[z]

Entry designation[y]	No. weevils per 20 plants	Resistance rating	Damaged plants (%)	Resistance rating
WT81	0	MR	26	HR
WT230	0	MR	10	HR
WT325	0	MR	50	HR
WT57	1	MR	50	HR
WT452	1	MR	40	HR
I 44	1	MR	55	HR
I 146	1	MR	95	S
I 319	1	MR	45	HR
I 488	1	MR	65	MR
I 839	1	MR	50	HR
I 942	1	MR	70	MR
I 1200	1	MR	20	HR
Mean of 751 entries	13.7		88.5	

[z]Planted 5-6 July 1989; observed dates 18, 19, 20 September 1989. [y]WT = These entries are progenies derived from cross between *I. trifida* and *I. batatas*.

Since the results of this test were based on a single experiment, the promising accessions will be evaluated again in a multireplicated test to confirm the results before making detailed investigations on the resistance mechanism or utilizing them in resistance breeding.

The results of the second screening of promising accessions from the first screening are summarized in Table 3. All accessions that showed less damage in the first preliminary test were also less damaged than the susceptible checks in the second test. In the past, accessions I 123, I 13 and I 198 showed varying levels of resistance to SPW in roots. Further confirmatory-multireplicated tests will be pursued and the mechanism of resistance of these three accessions will be evaluated.

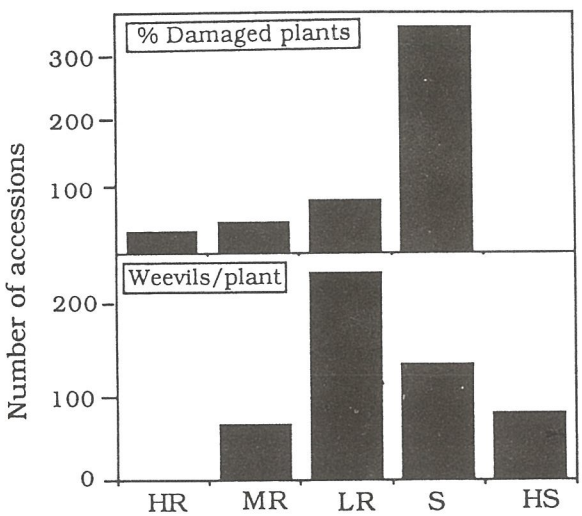

Fig. 2. Distribution of the first batch of 492 sweet potato accessions into various resistance categories based on percent of damaged plants and number of sweetpotato weevils per plant. HR = highly resistant. MR = moderately resistant. LR = has low resistance, S = susceptible, HS = highly susceptible.

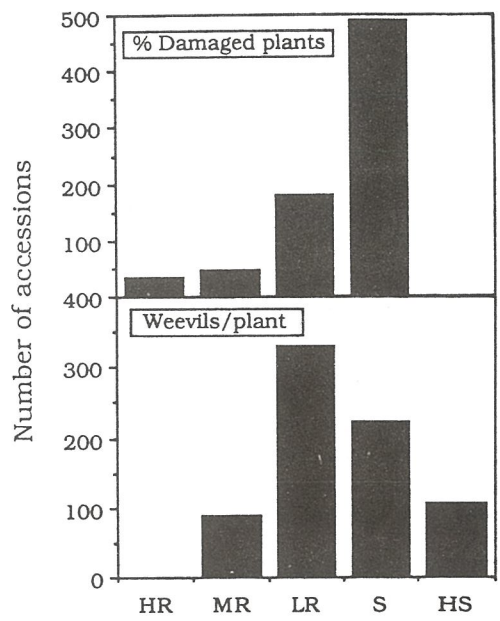

Fig. 3. Distribution of the second batch of 751 sweet potato accessions and elite clones with various resistance categories based on percent of plants damaged and number of sweetpotato weevils per plant. HR = highly resistant, MR = moderately resistant, LR = has low resistance, S = susceptible, HS = highly susceptible.

Table 3. Infestation of sweetpotato weevil in the crowns of selected accessions.[zy]

Acc. no.	No. of weevils/20 crowns[x]	Damaged crowns (%)[x]
I 198	7.5 d	70.0 c
I 123	12.3 cd	90.0 ab
I 13	12.8 cd	88.8 ab
I 562	13.5 cd	88.8 ab
I 202	13.8 cd	81.3 bc
I 221	14.3 c	81.3 bc
I 449	18.0 bc	95.0 a
I 118 (S)[w]	23.0 ab	96.3 a
I 243 (S)[w]	23.8 ab	92.5 ab
I 364 (S)[w]	26.3 ab	92.5 ab
I 453 (S)[w]	27.5 a	100.0 a

[z]Planted 18 July 1989. [y]Observed 25 September 1989. [x]Data are means of four replicates. Means in each vertical column followed by the same letter are not statistically significant at 5% probability level according to DMRT. [w](S) = Susceptible checks.

Effects of Plant's Age on Sweetpotato Weevil Infestation of Crown

Summary

Preference of sweetpotato weevil to infest crowns of sweet potato plants from 1 week to 8 weeks after planting was evaluated in the field. The older the plants the greater was the number of weevils found inside the crown. There was a highly significant positive correlation between plant age and insects found in the crown.

Introduction

Sweetpotato weevil (SPW), *Cylas formicarius* (F) (Coleoptera: Curculionidae), lays eggs in tuber roots as well as in stems of the sweet potato plant. In a newly planted field, the weevil lays eggs in stems and the larvae feed in this plant part in the absence of the roots. Although such larval feeding did not seem to reduce the yield most of the time, the adults developed from the larvae acted as a source of infestation when the roots enlarged. Investigations were made to determine the plant age when SPW starts laying eggs in the vines.

Materials and Methods

Once a week (for eight consecutive weeks), weevil-free cuttings of sweet potato were planted in four randomly selected 5 × 1 m plots arranged in a randomized complete block design. A 1-m wide empty area was maintained around each plot. On the four sides of the entire field, water was continuously maintained in 5-m wide channels to prevent weevil infestation from outside. When plants in the last planting were one week old, a large number of weevils were released uniformly in empty areas surrounding individual plots. About seven weeks after weevil release, all plants in each plot were harvested and the number of weevil larvae + pupae + adults found inside the crown was recorded. The insect count data were converted to total number of insects per crown and analyzed by ANOVA and means were separated by DMRT.

Results and Discussion

The number of weevils found inside the crowns of one to eight-week-old sweet potato plants are summarized in Figure 4. The older the plants, the more insects were found inside. There was a highly significant positive correlation (r = 0.92) between plant age and number of weevils in the crown. The older plants had thicker crowns. However, the biomass of younger plants was enough to accommodate as many weevils as those of older ones. The difference in the number of weevils seemed related to the preference of weevils for older plants for oviposition. Weevils preferred to lay eggs in older stems.

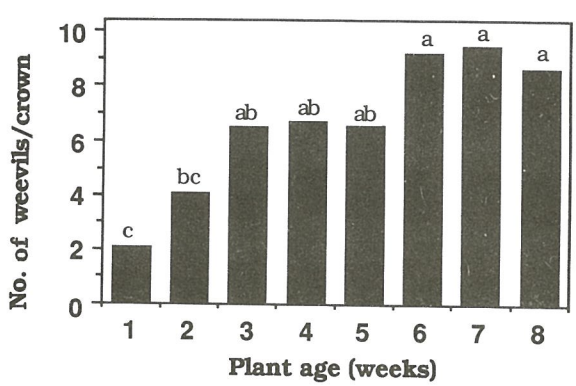

Fig. 4.
Infestation of sweet potato crowns at various ages.

Epidemiology of Sweetpotato Weevil

Summary

Infestation of sweet potato plants by sweetpotato weevil in the field and weevil-protected enclosed plots was monitored from planting to harvest. Weevil infestation became visible 8 to 10 weeks after planting, a period when roots began to form. In the field, infestation increased exponentially from the 12th week when root enlargement began and soil cracks started to appear. Infestation in the field was greater than in the enclosed field, obviously due to emigration of weevils from the surroundings. Should the external weevil source be removed, it would be possible to get a weevil-free crop.

Introduction

Infestation by sweetpotato weevil (SPW), *Cylas formicarius* (F) (Coleoptera: Curculionidae), is a major constraint in sweet potato production in tropical to subtropical areas. Although the use of SPW-resistant cultivar represents the cheapest and environmentally more acceptable method of reducing the damage of this pest, years of research at AVRDC and elsewhere in the world have failed to find a reliable SPW-resistant sweet potato cultivar. To develop a simple, practical and economical control measure, research to understand various aspects of interaction of the weevil with its host was initiated. This experiment, one of a series, investigated the epidemiology of the weevil infestation to understand when SPW infestation begins in the field. The contribution of weevil inoculum source from the surroundings and the carry-over of the weevil in the planting material were also studied.

Materials and Methods

A parcel of land was plowed and worked into 1-m wide beds. These beds were further divided into eight, 15 × 10 m plots. The plots were grouped into two blocks of four plots each. A 6-m distance was maintained between two blocks and 3 m between two plots each block. In one block, standing water was maintained in a 3-m wide ditch on four sides of each plot from planting to harvest. This was done to prevent weevils from the surrounding area from infesting the crop. In the second block the empty area surrounding each of the four plots was kept fallow. This arrangement allowed the weevils from the surrounding to migrate and infest the crop.

Starting two weeks after planting, 20 plants from each plot were uprooted. Crowns, vines and storage roots (if present) were cut. The number of insect larvae, pupae and adults found inside each plant part was recorded. The number of plants showing insect damage was also recorded.

At harvest, six months after planting, 5 kg of roots from each plot were cut. The number of weevils (larvae + pupae + adults) inside each sample was recorded.

Results and Discussion

Results of SPW damage to plants and the number of weevils found inside the plants are summarized in Figure 5. In both open and closed plots SPW damage in the crowns became visible starting 8 to 10 weeks after planting. This was due to the carry-over of weevil infestation from an old infested field via cuttings. The mode of infestation progressed gradually when the outside weevil source was absent. A maximum of 10% of the plants showed damage in weevil-protected plots during the six-month growing season as against 30% in an open field.

In the open field emigrating weevils seemed to infest the crop 8 to 10 weeks after planting, when tuber roots begin to form. The number of weevils followed a similar trend as the percentage of damaged plants. There was an exponential increase in the weevil population in the crown and roots from 12 to 14 weeks after planting. This coincided with root enlargement and cracking of the soil.

In closed system, however, very few weevils (less than one per 20 plants up to 22nd week and only one per plant in 24th week) were found. Open plot plants had two to six weevils/20 plants in their roots as against less than 1 in the closed system. At harvest the open plots had an average of 19.5 weevils/5 kg of roots whereas in closed plots it was only 0.5.

The crop was planted in January and during most of its early growth the average daily temperature was less than 20°C. This slowed down crop growth and root development. In summer, the crop grew faster and insect infestation could have started sooner. Nonetheless, the pattern of SPW infestation in an open field and in fields where outside source of weevils is limited is expected to remain the same.

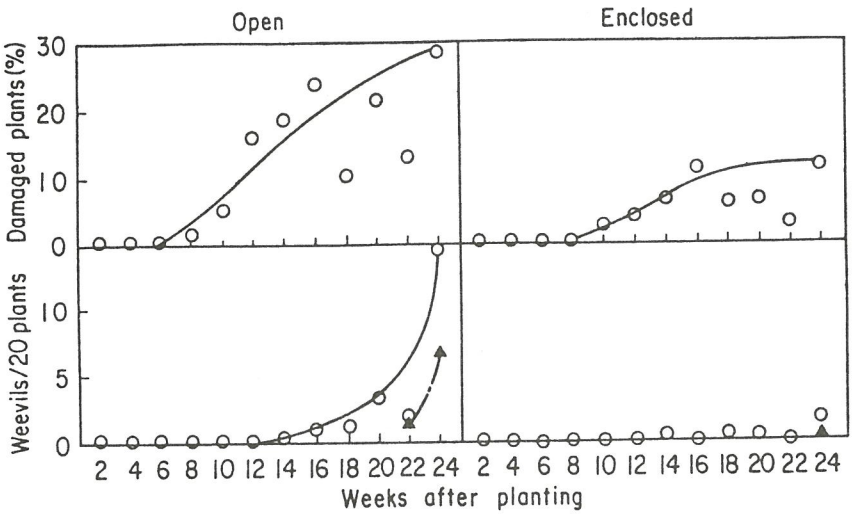

Fig. 5. Pattern of sweetpotato weevil infestation of sweet potato plants in an open field and enclosed weevil-protected enclosed plots throughout the season. The solid triangles in the lower half of the figure indicate the number of weevils in sweet potato roots.

Role of Tender and Mature Stem Cuttings in the Carry-over of Sweetpotato Weevil Infestation

Summary

The role of fresh cuttings and old cuttings in the carry-over of sweetpotato weevil infestation from weevil-infested field to the new planting was studied in the field. In an open field, crops planted using fresh cuttings had as much damage as the one planted with old cuttings. However, in enclosed weevil-protected plots, sweet potato planted using old cuttings was seriously damaged while the one that used fresh cuttings was practically free of weevils. For planting new sweet potato crop, it is advisable to use tender growth cutting and plant the crop away from a weevil source. This will lead to weevil-free roots.

Introduction

Sweetpotato weevil (SPW), *Cylas formicarius* rarely flies on its own instinct. It crawls from plant to plant within the field or from one field to the neighboring one. This insect from an infested field migrates to a newly planted one through stem cuttings which are used to plant the new crop. The insect lays eggs in the cuttings and when these are used for planting, SPW infestation spreads. To minimize the spread of the weevils, the types of cuttings prone to weevil infestation and responsible for the spread of the weevil were investigated. In this experiment, fresh and old cuttings were used and the SPW infestation of the crop was monitored.

Materials and Methods

A parcel of land was plowed and worked into 1-m wide raised beds. These beds were further divided into 10 m^2 plots with a distance of 7 m between two adjacent plots. In one block of eight plots, each plot was surrounded by a 5-m wide flooded trench. This isolated individual plots from surrounding weevil sources. Another block of eight plots was maintained in the open.

Sweet potato vines from a weevil-infested field were selected as planting materials. The distal 30-cm shoot (fresh cuttings) were cut and planted in four plots surrounded by water and four open plots. From the same shoot, starting with the cut distal end, a further 30-cm piece of cutting (old cutting) was taken. These cuttings were planted in four water-surrounded and four open plots. All standard cultural practices were adopted except that no insecticide was sprayed. Once every two weeks 20 plants from each plot were uprooted and the crowns were cut. The SPW larvae, pupae and adults found inside and the number of plants with visible weevil damage in the crown were recorded. At harvest, a 5-kg root sample was taken from each plot and their roots were cut. The number of SPW larvae, pupae and adults found inside was noted.

Results and Discussion

Figure 6 shows the pattern of weevil damage in plants derived either from tender or old growth cuttings and planted in an open field and in plots surrounded by water. In the open field, old cuttings were damaged much earlier than the new ones, but as the season advanced plants derived from new cuttings were damaged as much as those derived from old cuttings. This was due to the migration of weevils from the surrounding area which invaded the new planting due to the lack of barriers. In water-surrounded area, old cuttings showed moderate level of SPW damage from planting time. The insects came from old cuttings. There was, however, less SPW damage in plants derived from tender cuttings. Obviously the weevil did not lay much eggs in new cuttings hence, these cuttings remained practically weevil-free.

The number of weevils found in the crown (Fig. 7) corresponded with the number of plants that were damaged. Old cuttings planted in both open and water-enclosed plots had weevils, obviously carried over from the old plantings to the new via cuttings. New cuttings planted in the open field had insects inside the crown from migrating weevils but the plots surrounded by water remained

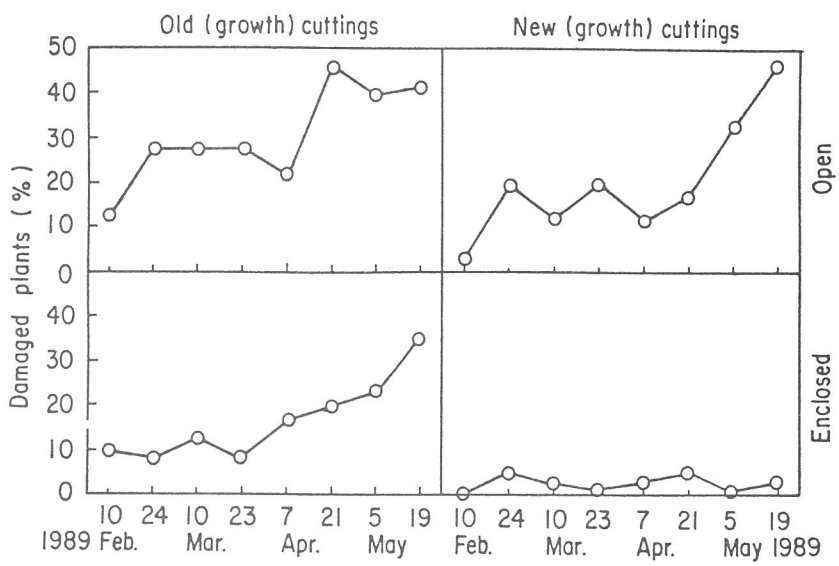

Fig. 6. Influence of old and new growth cuttings on sweet potato weevil damage to sweet potato potato plants in enclosed weevil-protected plots and an open field.

insect-free. These plots were cut off from any outside weevil source and obviously the fresh growth cuttings did not carry the weevils from the old plantings.

At harvest (4.5 months after planting), very few plants in plots planted with old cuttings were available while in plots planted to fresh cuttings, several plants were still standing. The number of weevils (larvae + pupae + adults) was 1.2 in open plots against 0.2 in water-surrounded plots.

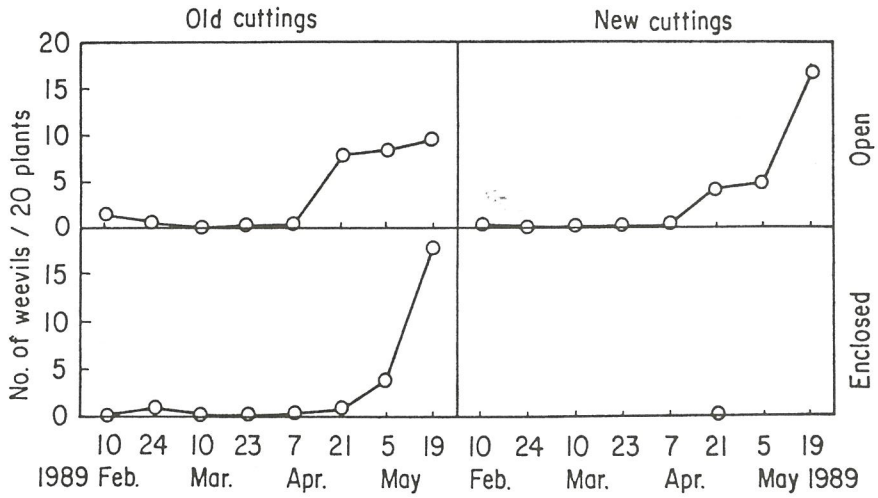

Fig. 7. Influence of age of cuttings on the number of weevils in sweet potato plants in enclosed weevil-protected and open plots.

Sweetpotato Weevil Control in Planting Material

Summary

Twenty-one organic insecticides were screened for their suitability for dipping preplant sweet potato cuttings to control sweetpotato weevil. Sweet potato (cultivar Tainung 57) cuttings were dipped for 1 or 3 h in 0.05 or 0.1% active ingredient of each chemical. Chlorfluazuron, DDVP, diazinon, dimethoate, fenitrothion, methyl parathion, mevinphos, permethrin, and prothiophos showed severe phytotoxicity. Carbosulfan, methomyl, monocrotophos and omethoate showed mild phytotoxicity. Carbaryl, carbofuran, cartap, diflubenzuron, malathion, methamidophos, profenophos and teflubenzuron were not phytotoxic. Diflubenzuron and teflubenzuron are relatively costly. The other six chemicals can be used as dip for cuttings. Dipping of sweet potato cuttings in carbofuran solution prior to planting delayed weevil infestation in treated plants compared with the plants that utilized untreated cuttings. About 16 weeks after planting, weevil infestation was always lower in treated than in untreated plants.

Introduction

Carry-over of sweetpotato weevil (SPW) eggs or larvae inside the cuttings used for planting or adults hiding among foliage is one of the principal sources of SPW distribution from one field to another and in one season to the next. The best way to ensure that the cuttings are weevil-free is to propagate them inside an insect-proof nethouse or subject them to intensive insecticide spraying. However, this is not always possible, and in some cases farmers obtain their cuttings from neighbors or suppliers without being sure of the quality of the planting materials. Dipping the cuttings in a suitable insecticide solution immediately before planting reduces or even eliminates SPW.

In 1979-80, dipping of cuttings in 0.05 to 0.1% active ingredient (AI) carbofuran solution for 30 to 60 min was found effective to eliminate or reduce SPW infestation. However, carbofuran liquid formulation is highly toxic to humans. In 1988-89, therefore, a large-scale screening was conducted to test the suitability of several alternate insecticide formulations. In an additional test, the effectiveness of using a carbofuran dip to protect treated cuttings from weevil reinfestation over a period of time in the field was also studied.

Materials and Methods

Twenty-one organic insecticides belonging to chemical classes of organophosphorus, carbamate, synthetic pyrethroids and benzoyl phenylurea were utilized. These chemicals, formulated in emulsifiable concentrate, suspendable concentrate or wet powders, were diluted in water to give concentrations of 0.05 or 0.1% active ingredient. Sweet potato (cv Tainung 57) cuttings were obtained from a weevil-infested field and dipped in the insecticide solution for 1 or 3 h. Immediately after dipping, the cuttings were planted in randomly selected three 5 × 1 m plots. Forty cuttings were planted in each plot spaced 2 m apart. The fallow area between the plots was sprayed with triazophos once a week to minimize SPW movement from the surroundings into the planted area and from one plot to the next.

Three weeks after planting, plots were observed for symptoms of phytotoxicity. At this stage, half of the cuttings were uprooted and the SPW larvae, pupae and adults found inside and plants showing weevil damage were recorded. After another three weeks, the remaining cuttings were uprooted and observed for SPW infestation.

In the second experiment, half of the sweet potato cuttings obtained from the weevil-infested field were dipped for 30 min in 0.05% carbofuran solution. The other half was maintained as check. The treated cuttings were immediately planted in four randomly selected 20 × 1 m plots and untreated ones in the remaining four plots. The plots were located near the site of an old sweet potato planting heavily damaged by the weevil to allow weevils from the old planting to infest newly planted sweet potato crop. Two weeks after planting for the next three months, 15 cuttings were uprooted from each plot, cut and the number of weevils (larvae + pupae + adults) found inside each stem was recorded. Plants that showed weevil damage but no insects inside the stem were also recorded.

Results and Discussion

Among the 21 insecticides screened for SPW control, chlorfluazuron, DDVP, diazinon, dimethoate, fenitrothion, methyl parathion, mevinphos, permethrin, prothiophos showed severe phytotoxicity. Carbosulfan, methomyl, monocrotophos, and omethoate showed mild phytotoxicity. These 13 chemicals are not suitable for dipping sweet potato cuttings to get rid of weevils. Carbaryl, carbofuran, cartap, diflubenzuron, malathion, methamidophos, profenofos and teflubenzuron were not phytotoxic.

When plants were evaluated for SPW infestation, none of these was infested with weevils. The other chemicals are suitable for cutting dip treatment. Of these eight non-phytotoxic chemicals, diflubenzuron and teflubenzuron are rather expensive.

The results of dipping cuttings in carbofuran on SPW infestation are presented in Figure 8. Based on the plants' damage, weevils in carbofuran-dip-treated cuttings came two weeks later than in the untreated check. The presence of insects inside the plant was delayed by four weeks in carbofuran-treated plants compared with the control plants. This was probably due to the presence of toxic insecticide residues inside the plants which killed the newly hatched larvae thus delaying SPW development. The SPW infestation in carbofuran-treated sweet potato plants was always lower than in untreated control plants throughout the season. It must be emphasized that the temperatures during the experimental period were relatively low and there was no precipitation. When temperature is high, the insecticide residue will not last and carbofuran treatment may no longer be effective.

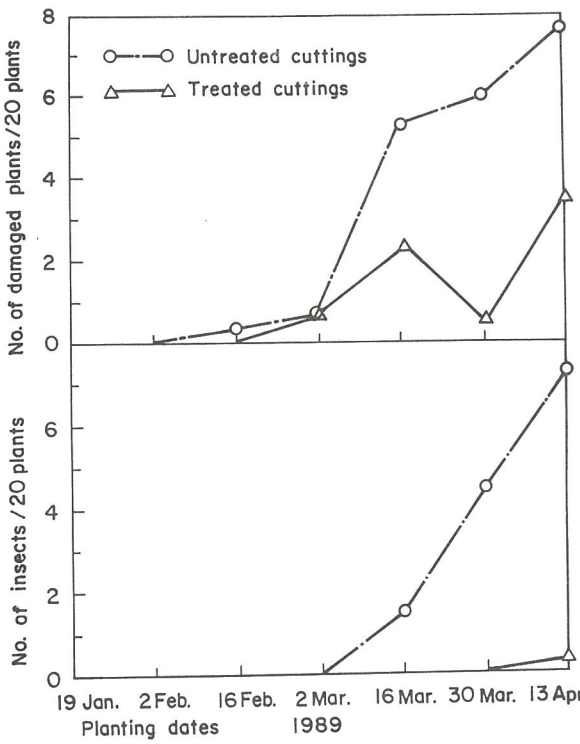

Fig. 8.
Sweetpotato weevil infestation of untreated and carbofuran-treated cuttings before planting.

Sweetpotato Weevil Control by Sex Pheromone

Summary

A three season (1987-89) experiment was conducted to study the use of a synthetic sex pheromone to control sweetpotato weevil in the field. In each of the three 0.1-ha parcels of land, weevil-free sweet potato cuttings were planted. Soon after planting and throughout the season, traps baited with 100 μg sex pheromone were placed 10 m apart in one parcel to trap male weevils. In the second field, rubber septa, each baited with 1 mg pheromone, were placed 0.5 m above the crop canopy at 5m-grid junctions to inundate the field with pheromone and prevent the weevils from mating. The third parcel was maintained as a check. Male weevil population was monitored once a week in all three plots. Although male weevil population in pheromone-treated plots was considerably lower than in the check plot in two years, this low population did not reflect less weevil damage in the sweet potato roots. In one year, there was less weevil damage in a pheromone-treated field. To get satisfactory SPW control, therefore, pheromone use alone may not be sufficient and should be supplemented with sanitary practices.

Introduction

Female sweetpotato weevils (SPW) produce a sex pheromone which attracts the males for mating. (Z)-3-dodecen-1-ol(E)-2-butenoate has now been synthesized in the laboratory and has been used in AVRDC's research and in an IPM program for the past three years. For insect pest control, sex pheromones which are species specific can be used in three ways: (1) monitoring the initiation of insect infestation so that other control measures, such as application of insecticides, can be used effectively, (2) trapping the males preferably before they mate, which will reduce mating and second generation population; and (3) inundating the field with synthetic pheromone to confuse the males

to prevent mating with the females. These could also reduce the second generation of pest population. Since SPW infests the crop throughout the year and other control measures such as insecticide application are barely economical, the use of sex pheromones to monitor the pest is limited. The remaining two techniques, mass trapping (MT) and communication disruption (CD), were therefore tested to judge their utility in controlling SPW.

Materials and Methods

This experiment was done in the field in three seasons. In the first season, three 0.1 ha parcels of land were planted to sweet potato (cv. Tainung 57) on 25-27 August 1987. Immediately before planting, cuttings used for planting were dipped in 0.05% AI carbofuran solution to cleanse them of weevils. Immediately after planting, water trough traps baited with 100 μg sex pheromone were set up in one parcel of land. The traps were placed every 10 m, between two adjacent traps and the number of insects trapped were monitored. This treatment was designated as mass trapping (MT).

In the second parcel of land, rubber septa baited with 1 mg of sex pheromone were placed at the junctions of a 5-m grid throughout the field soon after planting. Each septum was fastened to the center of a petri dish attached to a stick, 0.5 m above the plant canopy in an inverted manner to protect the pheromone from rain. This treatment was designated as communication disruption (CD).

No sex pheromone was utilized in the third parcel of land; this was designated as the control (CK).

The borders and empty areas around the plots were maintained free of *Ipomoea* weeds which are important alternate hosts of the weevil. Standard cultural practices such as weeding, irrigation when needed and fertilizer application were undertaken to assure good yield.

In 1987 about a month after planting an equal amount of sweet potato roots damaged with weevils was placed to assure even weevil infestation. The roots were externally cleaned of weevil adults to ensure that already mated adults were not introduced.

Once every week, the pheromone source septa were removed from both MT and CD fields and three traps baited with 10 μg sex pheromone were placed in MT, CD, and CK fields overnight to monitor weevil population. The number of SPW males captured in these traps was recorded the following morning. The pheromone coated septa were then returned in each trap in the MT and CD plots.

At harvest 10 samples, each consisting of plants in 10 5 x 1 m randomly selected plots in each field were taken. All roots in the sampled areas were harvested and 5 kg of the roots were cut and sliced. The damaged and healthy slices were separated and weighed and percent of root mass damaged by the weevil was computed.

In 1988, this experiment (planted 2-3 February 1988) was repeated in an identical manner except that weevils were not introduced. In 1989 (planted 14-15 September 1988, harvested 10 February 1989), the experimental procedures used were similar to the 1988 experiment except that two MT fields were planted. Male weevils in both MT plots were monitored separately but since no significant differences were found, the average of root damage in both fields was taken.

Results and Discussion

In all observation intervals, the number of SPW males in MT and CD fields was less than in CK fields. The use of pheromone indeed reduced the male population. In 1987, during rains in September and at the start of the experiment in 1988 when weevil population was low, no difference in insect population in the pheromone treatments and check fields was observed.

Damage to sweet potato roots in three seasons is presented in Figure 9. In two out of three seasons, the insect monitoring data were not reflected in the root damage data. In 1987 and 1988, the male population was substantially lower in the MT and CD fields than in the CK field but their root damage was higher.

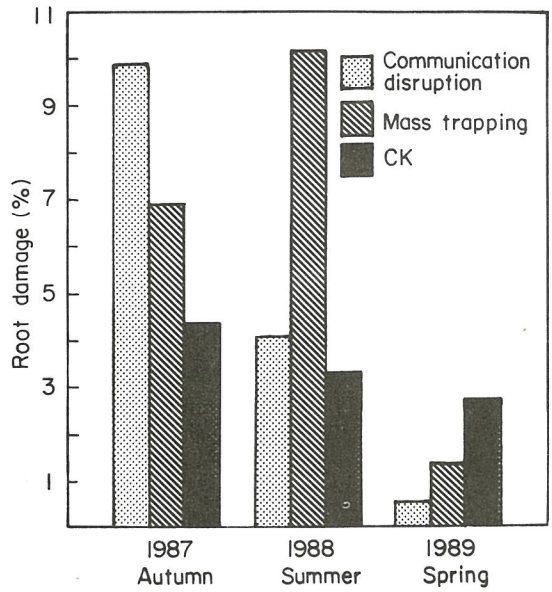

Fig. 9.
Sweetpotato weevil damage to sweet potato roots in two pheromone-treated fields and control during three seasons.

The pheromone has no effect on females. Thus the mated females from the neighboring fields or *Ipomoea* weeds can come into the pheromone-treated fields unobstructed and cause damage to the roots. Weevils seem to migrate long distances and sweet potato is always planted on the AVRDC campus. It is thus not possible to totally eliminate a weevil source in the vicinity. A similar situation exists on farmers fields unless all farmers cooperate in a community-wide weevil eradication program.

Late in the growing season, sweet potato vines form a thick canopy all over the field. This canopy probably reduces the penetration of sex pheromone to the soil surface where weevils search for land cracks to reach the roots and lay eggs.

Screening for Resistance to Sweetpotato Vine Borer

Summary

Two hundred and sixty-five newly received accessions in the AVRDC sweet potato germplasm collection and 45 improved breeding lines were screened for resistance to sweetpotato vine borer (*Omphisa anastomasalis*) in a field test on Penghu Island. All entries along with two known resistant and one susceptible check, were planted in single row 5 × 1 m nonreplicated plots and exposed to natural vine borer population. At harvest each plant in each plot was observed for vine borer damage. Fifty-four entries were considered moderately resistant. These included six breeding lines, including two crosses between *Ipomoea trifida* and *I. batatas*.

Introduction

In tropical to subtropical Asia and the Pacific, sweetpotato vine borer (SPVB), *Omphisa anastomasalis* (Guene) (Lepidoptera: Pyralidae) is a serious pest of sweet potato. The adult lays eggs on foliage and soon after hatching the larva bores and feeds concealed in the stem where it pupates. As a result of this feeding, the plant weakens, resulting in stunted growth and reduction in yields. AVRDC aims to develop sweet potato cultivars resistant to this pest. In 1983, accessions I55 and I92 were found moderately resistant to SPVB. These accessions are being used in the SPVB

resistance breeding program. The new germplasm received and breeding lines with desirable agronomic characters developed by AVRDC during the past five years were screened for resistance to SPVB to find sources with higher levels of resistance.

Materials and Methods

Stem cuttings of 265 accessions and 45 improved breeding lines along with that of two resistant and one susceptible check were planted as a single row on the top of individual 5 × 1 m beds on Penghu Island where SPVB is serious. The crop was raised by standard cultural practices except that no insecticide was applied. The crop was exposed to SPVB and at harvest each plant was observed for SPVB infestation. The SPVB-damaged plants had adult escape holes in the older portion of the vines and in most cases frass accumulated on the soil surface in the vicinity of the holes. The number of damaged and healthy plants was recorded and the percentage of damaged plants was computed. The percentage of damage was analyzed by a statistical procedure based on mean and standard deviation which enabled the classification of entries into highly resistant (HR), moderately resistant (MR), low resistance (LR), susceptible (S) and highly susceptible (HS) categories.

Results and Discussion

The results of the screening are summarized in Figure 10. Plant damage ranged from 0 to 100% of plants. Fifty-four accessions were classified moderately resistant. Nine entries, including one standard resistant accession, were free of SPVB damage. Since the results were based on a single replicate, the 54 MR entries will be screened in 1990 to confirm the resistance.

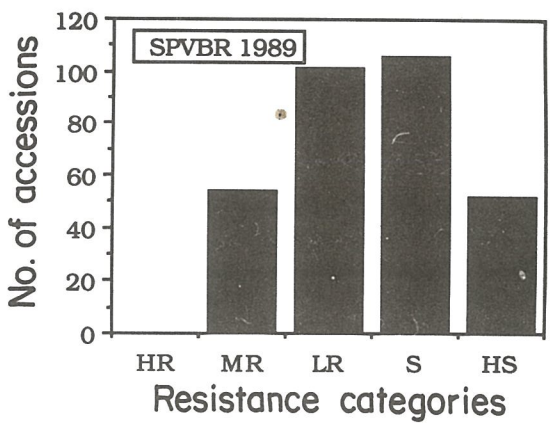

Fig. 10.
Distribution of sweet potato germplasm screened into various SPVB resistance categories.

Screening of Sweetpotato Vine Borer Resistant Breeding Progeny

Summary

Progenies from crosses between a sweetpotato vine borer (*Omphisa anastomasalis*) resistant accession and agronomic clones, along with locally adopted commercial cultivars, were screened for resistance/tolerance to vine borer. Clone CN1756-163 proved to be tolerant as it gave high yield of 15.4 t/ha under severe vine borer infestation. Although insecticide application reduced vine borer damage, it did not increase the yield of this clone. A commercial cultivar, Tainung 66, also showed similar tolerance. Four clones which showed moderate levels of resistance to the vine borer in the past tests were also found moderately resistant in this test.

Introduction

Sweetpotato vine borer (SPVB), *Omphisa anastomasalis* (Guene) (Lepidoptera: Pyralidae) is an endemic pest of sweet potato in Asia and the Pacific. The adult lays eggs on foliage and the first instar larva bores inside the vine. The larval and pupal stages entirely take place inside the stem. Infested plants are weakened, resulting in yield reduction up to 50%. Due to its concealed mode of life, this insect is difficult to control by conventional use of insecticide. Besides, insecticides use is not always economical. AVRDC therefore aims at breeding sweet potato cultivars resistant to this pest. In 1983 AVRDC identified two sweet potato accessions with moderate levels of resistance to this pest. Breeding to transfer the resistance gene into agronomic cultivars has been in progress since 1984. In 1989, progenies with moderate levels of resistance or tolerance (no yield reduction despite heavy vine borer damage), the AVRDC elite lines and locally adapted commercial cultivars were screened to confirm their resistance/tolerance to SPVB.

Material and Methods

Twelve entries including one tolerant and four resistant breeding materials from the cross between SPVB-resistant accession I 55 and agronomic breeding lines along with two AVRDC elite breeding lines and four locally adapted commercial cultivars were included in this screening. Each entry was planted in three randomly selected 10-m long single row plots, each plot representing one replication. Starting three weeks after planting and once every three weeks thereafter, half of the plot (subplot) was treated with carbofuran 3G at the rate of 2 kg AI/ha. The crop was grown using standard cultural practices to achieve high yields. At harvest, all plants in each subplot were observed for SPVB infestation. The number of insect-damaged and healthy plants was recorded and percent of damaged plants for each subplot was computed. All roots in each subplot were harvested and their weights were recorded; root yield per hectare was computed. The t test was used to compare the differences in plant damage and root yields in insecticide-treated and check plots. In addition, the insect damage was analyzed by ANOVA and means separated by DMRT.

Results and Discussion

Four resistant entries, namely CN 1759-47, CN 1759-316, CN 1759-330 and CN 1759-635 which showed moderate resistance in past tests were significantly less damaged than the susceptible check AIS35-2 in this test. Among the four, CN 1759-47 had the highest yield potential and was the most stable as its performance under treatments with and without insecticide was identical. CN 1756-163 which had shown considerable tolerance to SPVB (high yield under heavy SPVB infestation) also showed tolerance in this test. Although insecticide application significantly reduced plant damage by 45% its yield remained unchanged. Tainung 66, a local high yielding agronomic cultivar showed a similar tendency. However, it must be emphasized that this year the SPVB population was exceptionally high and application of carbofuran once every three weeks was inadequate for satisfactory control. Under such high infestation rates, CN 1756-163 and Tainung 66 gave very high yields and were thus considered tolerant materials. Their tolerance probably resulted from having a vigorous growth especially during the first two months after planting when SPVB damage adversely affected plant growth. The mechanism of SPVB tolerance in these two entries will be investigated in 1990 to obtain criteria for selecting SPVB-tolerant progeny.

Sweet Potato Pathology

Inoculation Techniques and Evaluation of Resistance to Scab

Summary

Abundant conidia of *Sphaceloma batatas* were produced at a pH of 5.3-5.5 on potato dextrose agar. A young actively growing tissue of sweet potato was more susceptible than an older one. The method of inoculation for resistance screening was changed using 7 to 10-day-old cuttings or seedlings. A new rating scale was developed to simplify the procedure for evaluating the resistance.

Introduction

One of the emphases in sweet potato breeding program at AVRDC is to develop resistance to scab. In 1985, initial studies focused on developing screening methodologies and evaluation techniques. Up to 1988, more than 200 lines had been screened for resistance with 13 lines assessed as highly resistant.

Inoculation techniques for the evaluation of resistance requires the production of conidia by the fungus *Sphaceloma batatas*. The fungus is generally difficult to isolate and its sporulation in culture is often difficult to induce unless it is grown on specialized media like carrot or sweet potato leaf agar.

In the past, screening for scab resistance at AVRDC was done by inoculating 30 to 50-day-old cuttings with conidia under uncontrolled environmental conditions. Evaluation of plants was based on an accumulated rating of percent foliage, shoot tips, stems, and petioles. This method was later modified using nine classes.

These experiments aimed to simplify the techniques for the production of inoculum, inoculation procedures and rating methodology.

Materials and Methods

The production of conidia by fungus was compared in several types of media, including carrot and sweet potato leaf agar, and by using a range of pH values in potato dextrose agar.

Cuttings of various growth were inoculated to determine which tissues were most readily infected. Along with this, the old rating scales were investigated and a new simplified scale was tested and modified.

Seedlings from true seeds were inoculated 20 days after sowing to determine if seedling screening could be useful in evaluating resistance.

Results and Discussion

Conidia were observed on all the media tested usually in very low quantities. However, the fungus sporulated equally better on PDA at a lower pH (5.3-5.5) than on carrot leaf agar.

From observations of inoculated cuttings at various growth stages, almost all infected tissues occurred on new growth. From this information, a new assessment scale was devised based on rating new tissues that developed after inoculation (Table 1). This scale has fewer intervals at the lower end

Table 1. Simplified rating scale used to evaluate scab resistance in sweet potato.

Rating	Severity (%)	Reaction
1	<3%	R
2	3-10%	MR
3	10-25%	MS
4	25-50%	S
5	>50%	HS
6	100%	Dead

of the severity rating because it is intended to assess more accurately low levels of severity. The simplified scale is easy and quick to use.

By inoculating cuttings at various ages, symptoms developed on the new growth after inoculation regardless of cutting age. This had changed the approach for screening and instead of waiting until cuttings are over 40 days old, inoculations were done after 7-10 days of regrowth. This saves time and space and allows simultaneous assessment of many more cuttings.

Another approach to screening for resistance was developed based on inoculating seedlings instead of cuttings. From preliminary tests, crosses from highly resistant parents had over 25% of their progeny rated as resistant (Fig. 1). Crosses using one or two susceptible parents had 5% of the progeny classified as resistant. This method of screening has many advantages; the biggest being that seedlings from crosses can be tested directly without increasing the cross number by planting it in the field to make cuttings for screening.

This past summer-fall season, field screening was conducted to compare results with the greenhouse screening. The level of disease occurrence in the field was lower than the severity in greenhouse inoculations, but generally the two assessments corresponded. For example, resistant accessions and cross numbers, I 949, I 1189, I 1175, and CN 1489-89 had average severity ratings of 1.2 and 1.1 in the field and greenhouse tests, respectively, while susceptibles, such as I 55, CN 1108-13, and CN 1510-25 had an average rating of 3.6 and 3.7 in the field and greenhouse tests, respectively. Research is now focused on determining the relationships between field and greenhouse screenings.

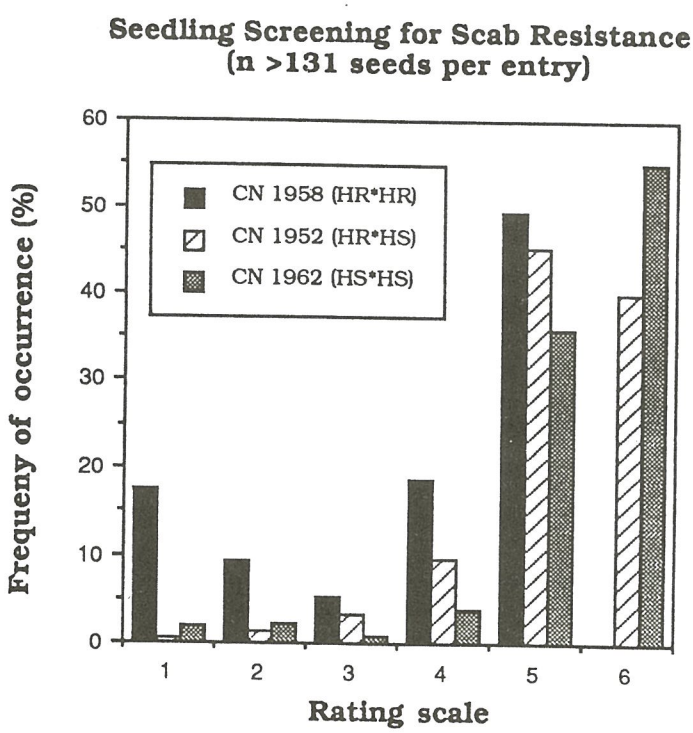

Fig. 1.
Frequency of occurrence of severity rating per class for three sweet potato lines rated for scab resistance.

Virus Elimination and Indexing of Germplasm

Summary

The virus elimination and indexing method described previously was used to obtain seven virus-free breeding lines (set 3) and accessions, 10 new lines from Thailand, five from China, eight each from Puerto Rico and Nigeria, six from Peru, seven from Tonga, 12 from Papua New Guinea, 20 from Solomon Islands and 65 from the U.S.A. A total of 238 virus-free lines are now available for international distribution. An ELISA test conducted before growing of the tissue cultured plantlets effectively reduced the number of virus-infected plants. The collections from Thailand and Solomon Islands were heavily infected with virus. About 80 virus isolates which did not react to any of the known viruses have been recovered. These isolates were thought to be new viruses.

Introduction

Most sweet potato collections are infected with viruses. A virus elimination and indexing scheme was established at AVRDC in 1986 to prevent the introduction of viruses to Taiwan and avoid the transfer of viruses to other countries which receive the AVRDC germplasm collections. Priority is presently given to elite breeding lines and germplasm collections in Southeast Asia and the Pacific region. AVRDC accessions are subjected to meristem culture.

Materials and Methods

All incoming materials were transferred immediately to a quarantine screenhouse where these were treated for 20 min in Furadan (0.04%) and Benlate (0.05 %) to eliminate any insects, nematodes and fungi. After rinsing the materials in tap water (four times), these were placed in sterile soil mixture or in liquid growth medium containing 2% charcoal and transferred to a closed room inside the quarantine house. Fungicide and insecticide solutions were autoclaved before disposal.

Twenty 0.3 mm meristems were excised from each accession and placed on medium L (Love et al.1987)[1] and then to medium K (Kuo et al. 1985)[2] as soon as the shoots started to develop.

When the plantlets were ready to be transferred to Jiffy pots, all leaves of each plantlet were excised, pooled and tested by ELISA for the presence of feathery mottle virus (FMV), sweet potato virus II (SPV II), sweet potato latent virus (SPLV), mild mottle virus (MMV) and yellow dwarf virus (YDV). Two plantlets per accession, tested negatively by ELISA were then grown in the quarantine screenhouse. A 1-cm long stem tip from each of the two selected plantlets was transferred aseptically to a fresh growth medium for further *in vitro* maintenance. The remaining part of the plantlet was allowed to grow.

The plants (with 15 nodes) were subjected to graft indexing using two *I. nil* and *I. setosa* each per sweet potato plant tested. Two 3-cm long one-node stem cuttings from two different sections of the sweet potato plant were excised and grafted onto each of the two indicator species. When no symptoms developed at four weeks, the sweet potato plant was pruned, allowed to grow into a mature plant again, and subjected to a second indexing.

All indicator plants showing symptoms were tested by ELISA for the presence of any of the known viruses. When plants reacted negatively by ELISA test, these were maintained for virus identification in the future.

The second graft indexing was performed like the first one, except that one additional graft was made on the sweet potato clone TIB 8, preinfected with the Nigerian aphid-transmitted virus component.

The original tissue cultured plantlets of plants negatively indexed by any of the methods described above were given to GRSU for further *in vitro* multiplication.

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[1]Love, S. L., B. B. Rhodes and J. W. Moyer. 1987. Meristem culture and virus indexing of sweet potatoes: Practical Manual for Handling Crop Germplasm *in vitro*. International Board for Plant Genetic Resources.

[2]Kuo, C. G., B. J. Shen, M. J. Shen, S. K. Green and D. R. Lu. 1985. Virus-free sweet potato storage roots derived from meristem tips and leaf cutting. Scientific Hort. 26:231-240.

Results and Discussion

Ninety virus-free lines were produced in 1989. (Information on these lines is available at CIP-Pathology, AVRDC.) Meristem survival ranged from 84% (lines from China) to 40% (from Solomon Islands) with an average of 55%. It is possible to increase the survival rate through changes in the tissue-culture media.

The two ELISA tests were very effective in reducing the number of virus-infected plants. The number of plants still carrying virus in the first graft indexing was generally found to be much less than in previous years. This was attributed to the quality antisera produced at AVRDC which allowed the detection of a higher percentage of virus-infected plantlets before planting and grafting. With three exceptions, all plants that underwent graft indexing II were virus-free.

During graft indexing, a number of unknown viruses were detected in 1989, particularly from the collections from Thailand and Solomon Islands. Some may be of the leaf curl virus type as evidenced by strong curling on *I. nil*.

Rotten tissue from cuttings derived from the lines from Solomon Islands were trimmed. The remaining stem sections were placed individually in test tubes filled with a broad spectrum antibiotic solution (Rifamactin 300 mg). However, only a small portion of the original shipment could be saved and a second collection had to be requested. Future collections should be inspected at the place of origin. Preliminary cataloguing could also be done at the place of origin.

Improvement of Virus-indexing Method

Summary

A problem previously encountered in virus indexing was lack of sufficient *I. setosa* indicator plant seeds. A new SPYDV antiserum, using a different propagation host (*I. nil* instead of *Sesamum indicum*) was produced which gave a positive/negative threshold of 2 x = 0.144. This was higher than the highest absorbance of healthy plants and 0.37 absorbance values less than the lowest value of infected plants. Thus, healthy plants can now be clearly distinguished from virus-infected plants by DAS ELISA. Sufficient seeds of *I. setosa* were produced when plants had been grown in the field in the spring. Although all field grown *I. setosa* plants were found to harbor FMV, SPYDV and SPLV, none of the seeds originating from these plants carried the virus.

Introduction

High titered antisera which can clearly differentiate healthy from infected plants are essential in the present virus-indexing scheme. All antisera for virus indexing are produced at AVRDC. However, two of the antisera used in the past, namely SPYDV and SPMMV, were not very effective in differentiating healthy from diseased plants by DAS ELISA. Another problem encountered was the shortage of seeds of the indicator plant *I. setosa*. The plants flowered only during a few months and produced very few seeds. Pollination by insects greatly enhanced fruit-set. However, all mother plants showed severe virus symptoms. Since information on transmission of sweet potato viruses through seed in the wild *Ipomoea species* used for virus indexing is yet available, these field-propagated plants were tested for seed transmission.

Materials and Methods

Purification and antiserum production. Two multiplication hosts, *Sesamum indicum* and *I. nil* were used. In the first purification run, virus yields obtained from *S. indicum* were very low and consequently only *I. nil* was used for further purification.

The virus was mechanically transmitted to these two hosts and purified by modifying the method used by Lisa et al. 1981[3]. The leaves were harvested two weeks after inoculation. Antiserum was

[3]Lisa, V., G. Boccardo, G. DAgostino, G. Dellavalle, M. DAquils. 1981. Characterization of potyvirus that causes Zuchini yellow mosaic. Phytopathology 71:667-672.

prepared through four weekly intramuscular injections on New Zealand white rabbits. In the first injection, 1 ml antigen solution (containing 0.6 mg virus/ml) was emulsified with 1 ml Freund's complete adjuvant. The other three injections were made with incomplete adjuvant. The rabbits were bled weekly, starting one week after the first injection.

A DAS ELISA test was conducted to determine the absorbance range of healthy and infected plants and if the antiserum could clearly separate virus-infected from healthy plants. Healthy plant materials were meristem-derived virus-indexed sweet potato plants. Infected plants consisted of known SPYDV-infected sweet potato plants. Leaves were collected from 29 healthy and 59 infected plants. Samples consisted of three pooled leaves per plant, extracted with an extraction buffer, containing 1% egg albumin and 0.01 M Na-DIECA. Duplicate wells were filled with each sample.

Seed transmission in *I. setosa*. Thirty seeds each of *I. setosa* VC 40 and 41 were sown in the field where these were subjected to natural virus infection. At flowering stage, most plants showed yellowing, vein clearing, leaf distortion and various degrees of stunting. An ELISA test confirmed the presence of FMV and YDV in all plants. Latent virus was detected only in few plants. Four hundred seeds from each accession were collected from plants infected both with a mixture of FMV and YDV and 80 from those infected with FMV, YDV and LV. The seeds were sown in sterile soil in an insect proof screenhouse and observed for symptom expression for 10 weeks. The plants were pruned twice above the first true leaf at three weeks and six weeks after sowing. The plants were allowed to grow new shoots. A DAS ELISA test using FMV, SPYDV and SPLV antiserum was conducted on all plants after 10 weeks.

Results and Discussion

Virus purification and antiserum production. Electron microscope observation showed numerous nonaggregated filamentous particles. Virus yield was 2.6 mg/100 g infected leaves. Using an extinction coefficient of E 0.1% at 260 nm = 2.4, the virus concentration was calculated to be 0.5-1.3 mg/ml. The ELISA absorbance histogram showed the antiserum clearly distinguished between healthy and virus-infected tissues both at a concentration of 1/500 for IgG and enzyme conjugate (Fig. 2).

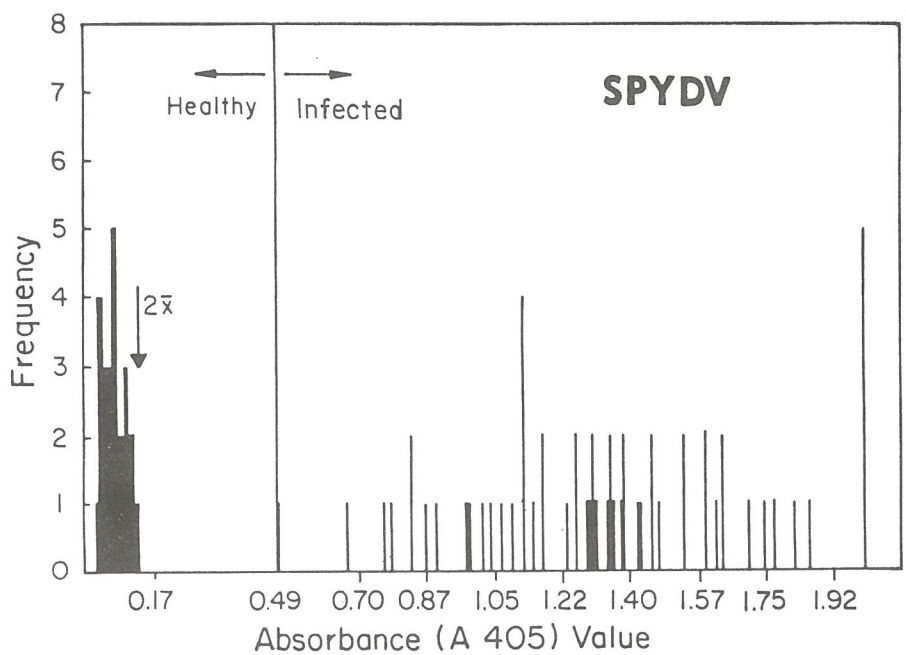

Fig. 2. ELISA histogram for SPYDV antiserum.

A positive/negative threshold of 2 x = 0.144 which is above the absorbance range of healthy plants and well below the lowest value of infected plants was useful in distinguishing infected plants from healthy ones. The high background in the antiserum previously produced in *Sesamum indicum* which could have been caused by antibodies in healthy plant proteins was not present in the newly produced antiserum.

Seed transmission in *I. setosa*. None of the plants showed virus-like symptoms during the 10-week observation period. The DAS ELISA test gave a negative reaction to all three antisera tested, indicating nontransmission of virus through the seeds despite virus infection of the mother plant. Field propagation of the indicator plant *I. setosa* is recommended for producing a large amount of indicator seeds needed for virus indexing.

Effect of Meristem Culture on Yield and Quality

Summary

Vegetatively propagated plants are prone to virus contamination. Thus, a replicated field trial was conducted to compare yield and quality parameters in six meristem-derived and field-propagated sweet potato lines. Although some meristem-derived plants were reinfected with virus within the first growing season, their yields (except one line) were significantly higher. Yield increases ranged from 5% to 65%.

Introduction

In most vegetatively propagated materials the carry-over of disease from one generation to another has lead to gradual decline in crop yields. Most AVRDC germplasm collections vegetatively propagated in the field were found virus-infected by ELISA tests.

Different cultivars have varying degrees of tolerance to virus infection and are affected differently in terms of yield and quality. Yield trials carried out with field-propagated and possibly virus-infected clones may therefore not always accurately reflect the true yield potential. Trials were therefore conducted to compare yields and quality of meristem-derived and field-propagated sweet potato and to determine how many field plantings are possible to maintain the positive effect of meristem culture.

Materials and Methods

Five improved sweet potato lines TN 66, CN 1108-13, I 57, CN 1510-25 and CN 1028-15 were used. One set of these five lines originated from mature meristem-derived and virus-indexed plants (M); the other set was from field-maintained plants (F). Cuttings of both sets were multiplied in an insect proof screenhouse three months before the trial began. Tip cuttings of 20 cm long were used as planting materials.

A randomized complete block design with six replications was used. Plot size was 4 × 5 m, with four rows per plot. Plant-to-plant spacing within rows was 25 cm, giving a plant density of 20 plants per row while the distance between plots was 2 m. The cuttings received a 30 min preplant drench of Furadan (0.04%). Furadan (0.04%) and Dimethyl (0.04%) were applied alternately every two weeks supplemented by a pheromone trap every 20 m. The first experiment was planted on 20 September and harvested 24 January. Data collected included total and marketable yield, dry matter, starch, sugar, protein and fiber contents.

A second experiment was planted in the field in May and harvested in October. The same lines as in Experiment 1 were used. Treatments of Experiment 2 consisted of field propagated (F), meristem-derived (M) and meristem-derived plants (M_1) grown in the field for one growing season (MF_1).

Before harvest, 10 randomly chosen plants per plot were tested for virus infection by ELISA using antisera to FMV, YDV and LV. Three leaves each from the top, middle and bottom part of each plant were collected. The leaves of individual plants were pooled for ELISA test.

Results and Discussion

Only data collected from Experiment 1 are thus presented in this report. Experiment 2 could not be evaluated because no root yields were obtained.

ELISA test revealed that virus reinfection occurred in the meristem-derived plants at the end of the growing season. Except in CN 1028-15, the percentage of virus-infected plants was generally lower in the meristem-derived plants than in the field-propagated plants. It was also noted that incidence of FMV and YDV was higher than latent virus in both meristem-derived and field-propagated plants.

Although virus reinfection in meristem-derived plants occurred in some plants within the first growing season, their yields with the exception of CN 1108-13, were significantly higher than those of field-propagated plants (Table 2). The effect of variety was noted. Some lines were affected more by meristem culture than others.

Yield increases as a result of meristem culture ranged from 5% (for CN 1108-13) to 65% (for I 57). The high yield increase in I 57 (Table 2) indicated that field-propagated plants were severely infected with virus. However, the insignificant effect of meristem culture in line CN 1108-13 suggested that this line is tolerant to virus infection in the fields. For TN 66, CN 1510-25 and CN 1028-13, meristem culture resulted in yield increases of 27, 29 and 28%, respectively, indicating that vegetatively propagated plants of these lines were not tolerant to virus infection.

Meristem culture had no significant effect on dry matter content, starch, sugar, protein and fiber, although in line I 57 the sugar and fiber were found significantly reduced in meristem-derived plants. A tendency to increase the percent of starch was noted in meristem-derived plants of CN 1108-13.

Table 2. Effects of meristem culture on yields and quality of five sweet potato lines.[z]

Line	Treatment[y]	% virus infected plants	Marketable yield/plot (kg)	Total yield/plot (kg)	Dry matter (%)	Starch (%)	Sugar (%)	Protein (%)	Fiber (%)
TN 66	M[y]	8	56.5[x]	64.7	31.0	72.1	6.3	8.4	2.8
	F	50	43.9	49.8	30.5	70.6	5.9	8.7	2.7
CN 1108-13	M	42	37.8	39.5	27.2	77.1	5.9	7.9	2.4
	F	82	36.0	38.0	27.9	78.3	5.7	7.5	2.4
I 57	M	13	49.5	63.2	27.6	72.5	7.3	7.4	2.9
	F	90	17.8	35.0	27.5	70.6	8.4	7.7	3.2
CN 1510-25	M	17	54.6	59.4	31.6	80.8	5.1	6.8	2.5
	F	85	39.2	44.5	31.4	79.8	5.7	6.5	2.6
CN 1028-15	M	5	68.5	74.1	25.8	71.2	10.5	7.2	3.1
	F	5	49.1	55.1	26.8	71.0	10.0	7.5	3.1
CV			**10.49**	**8.93**	**3.05**	**2.81**	**10.88**	**9.82**	**8.71**
LSD (0.01)			**5.21**	**5.14**	**0.96**	**2.30**	**0.85**	**0.82**	**0.26**

[z]The experiment was planted on September 20 and harvested on January 27. [y]M = meristem-derived, F = field-propagated. [x]Means of 80 plants/plot.

Effects of Virus Infection on Yield and Quality

Summary

Although it is assumed that virus infection in sweet potato leads to reduction in yield, there is limited information on the effects of specific viruses on yield and quality. The effects of FMV, SPV II, SPLV, SPLCV and SPYDV on two sweet potato lines (TN 66 and CN 1108-13) were studied in a replicated field trial. All viruses significantly reduced the yield. In line TN 66, FMV caused the highest yield reduction, followed by LCV, LV, SPV II, and YDV. In line CN 1108-13 yield reduction was highest with SPV II, followed by SPLCV, FMV, YDV and SPLV. Infection with some viruses also affected the sugar and fiber contents of the roots.

Introduction

Virus infection in sweet potato reduces crop yields. However, there is no information yet available on the effects of specific viruses on sweet potato yield. Different cultivars react differently to infection with particular viruses. The effects on yield and quality of five viruses known to occur on sweet potato in Taiwan were investigated in two elite sweet potato lines.

Materials and Methods

Healthy stock plants of the local sweet potato cultivar Tainung 66 and the AVRDC breeding line CN 1108-13 were propagated from meristem-derived and virus-indexed plants. Virus-free cuttings sprayed weekly with Furadan (0.04%) 4 and Benlate to control insects and fungi were propagated in an insect-proof screenhouse. Virus-infected plants of the two cultivars were produced using two 30-cm long cuttings each of FMV-, SPV II-, SPLV-, SPLCV-, and SPYDV-infected sweet potato plants placed in water culture.

When the roots started to develop, one cutting was grafted with a two-node virus-free cutting of Tainung 66; the other one with a virus-free cutting of CN 1108-13. After seven weeks, the scion was cut above the graft union and tested by ELISA and by grafting to *I. setosa* for the presence of the respective virus. The positively virus-tested scion was cut above the graft union and served as the mother plant for propagating the virus-infected plants.

The first experiment was planted in the field in October using a randomized complete block design with three replications. The plot was 1 × 2.5 m and a plant-to-plant distance of 25 cm. The distance between plots was 2 m. The experiment was protected by an insect-proof netting (32 mesh size) to avoid contamination with other viruses through aphid and whitefly vectors. All cuttings received a preplant treatment with a 1:1000 solution of Furadan. The same insecticide treatments described for SPV I were used. The experiment was harvested on 20 February.

Total and marketable yields were collected. Data on dry matter, starch, sugar, protein and fiber contents were analyzed.

Results and Discussion

FMV-infected plants of both cultivars showed distinct chlorotic spots. LCV-infected plants of TN 66 showed severe leaf rolling, whereas CN 1108-13 plants produced only mild symptoms. SPYDV-infected plants of both cultivars exhibited mild yellowing. SPV II-infected plants of both cultivars showed very mild mottling with small irregular spots. No visible symptoms developed in plants infected with latent virus.

Analysis of total and marketable yields of Experiment 1 showed high significance of treatment and variety × treatment interactions. In line TN 66 all viruses caused significant yield reduction. The highest was caused by FMV, followed by LCV, LV, SPV II and YDV. In line CN 1108-13 yield reduction was highest with SPV II, followed by LCV, FMV, YDV and LV. The effect of LV on marketable yields of CN 1108-13, however was not significantly different from that of uninfected plants (Table 3).

It can be concluded, therefore, that viruses significantly affect sweet potato root yields.

The quality was not significantly affected by virus infection. However sugar, protein and fiber contents significantly increased but starch decreased. The reason for this was not clear.

Experiment 2 experienced excessive rain and flooding, resulting in rotten roots in CN 1108-13. Data on yield were collected only from line TN 66. However, analysis showed a very high coefficient of variation for yield, thus the results have to be interpreted with caution. FMV infection resulted in very high yield reduction. Dry matter and starch contents were generally lower but protein and sugar were higher in the summer experiment. The fiber content remained the same.

Table 3. Effects of virus infection on yields and quality of two sweet potato lines.

Line	Virus	Marketable yield/plot (kg)	Total yield/plot (kg)	Dry matter (%)	Starch (%)	Sugar (%)	Protein (%)	Fiber (%)
Experiment 1								
TN 66	FMV	6.7[z]	7.4	28.90	67.66	8.48	7.98	3.05
	YDV	13.5	14.2	29.49	71.27	7.85	7.16	2.77
	SPV II	12.7	13.2	29.04	69.04	8.58	7.54	2.94
	SPLV	11.7	12.1	29.11	69.84	8.23	7.44	2.66
	SPLCV	8.3	8.8	28.50	68.28	8.87	7.93	3.05
	Healthy	16.1	16.8	28.50	69.74	8.29	7.41	2.73
CN 1108-13	FMV	11.9	12.4	27.52	76.61	7.99	7.18	2.52
	YDV	15.1	15.6	27.94	79.25	7.50	6.68	2.56
	SPV II	3.5	3.9	25.25	69.01	10.83	8.17	3.74
	SPLV	16.4	16.9	27.16	78.07	7.53	6.99	2.63
	SPLCV	9.4	10.0	27.89	76.58	8.00	6.42	2.28
	Healthy	17.1	17.4	27.96	78.70	7.58	6.69	2.56
CV		**13.25**	**13.48**	**3.67**	**2.98**	**6.52**	**9.86**	**7.46**
LSD (.01)		**2.56**	**2.74**	**1.67**	**3.53**	**0.88**	**1.17**	**0.34**
Experiment 2								
TN 66	FMV	8.4[y]	9.6	25.81	56.75	15.61	8.75	2.79
	YDV	14.2	15.3	24.83	57.50	14.80	9.12	2.83
	SPV II	16.5	18.5	24.32	57.79	14.77	8.77	2.78
	SPLV	17.3	18.6	25.01	56.51	15.76	8.85	2.63
	SPLCV	19.6	21.1	24.55	56.50	15.59	9.02	3.07
	Healthy	19.9	21.3	24.18	56.55	15.94	8.55	2.78
CV		**>35**	**>35**	**3.77**	**2.30**	**5.33**	**10.18**	**6.92**
LSD (.01)				**2.42**	**3.39**	**2.12**	**2.33**	**0.50**

[z]Values are means of 20 plants/plot and three replications. [y]Values are means of 40 plants/plot and three replications.

Etiology of Sweet Potato Leaf Curl Virus

Summary

The etiology of sweet potato leaf curl disease is not known. Electron microscope examinations have revealed the presence of gemini-type particles in adsorption preparates of leaf curl-infected plants. Nuclear inclusion bodies of gemini viruses were observed under the light microscope after staining with Azure A. These findings and the isolation of single-stranded DNA strongly suggested that the causal agent of sweet potato leaf curl disease is a gemini virus.

Introduction

Sweet potato leaf curl disease which causes upward leaf rolling in some sweet potato cultivars has so far only been reported in Taiwan (Chung et al. 1985)[4] and Japan (Yamashita et al. 1984)[5]. The disease is transmitted by whiteflies but not by sap. The causal agent has not yet been identified. Studies were conducted to further look into the etiology of this disease.

Materials and Methods

Electron microscopy. Leaf curl-infected *Ipomoea batatas* Tainung 63 and *I. nil* were used. Leaf and stem tissues taken from various parts of the plant were excised, placed on a glass slide on

[4]Chung, M.L., C. H. Liao, M. J. Chen and R. J. Chiu. 1985. The isolation, transmission and host range of sweet potato leaf curl disease agent in Taiwan. Plant Prot. Bull. (Taiwan, R.O.C.) 27:333-342

[5]Yamashita, S., Y. Doi, and K. A. Shin. 1984. Short rod particles in sweet potato leaf curl-infected plant tissue. Ann. Phytopath. Soc. Japan. 50:438.

drops of phosphate buffer (pH 7.0) and squashed with a glass rod. The glass slide was slightly tilted and the clear liquid was taken up with a Pasteur pipet and placed on a parafilm membrane. A nickel grid was placed on the drop with the carbon-coated side downward. After 5 min of floating on the drop, the grid was rinsed with 40 drops of distilled water and stained with five drops of 2% uranylacetate. The grids were viewed in a Zeiss EM 902 electron microscope. For ultrathin sectioning, infected tissues were fixed with 1% glutaraldehyde dehydrated in acetone series and embedded in Araldite 502 plastic.

Light microscopy. To identify the inclusion bodies, an epidermal (post fixed in osmiumtetroxide) leaf tissue was excised and stained with 1.25% Azure A in 2-methoxyethanol.

Purification and gel electrophoresis of nucleic acid. A slightly modified procedure for isolating the squash leaf curl virus (Cohen et al. 1983, 1988)[6] and tomato yellow leaf curl virus (Czosnek et al. 1988)[7] was used. About 100 g of infected leaves or petioles were first frozen in liquid nitrogen and crushed to a fine powder. The frozen powder was homogenized in a Waring blender with 0.1 M citrate buffer pH 8.0, containing 18.5 mM ascorbic acid, 60 mM sodium sulfite and 5 mM EDTA. The homogenate was made 2.5% (v/v) in Triton X-100, stirred overnight, filtered through cheese cloth and centrifuged at 8000 g for 10 min. The supernatant was treated with a 20% chloroform and subjected to another low speed centrifugation. The clarified extract was centrifuged at 35 krpm for three hours through 20% sucrose cushion. The pellet was resuspended in 10 mM citrate buffer containing 1 mM EDTA and recentrifuged at high speed. The final pellet, resuspended in 200 μl of 10 mM Tris buffer pH 8.0 with 1 mM EDTA was used for further nucleic acid analysis.

The purified preparation was treated with 1% SDS and 0.5 mg/ml of proteinase K for 10 min at 65°C followed by phenol chloroform extraction. The nucleic acid was precipitated by two volumes of 95% ethanol and analyzed by electrophoresis in a 1% agarose gel with TAE buffer (40 mM Tris-acetate 2 mM EDTA, pH 8.0).

Results and Discussion

Most adsorption preparates did not reveal virus particles. However, a few adsorption preparates of the vein tissues of newly expanded leaves revealed the absence of gemini-type particles (Fig. 2) in the same tissues of healthy leaves. Such particles could not yet be visualized in ultrathin sections. Abnormal ultrastructural changes such as crystal-like inclusions occasionally found in the nuclei and clusters of vacuoles in the cytoplasm of infected cells were observed in infected tissues. Electron-dense fibrillar materials were noted at the periphery of the vacuoles.

A single nucleic acid band was visualized after electrophoresis on 1% agarose gel, following virus purification and nucleic acid extraction with phenol and chloroform, which was sensitive to DNase digestion. This band was not obtained from healthy tissues.

Reports on a single-stranded DNA and gemini-type particles associated with diseased tissues and findings of a whitefly vector of the disease strongly suggested that sweet potato leaf curl disease is caused by a gemini virus. This is further supported by the presence of crystalline nuclear inclusions in ultrathin sections which are known to be associated with gemini viruses. These nuclear inclusions were also seen under the light microscope after special staining.

Short rod-shaped virus-like particles in the cytoplasm of phloem cells of leaf curl-infected plants previously reported by Chung et al. (1985) and Yamashita (1984) were thought to be phloem-related protein (P protein). These have similar size but are nonviral in origin. Knowledge about the exact size and morphology will enable the purification of the virus and production of antiserum which can be used in virus indexing employed at several IARCs and national institutes.

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[6]Cohen, S., J. E. Duffus, R.C. Larsen, H. Y. Lin, and R. A. Flock. 1983. Purification, serology and vector relationships of squash leaf curl virus, a white fly-transmitted gemini virus. Phytopathology 73:1669-1673.

[7]Czosnek, H.,R. Ber, Y. Antignus, S. Cohen, N. Navot and D. Zamir. 1988. Isolation of tomato yellow leaf curl virus, a gemini virus. Phytopathology 78:508-512.

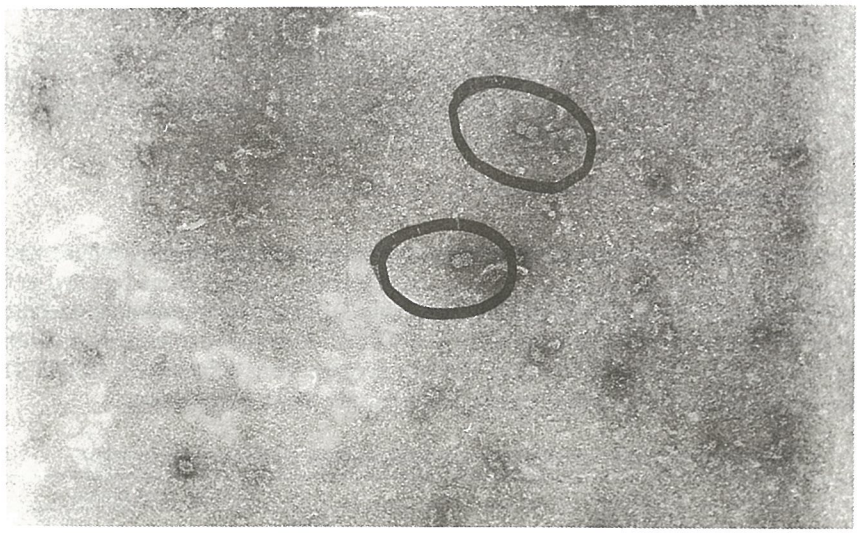

Fig. 3 Gemini particles in leaf adsorption preparates of leaf curl-infected sweet potato.

Elimination of Viruses Through Virazole

Summary

Antiviral chemicals such as ribavirin (virazole) have shown effectiveness eliminating sweet potato viruses from infected tissue. The effect of different concentrations of ribavirin on the elimination of FMV and YDV in stem tips was investigated. Virus elimination in plantlets derived from meristems placed on regular and virazole-containing media was compared.

Higher concentrations of virazole increased the efficiency of virus elimination in stem tips. At 100 mg/l virazole eliminated FMV in 57.6% and SPYDV in 79.1% of the stem tips, which however were not higher than virus elimination achieved by meristem culture alone. Placing meristems on medium containing 50 mg/l virazole did not result in higher virus elimination.

Introduction

Virazole, a nucleoside analogue which suppresses virus replication in infected plant tissue was effective in eliminating sweet potato leaf curl virus. When added into the culture medium at 50 mg/l it eliminated SPLCV in 86% of the plants. Ribavirin was tested for its effect on FMV and YDV which commonly infect sweet potato. This experiment also investigated whether incorporation of virazole in the tissue culture could improve the virus elimination efficiency.

Material and Methods

Stem tips of YDV-infected *I. batatas*, I 423 and FMV-infected *I. batatas* TN 63 were grown. Meristems of 0.3-mm and 1-cm long stem pieces (S_1) immediately below the meristems were excised and placed on LR medium. Another 1-cm long stem section below S_1 (S_2) was excised and placed on LR medium containing 30 mg/l virazole. Similarly, nine 1-cm long sections below S_2 (S_3), a 1-cm long section below S_3 (S_4) and a 1-cm long section below S_4 (S_5) were excised and placed on LR medium supplemented with 50, 60 and 100 mg/l virazole, respectively. Another 1-cm long stem section also excised below S_5 (S_6), was placed on LR medium without virazole. When the plantlets developing from these explants reached four to five leaf stage, they were tested by ELISA for FMV and SPYDV and

transferred to Jiffy 7 pellets. When the plants reached maturity and showed none or very mild symptoms, these were transferred to clay pots and grafted to two *I. setosa* indicator plants.

Half of the meristems excised from 26 lines from the Philippines, Tonga, Solomon Islands and Peru were placed on the regular media (LR and MS); the other half were placed on LR and MS medium supplemented with 50 mg/l virazole. Ten to 20 meristems per line treatment were used. All plantlets were subjected to the regular virus-indexing method by ELISA.

Results and Discussion

Incorporation of virazole into the tissue culture medium did not significantly reduce virus infection in 1-cm stem tips as much as the meristem culture did. Meristem culture alone resulted in 89% virus-free plants in the case of FMV and 79% in SPYDV (Table 3). The virus elimination method (meristem culture) used in the past will continue to be used at AVRDC. Compared to meristem culture, placing of meristems on virazole (50 mg/l) medium did not ncrease virus elimination (Table 4). Virazole will therefore be dropped in the tissue culture medium for virus elimination.

Table 4. Effects of virazole on elimination of FMV and SPYDV.

Excised plant part	Treatment (Virazole conc.) (mg/l)	% virus free plants	
		FMV	SPYDV
M	0	89.3[z] + 3.1	79.9 + 3.0
S_1	0	1.7 + 1.5	1.3 + 1.3
S_2	30	9.3 + 2.1	12.6 + 1.5
S_3	50	21.7 + 2.5	43.8 + 3.0
S_4	60	37.4 + 2.5	70.3 + 3.5
S_5	100	57.6 + 4.2	79.1 + 3.0
S_6	0	1.0 + 0.7	0.7 + 0.5

[z]Values represent means of 20 plants and three replications.

Table 5. Effects of virazole in the tissue culture medium.

Treatment	Total no. of virus infected		
	meristems excised	meristem survival	meristems (%)
M + V (50 mg/l)	202	64.9	9.5
M – V	314	65.9	9.4

M = meristem culture. +V = virazole added to the tissue culture medium. –V = no virazole added to the tissue culture medium.

Sweet Potato Physiology

Growth and Partitioning of Dry Matter

Summary

Production of dry matter, partition of assimilates, formation and growth of storage root of 10 improved sweet potato clones were investigated under five distinct seasons to examine the effect of environmental conditions on yield. Harvest indices and dry matter accumulations of storage roots increased throughout the growing season but in a slower rate under conditions with increasing temperatures and heavy rainfall. The relative importance of source, sink and partitioning effects changed during the growing season and differed among clones. Two major determinants were total dry matter production and partition of assimilate to the storage root. Partition, however, seemed to play a major role regardless of the planting season. Inclined diversion of dry matter to the storage root was related to sink strength. This trend was affected by environmental conditions such as high temperatures and soil flooding. Balance between top growth and storage roots could be a factor in obtaining maximum yield.

Introduction

It was previously demonstrated that translocation of dry matter in sweet potato is more important than dry matter production, and that yield is affected more by sink strength than source potential. On the other hand, unit area yield of sweet potato fluctuates with changes in environmental conditions. Efforts to ascertain how environmental factors limit storage root formation have been limited. This study quantitatively examined the assimilation, partition and growth of AVRDC-improved sweet potato clones under different growing conditions using growth analysis. The study also clarified the relationships between different environmental conditions and yield potential of sweet potato. Better understanding of these relationships may redound to more efficient production and breeding of sweet potato.

Materials and Methods

Ten clones of sweet potato, Kinmen, Tainung New 31, Tainung 66, I 1192 (low β-amylase), CN1028-15, CN1108-13, CN1121-312, CN1232-9, CN1367-2 and CN1517-139 were planted on 21 July and 19 October 1987, 1 March, 19 May and 21 July 1988. Mean temperatures and total precipitation during 30-day growth duration of each planting are presented in Figures 1 and 2.

A randomized complete block design with four replications was employed for each planting. Plot size was 3 $\times$ 7 m. Four plants from the middle row of each plot were randomly sampled once a month, starting one month after planting. Five samplings were made with the last one done 150 days after planting. Harvested plants were measured for leaf area, dry weights of different plant parts, and the number of storage roots and yields. Leaves and storage roots were also evaluated for α-amylase activities, and petioles and storage roots for sugar and starch contents. Crop growth rate (CGR), leaf area ratio (LAR), leaf area index (LAI), leaf area duration (LAD), net assimilation rate (NAR) and relative growth rate (RGR) of the plant and storage roots were calculated.

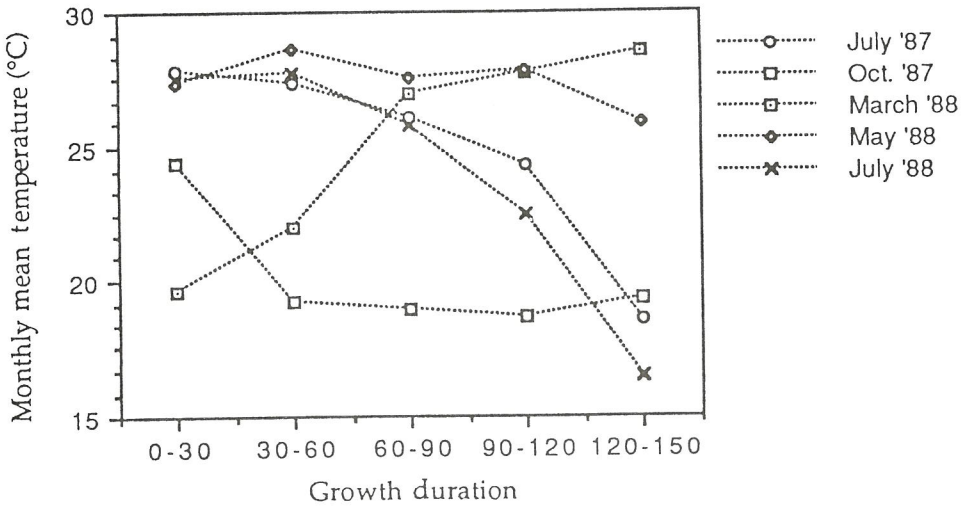

Fig. 1. Mean temperatures of five plantings of 10 sweet potato clones at 30-day intervals.

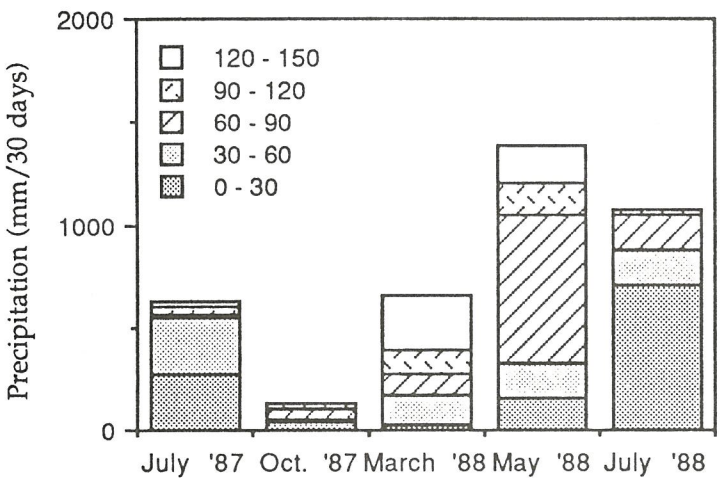

Fig. 2. Total precipitation of five plantings of 10 sweet potato clones.

Results and Discussion

When data were averaged across five plantings, CN 1028-15 had the highest storage root yields due to its high dry matter production and harvest index (Table 1a). Among entries, CN 1517-139 also had high total dry matter production and harvest index. CN 1108-13 and CN 1028-15 had comparable harvest indices. The differences in maximum and minimum values in harvest index were greater than in total dry matter production: a difference of six times in harvest index versus two times in total dry matter production. Results suggested that enhanced dry matter production and harvest index are two important determinants for yield potential of sweet potato. However, enhanced harvest index seemed more critical than increased dry matter production among 10 clones examined.

When data were averaged across 10 clones, planting in October 1987 had the highest storage root yields, total dry matter, number of storage roots and harvest index (Table 1b). This could be attributed to the decreasing temperatures throughout the growth period and absence of heavy rainfall

Table 1a. Means of total dry matter and yields of 10 sweet potato clones in five plantings.

Clone	Storage root yield (g/plant)	No. of storage roots (/plant)	Total dry wt. (g/plant)	Harvest index (%)
Kinmen	305.1 de[z]	5.1 ab	168.0 cd	40.4 cd
TN 31	162.3 f	1.9 e	141.1 de	22.6 e
TN 66	355.6 c-e	4.1 cd	182.1 bc	41.9 cd
I 1192	196.5 f	3.5 d	147.0 de	28.6 e
CN 1028-15	666.7 a	5.1 ab	265.6 a	60.8 a
CN 1108-13	504.0 b	5.6 a	196.2 bc	56.1 ab
CN 1121-312	261.9 ef	4.5 bc	132.5 e	37.4 d
CN 1232-9	441.6 bc	5.4 ab	202.7 bc	48.6 bc
CN 1367-2	56.7 g	1.0 f	125.7 e	9.3 f
CN 1517-139	370.6 cd	3.9 cd	207.8 b	51.3 b

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

Table 1b. Means of total dry matter and yields of 10 sweet potato clones in five plantings.

Planting month	Storage root yield (g/plant)	Storage root no. (/plant)	Total dry wt. (g/plant)	Harvest index (%)
July 1987	324.1 bc[z]	3.4 b	149.1 b	42.1 b
Oct. 1987	579.7 a	8.0 a	214.2 a	71.1 a
March 1988	339.8 b	2.3 c	198.1 a	32.2 c
May 1988	145.6 d	3.1 b	123.1 c	21.8 d
July 1988	271.2 c	3.2 b	199.9 a	31.3 c

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

(Fig. 2). On the contrary, planting in May 1988 had the least storage root yields, total dry matter production and harvest index because plants were exposed to an increasing temperature (Fig. 1) and heavy rainfall (near 700 mm) at the time of bulking of storage roots. Sweet potato plantings in July 1987 and July 1988 were both exposed to decreasing temperatures. However, planting in July 1987 tended to have higher yield than July 1988 despite less dry matter production. Thus, it can be concluded that high precipitation favorably affects top growth but not storage root.

High dry matter production in CN1028-15 and CN1517-139 could be attributed to high CGR (Table 2). Since total dry matter production is correlated with photosynthetic potential of the plant, the source potential of both CN1028-15 and CN1517- 139 could be higher than other clones.

Similarly, high CGR (Fig. 3) resulted in high dry matter production during planting in October 1987 possibly because of decreasing temperatures and low precipitation (Figs. 1 and 2). Low CGR in May 1988 was caused by heavy rainfall and high temperatures which impaired storage root development. The ineffectual storage root likely blocked the amount of assimilate translocated as storage root developed.

Table 2. Changes in mean crop growth rates (g/m^2/day) at 30-day intervals of 10 sweet potato clones in five plantings.

	Growth intervals (days after planting)			
	30-60	60-90	90-120	120-150
Kinmen	9.5 ab[z]	4.0 cd	5.9 ab	0.3 b
TN 31	8.8 ab	5.3 a-d	2.8 b	-0.3 b
TN 66	8.1 b	8.7 a	3.2 b	1.2 b
I 1192	5.4 c	7.0 a-d	5.9 ab	0.2 b
CN 1028-15	10.0 a	7.5 a-c	8.5 a	7.1 a
CN 1108-13	8.6 ab	8.4 a	7.5 ab	-0.7 b
CN 1121-312	5.8 c	4.8 b-d	5.6 ab	-0.1 b
CN 1232-9	8.9 ab	5.8 a-d	5.1 ab	4.4 ab
CN 1367-2	5.9 c	3.7 d	5.1 ab	1.3 b
CN 1517-139	8.2 b	7.6 ab	8.0 ab	1.3 b

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

Moreover, high CGR of CN1028-15 and CN1517-139 could be ascribed to high NAR which is a component of CGR and approximately equivalent to the net photosynthetic rate. CN1028-15 maintained relatively high NAR throughout the 150-day growing period. In an earlier report, CN1028-15 leaf cuttings had significantly higher net photosynthetic rates than CN1367-2. High NARs in the later growth stages of CN1028-15, CN1232-9 and CN1517-139 could be attributed to sink activity in the storage root which could have enhanced the photosynthetic activity in the leaf.

Seasonal comparison of NAR revealed that October 1987 planting maintained relatively higher NAR than others (Fig. 4). The extent to which CGR could be increased by increasing leaf area depends on whether NAR is affected by an increase in LAI. High NAR was due to small LAI (Fig. 5) brought about by reduced top growth. Small LAI enhanced light transmission (Fig. 6) because of less mutual shading of leaves, whereas NAR declined at the later growth stage (Fig. 4) due to an increased mutual shading. The NAR of plants grown in May 1988 was low (Fig. 4) although their LAI was comparable to other plantings. This supports the statement that if storage root development is inhibited by flooding, leaf photosynthesis would be reduced.

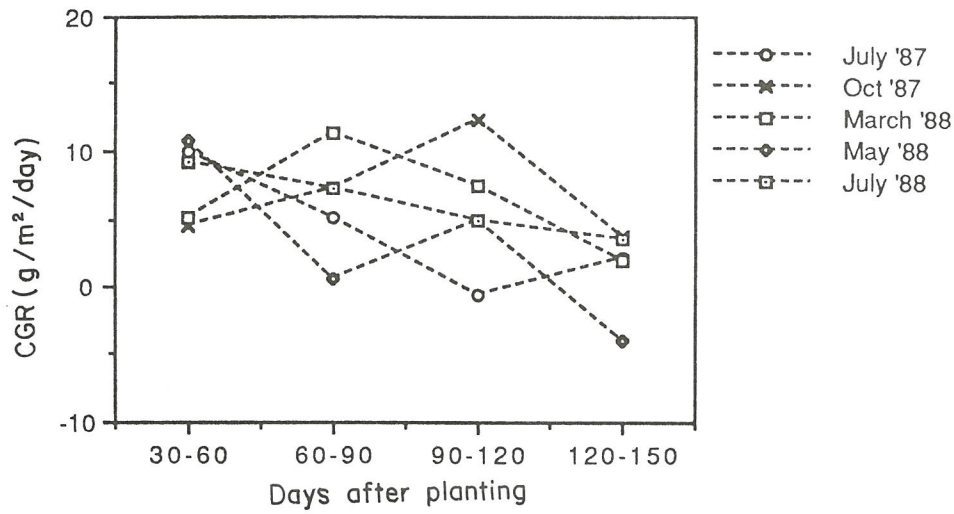

Fig. 3. Changes in mean crop growth rates (g/m^2/day) at 30-day intervals of 10 sweet potato clones in five plantings.

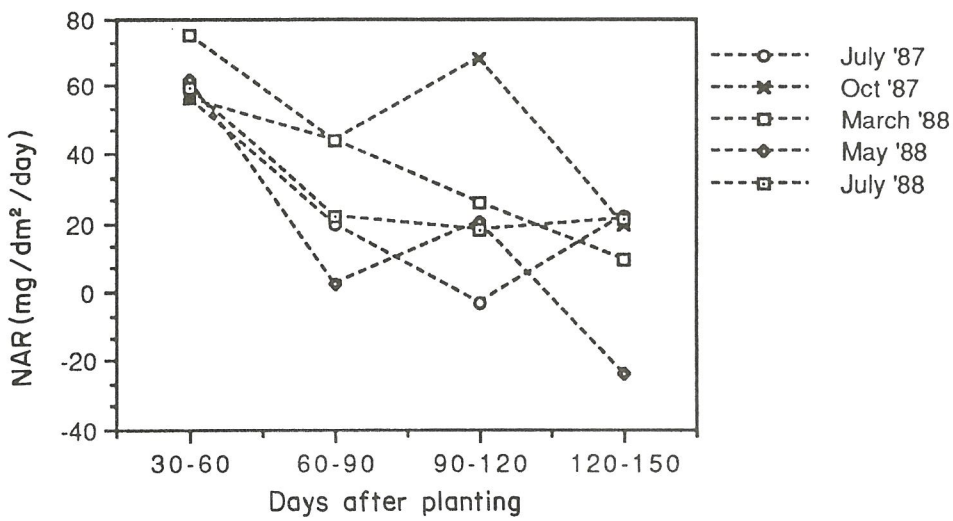

Fig. 4. Changes in mean net assimilation rates (mg/dm^2/day) at 30-day intervals of 10 sweet potato clones in five plantings.

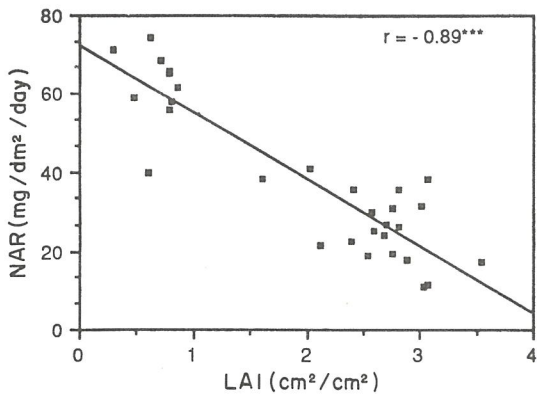

Fig. 5. Relationship between leaf area index (cm^2/cm^2) and net assimilation rate ($mg/dm^2/day$) of 10 sweet potato clones in five plantings.

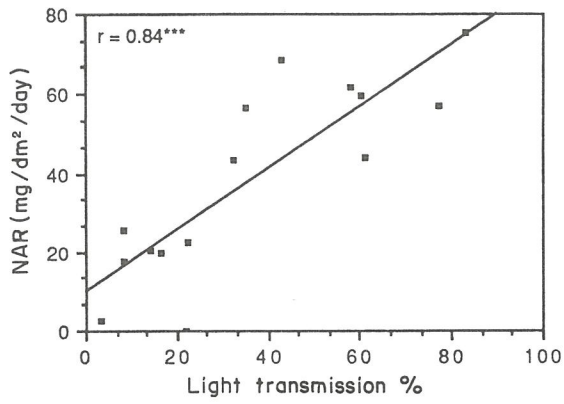

Fig. 6. Relationship between light transmission (%) and net assimilation rates ($mg/dm^2/day$) of 10 sweet potato clones in five plantings.

LAR expresses the ratio between leaf area and total plant dry weight and characterizes the relative size of the assimilatory apparatus versus total biomass. High yielding CN1028-15, CN1108-13, CN1232-9 and CN1517-139 had low LAR during the growing period, especially at the later stages of five plantings, whereas low yielding CN1367-2 had the highest LAR throughout the growing period. Results clearly indicated that high yielding clones were capable of diverting assimilates from the leaf.

Low LAR at 30 and 60 days after transplanting in May 1988 (Fig. 7) was mainly due to most dry matter diverted to nonleaf structures. On the average, planting in May 1988 had comparable leaf area as others. The decrease in sink load in the developing storage root because of heavy rainfall in May 1988 could have enabled the overall decrease in growth. Results suggested that maintaining an optimum balance between top growth and sink activity might ensure higher yield. It is important to note that optimum top/storage root ratios vary according to variety and time, and that absolute top weight at any point in the growing season is not as important as the dynamic balance between storage roots and top growth.

The ability of the storage roots to accept assimilates is a major factor leading to high yield. Both CN1028-15 and CN1517- 139 maintained high RGR throughout the growing period. This indicated the translocation of dry matter from other organs to the storage root. In the same manner, planting in October 1987 maintained high RGR in the storage roots (Fig. 8). Results also indicated that maximum bulking of the storage roots occurred 30 to 90 days after planting.

Since the RGR of storage roots is a partial expression of sink strength in the storage roots, it is possible that high yielding clones had high sink strength. Low temperatures and dry soil conditions in the late stage of plant growth may oblige the expression of sink strength potential. This could account for high harvest index in high yield clones of plantings in October 1987. Furthermore, there were negative correlations between storage root α-amylase activities and storage root yields of plantings in May 1988. Results suggested that sink strength in storage roots may be associated with α-amylase activities.

Storage roots of plantings in October 1987 harvested at 60 to 150 days after planting had high starch content among other planting, and those of May 1988 had the least. Soluble sugar/starch ratios in the storage root during 90 to 150 days after planting were below 30% in October 1987, and above 55% in May 1988. Results suggested that starch accumulation apparently could be limited by prevailing environmental conditions during the later growth of storage roots. On clonal variations, CN 1028-15, CN 1108-13 and CN 1517-139 maintained relatively high starch content and low soluble sugar/starch in the storage root.

Dry matter in the developing storage root comes from photosynthesis that occurs after storage root initiation. Sucrose and other metabolites reaching the storage root may be derived from leaves. Results showed that there were negative correlations between soluble sugar/starch ratios in the petioles

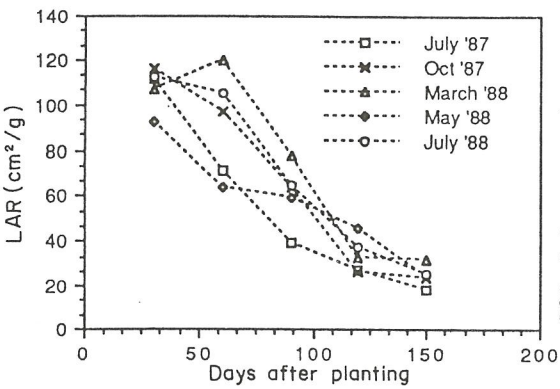

Fig. 7. Leaf area ratios (cm^2/g) of 10 sweet potato clones in five plantings.

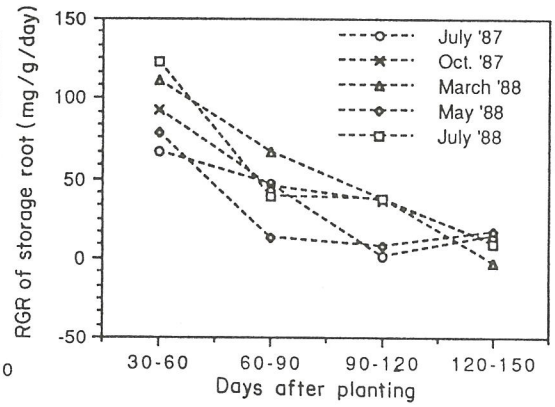

Fig. 8. Changes in mean relative growth rates (mg/g/day) of storage roots at 30-day intervals of 10 sweet potato clones in five plantings.

and starch content in the storage roots. Also α-amylase activities in the leaves at later growth stage were highest in October 1987. Apparently there was an efficient starch utilization from the leaves in clones with high sink strength or under favorable environments.

Based on the findings of this study, it is concluded that total dry matter production and partition of assimilates to the storage roots were two major determinants for yield difference. Inclined diversion of dry matter to the storage root was related to sink strength; this trend changed depending on the environmental conditions such as high temperatures and soil flooding. A balance between top growth and storage roots could help obtain maximum yield.

Evaluation of Tolerance to Excess Soil Moisture

Summary

Flooding at three or seven weeks after planting affected leaf growth and storage root formation of leaf cuttings. At three weeks after planting, flooding was more crucial than seven weeks after planting in accelerating leaf senescence and inhibiting storage root initiation. However, flooding at seven weeks after planting was more effective in impeding storage root enlargement. There were clonal differences in leaf senescence and survival of leaf cuttings after flooding treatments. CN1489-89 had the slowest rate of leaf chlorosis and the highest survival rate (>80%) during the 63-day growth duration with flooding at three or seven weeks after planting. Other clones, I392, I444, TN66 and TN67 also had more than 50% survival rates after flooding. In general, TN66, CN1108-13 and CN1489- 89 produced higher storage root yields than other clones under flooding conditions. In a screening of 214 unimproved entries, I100, I358, I381, I405 and I932 produced reasonable storage roots when the leaf cuttings were exposed to excess soil moisture three weeks after planting.

Introduction

Excess soil moisture, especially at critical stage of storage root formation limits sweet potato production. An assessment of clones which are able to produce storage roots under excess soil moisture condition is needed. However, great variations in field-grown sweet potato make evaluation difficult. This study evaluated the variations among 39 promising breeding clones in response to flooding using leaf cuttings under hot season conditions.

Materials and Methods

Leaves with petioles were detached from 39 field-grown sweet potato clones and transplanted to polyethylene tubes (ID 17 cm, height 40 cm) with soil-sand-compost mixture on 17 July 1989. Leaf cuttings were grown under screenhouse conditions. At three or seven weeks after transplanting, polyethylene tubes with leaf cuttings were submerged in water up to 5 cm below the soil surface for four days. There were six replicates per treatment and two tubes per replicate. Rates of plant survival and leafblade chlorosis were recorded. At 78 days after transplanting, leaf cuttings were examined for fresh and dry weights of leaf blade, petiole and fibrous pigmented and storage roots. Mean maximum and minimum temperatures were 33.8° and 25.3°C, respectively.

In another screening of 214 unimproved clones, leaf cuttings were planted in plastic pots (ID 10 cm) filled with growing media. At three weeks after planting, the pots were either submerged in water up to soil surface for one week or maintained normally without flooding. Flooding tolerance was based on plant survival, leaf blade chlorosis, number of storage roots and total fresh and dry weights.

Results and Discussion

Flooding at three weeks after planting significantly reduced storage root yields of leaf cuttings (Table 3). Flooding appeared to be critical in limiting the storage root formation at initiation stage.

Flooding at three weeks after planting was more crucial than at seven weeks in accelerating leaf senescence. There were clonal differences in leaf senescence and survival of leaf cuttings after flooding treatment. CN1489-89 had the slowest rate of leaf chlorosis and highest survival rate of more than 80% during the 63-day growth duration with flooding at three or seven weeks after planting. Other clones, I392, I444, TN66 and TN67 also had more than 50% survival rates after flooding.

In general, leaf cuttings attained maturity rather rapidly because of relatively high temperatures during the experiment. However, results showed that TN66, CN1108-13 and CN1489-89 produced higher storage root yields than other clones under flooded conditions.

In a screening of unimproved clones, susceptible ones were first weeded out based on plant survival and leaf chlorosis. Of the 214 entries examined, 34 clones survived under flooding conditions. Later, fresh and dry weights of different parts from these 34 entries were weighed. Among them, I100, I358, I381, I405 and I932 produced acceptable storage roots (Table 4).

Table 3. Effects of flooding at three or seven weeks after planting on the fresh roots of sweet potato leaf cuttings.

Flooding	Pigmented Root		Storage Root	
Treatment	no./cutting	g/cutting	no./cutting	g/cutting
Control	0.7	0.3	0.4 a[y]	1.2 a
3 WAT[z]	0.6	0.3	0.2 b	0.6 b
7 WAT	0.5	0.3	0.4 a	1.1 a

[z]Time, weeks after transplanting (WAT), flooding was imposed. [y]Mean separation within columns by DMRT at 5% level.

Table 4. Effects of flooding at three weeks after planting on the number and dry weight of storage roots of sweet potato leaf cuttings.

	No. of storage root		Storage dry wt. (g)		Total dry wt (g)	
	Control	Flood	Control	Flood	Control	Flood
Mean (34 clones)	1.6	1.2	2.3	0.9	4.8	4.0
I 100	3.1	3.1	5.3	2.7	7.7	5.6
I 358	2.5	2.2	3.7	2.9	5.5	5.6
I 381	2.8	1.9	3.6	2.3	5.5	5.0
I 405	1.8	1.6	3.4	2.2	6.0	7.2
I 932	1.3	1.6	3.1	2.2	5.7	6.2

Variations in Starch Content of Cultured Cells

Summary

Cells derived from meristem cultures of 18 sweet potato clones grown in MS media containing sucrose exhibited differences in relative growth rate (RGR) during five weeks of *in vitro* culture at 25-30°C. CN1489-89 and Tainung 31 had comparable RGR which is the highest among 18 clones, whereas AIS35-2 had the lowest. Under normal cell growth, starch formation also exhibited clonal differences in cultured cells. CN1661-15 had the highest starch content (8.9% on dry weight basis), highest number of cells with starch grains (82% of cells examined) and highest number of starch grains per cell (16% of cells with more than 50 starch grains per cell). Cells of I1192, CN71-4 and CN1517-139 had less than 3% starch content on dry weight basis.

Levels of amylase, an enzyme responsible for starch degradation inside the cells also exhibited three-fold differences among 18 clones examined. CN1108-13 had the minimum amylase activities in the cultured cells. GA_3 in the media decreased starch formation in the cultured sweet potato cells.

Introduction

Somaclonal variations arising from cultured cells have been used in selecting genotypes for particular traits such as disease resistance or stress tolerance. The advantages of selecting mutants by somatic cell/tissue culture include accuracy of treatment exposure under *in vitro* conditions and the facility with which a large number of cultured cells or partly regenerated embryoids may be served. The approach can also be extended to identify sources of resistance at cellular level. Sweet potato plantlets readily regenerate from cultured cells. Yet, to date very few attempts have been made on cell/tissue culture level of sweet potato for disease resistance, stress tolerance or desirable quality.

The study delved into the possibility of 1) regenerating plantlets from single cultured cells; 2) screening high quality starch clones from cell or callus culture; 3) identifying drought and/or salt tolerant clones from cell or callus culture; and 4) selecting scab-resistant clones from cell or callus culture. Clonal variations in growth rates, soluble sugar and starch content, and amylase activities in the cultured cells of 18 sweet potato clones are discussed in this report. Since amylase is initiated by gibberellins (GA) and responsible for starch degradation, the effect of GA_3 on soluble sugar and starch content of cultured cells of Tainung New 31 was also examined.

Materials and Methods

Calli of AIS35-2, I949, I1189 (Hawaii), I1192 (Ninety- nine), CN1028-15, CN1108-13, CN1232-9, CN1367-2, CN1489-89, CN1510-25, CN1517-139, CN1656-37, CN1661-15, CN71-1, CN71-4, Kinmen (I444), Tainung New 31 and Tainung 66 (I981) were grown from meristem culture in MS agar medium containing 3% sucrose.

The callus was then transferred to the liquid MS medium containing 3% sucrose, 5 mg/l IAA, 0.5 mg/l 2,4-D and 0.3 mg/l kinetin. Suspension cultures were maintained on a gyratory platform shaker under low light intensity at 25 to 30°C. Subcultures were initiated by placing equal wet weights of cells in a 125-ml Erlenmeyer flask containing 50 ml of modified MS liquid medium. After five weeks, the medium was separated from the cells by emptying the entire content of one flask onto a Buchner funnel containing a moistened gauze cloth. The medium was separated from the cells by suction and the cells' fresh and dry weights were evaluated. The fresh cell was examined under the microscope for starch grain-containing cells and number of starch grains per cell after staining with iodine and assayed for amylase activities using the 3,5-dinitrosalicylic acid procedures. One unit of amylase activity was defined as a change of 1 absorbance unit/min at 540 nm. Soluble sugar and starch content of dried cells were also determined. Each determination was performed three times with each sampling made and 200 cells per determination each time for counting number of starch grains.

In a separate experiment, cultured cells of Tainung New 31 were transferred to the modified MS liquid medium containing 4, 20 and 100 mg/l of GA_3, and cultured for four days before determining soluble sugar and starch content of dried cells.

Results and Discussion

Cells derived from meristem cultures of 18 sweet potato clones grew well in MS media containing sucrose as a source of carbon. However, cells exhibited appreciable differences in relative growth rate (RGR) in five weeks of *in vitro* culture at 25 to 30°C (Table 5). CN1489-89 and Tainung New 31 had comparable RGR, the highest among 18 clones. AIS35-2 had the least RGR. CN1489-89 possessed stable and high yield with high dry matter under field conditions. The relation of these characteristics to high RGR under cell culture conditions could be investigated further.

Table 5. Relative growth rate (RGR), amylase activity, soluble sugar, starch content and percent of cells with starch grains after five weeks of culture in the liquid medium.

Clone	RGR (mg/g/wk)	Amylase (unit/ml)	Sugar (% dry wt)	Starch (% dry wt)	Cells with starch grains (%)
AIS 35-2	38 h[z]	0.09 d	1.7 de	4.9 c	4.1 g
CN 71-1	288 a-c	0.16 a	2.3 c-e	4.0 de	4.4 g
CN 71-4	268 a-d	0.08 d	3.3 cd	2.6 h	53.7 b
CN 1028-15	246 b-f	0.11 c	1.6 de	5.5 b	48.2 b
CN 1108-13	292 ab	0.05 e	2.0 c-e	3.9 de	9.2 fg
CN 1232-9	275 a-d	0.06 de	1.5 de	4.3 cd	8.8 fg
CN 1367-2	205 ef	0.11 c	6.3 b	6.0 b	53.3 b
CN 1489-89	324 a	0.06 de	1.0 de	3.5 ef	3.7 g
CN 1510-25	296 ab	0.07 de	1.6 de	3.5 ef	9.6 fg
CN 1517-139	243 b-f	0.14 ab	1.9 c-e	2.7 gh	21.0 d-f
CN 1656-37	194 g	0.14 ab	2.2 c-e	5.7 b	91.4 a
CN 1661-15	240 b-f	0.12 bc	9.4 a	8.9 a	82.5 a
I 6 (TN New 31)	321 a	0.07 de	3.4 cd	4.5 cd	42.9 bc
I 444 (Kinmen)	266 a-e	0.08 d	2.0 c-e	3.0 f-h	19.2 ef
I 949	269 a-d	0.14 ab	0.8 e	3.4 e-g	23.1 de
I 981 (TN 66)	216 d-f	0.07 de	4.2 c	4.4 cd	23.7 de
I 1189	118 g	0.12 bc	1.0 de	3.5 ef	34.0 cd
I 1192	228 c-f	0.08 d	1.8 de	2.7 gh	23.6 de

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

Starch formation in the cells occurred in sucrose-containing MS medium. The iodine complex of starch in cultured cells was similar to those in storage root cells. Findings indicated the conversion of sucrose to starch during culturing of cells. In normal cell growth, starch formation also exhibited clonal differences in cultured cells. CN1661-15 had the highest starch content (8.9% on dry weight basis), highest number of cells with starch grains (82% of cells examined) and highest number of starch grains per cell (16% of cells with more than 50 starch grains per cell). Interestingly, CN1661-15 had the highest starch content in the storage roots grown in the 1987-88 wet season. Cells of I1191, CN71-4 and CN1517-139, on the other hand, had less than 3% starch content on dry weight basis.

Amylase levels inside the cells also exhibited a three-fold difference among 18 clones examined. CN1108-13 had the least amylase activity in the cultured cells, whereas CN71-1 had the highest. However, no relationships could be found between amylase activity and other parameters investigated.

GAs are usually associated with *de novo* synthesis of amylase. GA_3 in the liquid media decreased soluble sugar and starch content in the cultured sweet potato cells. These findings suggested that biosynthesis of starch in cultured cells might be repressed by GA_3 via the inhibition of uptake of substrate (sucrose in this case) which acts as a precursor of starch. In this connection, GA_3 was reported to relate to the biosynthesis of exocellular polysaccharides and may be important in regeneration capacity.

Sweet potato clones with high storage root yields and starch contents also tended to be high in these parameters under cultured cell conditions. It could be used in selecting cell lines with high or low starch contents and/or growth rates. The interrelationships of starch content and relative growth rate between cultured cells and storage roots need further investigation.

Tomato Breeding

Hybridization

Of the total 550 backcrosses made in 1989, 126 were made to incorporate the parthenocarpic trait (controlled by *pat-2* gene) into tropical lines which carry multiple resistance to bacterial wilt (BW), tomato mosaic virus (ToMV) and root knot nematode. These crosses were made to augment the fruit-setting ability of tropical lines under high temperatures using the parthenocarpic trait to complement the heat-tolerance genes. For black leaf mold resistance, 52 backcrosses were made. In addition, 30 backcross families for resistance to potato virus Y (PVY) and six crosses for resistance to insects were developed.

The search for fresh market tomato hybrid combinations which carry heat tolerance, resistance to diseases such as BW, ToMV and nematode, fruit firmness, improved fruit size, crack resistance, dark green shoulder and good fresh taste was continued. There were 89 cherry tomato hybrid combinations (247 crosses) aimed at combining disease resistance (as above) with heat tolerance, crack resistance and desirable cherry tomato traits such as more uniform and small fruits per cluster; good plum-shaped and firm fruits; thick pericarp with relatively tough skin, sweet and pleasant flavor. Other backcrosses were made to incorporate insect and PVY resistance.

Bacterial Wilt Resistance of Breeding Lines

Summary

Three SSD-derived breeding lines showed high levels of BW resistance. These lines are also homozygous for resistance to tomato mosaic virus and root knot nematode. Further selections were made from the best lines for heat tolerance, fruit firmness, jointless character and reduced fruit cracking.

Four fresh market tomato hybrids showed very high BW resistance. These hybrids are also resistant to tomato mosaic virus and root knot nematode. Three of these hybrids were also selected for good performance under hot and humid conditions in a separate hot set trial.

Several advanced determinate and indeterminate breeding lines showed high levels of BW resistance. These lines are also homozygous for resistance to both tomato mosaic virus and root knot nematode. Two determinate and one indeterminate line showed promising results when tested under hot and humid conditions and were selected for future trials.

The mortality rates due to BW infection among the advanced cherry tomato breeding lines were generally higher than in other materials tested in 1989. Even the highly resistant checks, L 285 and CLN 65-349, succumbed to a higher degree than in other BW tests. Only one cherry tomato line showed resistance comparable to that of L 285, the highly resistant check.

Introduction

All new breeding materials in the tomato breeding program were rigorously tested for BW resistance considering that this is the most important disease limiting tomato production in the tropics.

In 1989, a range of breeding materials was subjected to BW resistance tests using the field screening procedure developed at AVRDC in 1986.

Materials and Methods

The breeding materials tested in the 1989 BW nursery comprised of the following:

Materials	Sown	Transplanted
31 SSD DC_5 lines	14 April 1989	14 May 1989
49 F_6 tropical cherry tomato lines	21 April 1989	19 May 1989
49 determinate tropical breeding lines	14 April 1989	15 May 1989
28 indeterminate tropical breeding lines	14 April 1989	15 May 1989
47 F_1 fresh market tomato lines	14 April 1989	15 May 1989

L 390, a highly BW-susceptible cultivar was seeded thickly in the BW nursery, four rows in a bed with rows and hills 20 and 10 cm apart, respectively. Sowing of seeds was normally six weeks before transplanting the test materials. At the seventh true-leaf stage, the leaves of L 390 were swathed with sickle to artificially create an avenue for wilt infection. BW inoculum was immediately sprayed using a power sprayer. The field was plowed and prepared for planting the test materials when nearly 100% of the susceptible plants died. The new beds were prepared exactly at the same location as the original beds to ensure good inoculum potential in each bed.

Each test line was transplanted to two outside 4-m long rows with a spacing of 20 cm between plants. For relative comparison, susceptible L 390 and resistant L 285 plants were planted at intervals in the center of each bed. All tests were replicated twice in a randomized complete block 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 65), designated as RRB were calculated to determine their comparative levels of resistance. Further analyses compared the RRL of each entry with its RRL (derived by comparing its survival rate with that of L 285 in the same bed and designated as SRR) to test the homogeneity of inoculum distribution in the nursery.

Results and Discussion

SSD DC_5 lines. Figure 1 shows a very close relationship between the RRL and the SRR of test lines indicating uniform inoculum distribution. The advanced breeding lines which showed high levels of resistance to bacterial wilt are listed in Table 1.

Three new lines showed statistically similar levels of resistance as the resistant checks. In addition to BW resistance, these lines were also screened for heat tolerance in 1989 hot season from which further selections of the best lines were made for good fruit setting ability, enhanced fruit firmness, jointless

Table 1. Bacterial wilt reaction of the best SSD-derived DC_5 lines vs. checks, 1989.

Entry	SR (%)	RRL	RRB	Resistance to	
				ToMV[z]	Nematode[y]
L 285 (res check)	96.9 a	100.0	110.7	+/+	+/+
CLN 65-349D_5-2-0 (res check)	87.5 a	90.6	100.0	$2^a/2^a$	+/+
CLN 872-169-(1)475-1-1	92.8 a	95.8	106.1	$2^a/2^a$	*Mi/Mi*
CLN 872-150-(2)429-4-15	89.6 a	92.5	102.4	$2^a/2^a$	*Mi/Mi*
CLN 872-65-(4)199-2-2	88.4 a	91.2	101.0	$2^a/2^a$	*Mi/Mi*
L 390 (sus check)	15.0 d-g	15.5	17.1	+/+	+/+
Mean of all entries	27.2				
CV %	35.9				

[z] $2^a/2^a$ = homozygous resistant for gene *Tm2*^{a}; +/+ = susceptible. [y] +/+ = susceptible; *Mi/Mi* = homozygous resistant.

trait and minimal fruit cracking. The new selections are also homozygous for the gene *Tm2*^{a} which confers tomato mosaic virus resistance and *Mi* for nematode resistance.

Fresh market hybrids. The most resistant fresh market hybrids were from crosses among BW-resistant parent stocks (Table 2). Three of these wilt-resistant hybrids, namely FMTT 260, FMTT 264 and FMTT 265 were also selected for good overall performance under hot and humid conditions. These hybrids are also homozygous for the dominant gene *Tm2*^{a} for tomato mosaic virus resistance. Except FMTT 250, all are heterozygous for the dominant gene, *Mi* for nematode resistance. In other trials, distribution of BW inoculum in the test was good as evidenced by a nearly one-to-one correspondence between RRL and SRR (Fig. 2); coefficient of variation of the test was also reasonably low.

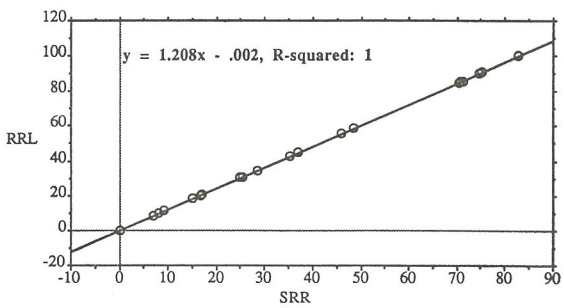

Fig. 1. Regression of RRL (relative resistance vs. an independent plot of L 285) on SRR (relative resistance based on comparison with L 285 in the same plot); advanced SSD-derived DC_5 lines.

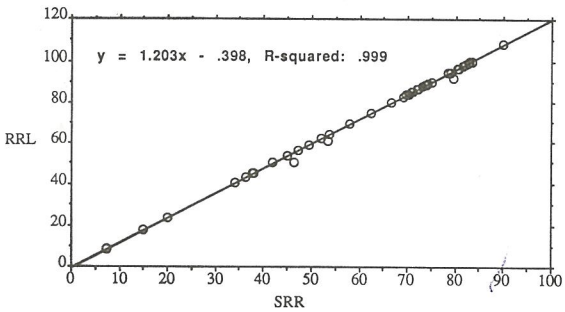

Fig. 2. Regression of RRL (relative resistance vs. an independent plot of L 285) on SRR (relative resistance based on comparison with L 285 in the same plot); fresh market hybrids.

Table 2. Bacterial wilt resistance of the best F_1 fresh market tomato lines vs. checks, 1988.

Entry	SR (%)	RRL	RRB	Resistance to	
				ToMV[z]	Nematode[y]
L 285 (res check)	97.4 ab	100.0	103.1	+ / +	+ / +
CLN 65-349D5-2-0 (res check)	94.5 a-c	97.0	100.0	$2^a/2^a$	+ / +
FMTT 235	100.0 a	102.7	105.8	$2^a/2^a$	*Mi* / +
FMTT 245	100.0 a	102.7	105.8	$2^a/2^a$	*Mi* / +
FMTT 260	100.0 a	102.7	105.8	$2^a/2^a$	*Mi* / +
FMTT 266	100.0 a	102.7	105.8	$2^a/2^a$	*Mi* / +
FMTT 264	96.9 ab	99.5	102.5	$2^a/2^a$	*Mi* / +
FMTT 265	96.2 ab	99.1	98.8	$2^a/2^a$	*Mi* / +
FMTT 250	94.8 a-c	97.3	100.3	$2^a/2^a$	+ / +
L 390 (sus check)	3.2 l	3.3	3.4	+ / +	+ / +
Mean of all entries	74.8				
CV %	20.9				

[z] $2^a/2^a$ = homozygous resistant for gene *Tm* 2^a; + / + = susceptible. [y] *Mi* / + = heterozygous resistant; + / + = susceptible.

Determinate breeding lines. Table 3 lists the advanced determinate breeding lines which showed high BW resistance. These lines are also homozygous for the dominant gene, *Mi* for nematode resistance, thus affording them greater protection from soil-borne pathogens. Lines CLN 698-358-4-13 and CLN 475-265-9-0 were also selected for good general performance under hot and humid conditions in a separate hot set trial.

An excellent distribution of BW inoculum in the nursery was indicated by the regression line in Figure 3. The CV for survival rate (24.7%) in this experiment was also low, indicating reliable results.

Indeterminate breeding lines. The most wilt-resistant indeterminate breeding lines which also carry nematode resistance are listed in Table 4. Line CLN 657-274-0-15-0 indicated good overall performance under hot and humid conditions in a separate hot set trial. In other trials, distribution of BW inoculum in the test was good (Fig. 4) and the CV for survival rate of 25.9% was also low, rendering the results of the experiment highly reliable.

Table 3. Bacterial wilt resistance of the best determinate tropical lines vs. checks, summer 1989.

Entry	SR (%)	RRL	RRB	Resistance to	
				ToMV[z]	Nematode[y]
L 285 (res check)	100 a	100	125	+ / +	+ / +
CLN 65-349D$_5$-2-0 (res check)	80 a-d	80	100	$2^a/2^a$	+ / +
CLN 698BC$_1$F$_2$-358-4-13	100 a	100	125	$2^a/2^a$	*Mi/Mi*
CLN 475BC$_1$F$_2$-265-4-16	100 a	100	125	$2^a/2^a$	*Mi/Mi*
CLN 475BC$_1$F$_2$-265-4-19	100 a	100	125	$2^a/2^a$	*Mi/Mi*
CLN 475BC$_1$F$_2$-265-9-0	100 a	100	125	$2^a/2^a$	*Mi/Mi*
CLN 475BC$_1$F$_2$-265-12-9-1	100 a	100	125	$2^a/2^a$	*Mi/Mi*
CLN 698BC$_1$F$_2$-512-0-12-6	100 a	100	125	$2^a/2^a$	*Mi/Mi*
CLN 684BC$_1$F$_2$-58-5	100 a	100	125	$2^a/2^a$	*Mi/Mi*
L 390 (sus check)	10 gh	10	13	+ / +	+ / +
Mean of all entries	59.5				
CV %	24.7				

[z] $2^a/2^a$ = homozygous resistant for gene *Tm2*^{a}; + / + = susceptible. [y] *Mi/Mi* = homozygous resistant ; + / + = susceptible.

Table 4. Bacterial wilt resistance of the best indeterminate tropical lines vs. checks, summer 1989.

Entry	SR (%)	RRL	RRB	Resistance to	
				ToMV[z]	Nematode[y]
L 285 (res check)	90.6 a	100.0	94.2	+ / +	+ / +
CLN 65-349D$_5$-2-0 (res check)	95.5 a	106.1	100.0	$2^a/2^a$	+ / +
CLN 657BC$_1$F$_2$-285-0-21-0-13	96.7 a	107.4	101.3	$2^a/2^a$	*Mi/Mi*
CLN 657BC$_1$F$_2$-274-0-15-0	95.5 a	106.1	100.0	$2^a/2^a$	*Mi/Mi*
CLN 656BC$_1$F$_2$-36p-7	92.3 a	102.6	96.6	$2^a/2^a$	*Mi/Mi*
CLN 500BC$_1$F$_2$-200-249-3-4-10-10	90.0 a	100.0	94.2	$2^a/2^a$	*Mi/Mi*
L 390 (sus check)	0.0 d	0.0	0.0	+ / +	+ / +
Mean of all entries	74.9				
CV %	25.9				

[z] $2^a/2^a$ = homozygous resistant for gene *Tm* 2^a; + / + = susceptible. [y] *Mi/Mi* = homozygous resistant for gene *Mi*; + / + = susceptible.

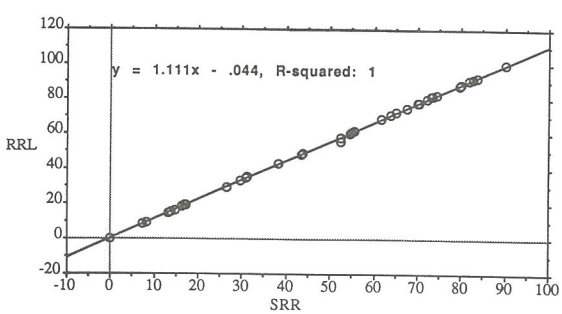

Fig. 3. Regression of RRL (relative resistance vs. an independent plot of L 285) on SRR (relative resistance based on comparison with L 285 in the same plot); determinate tropical lines.

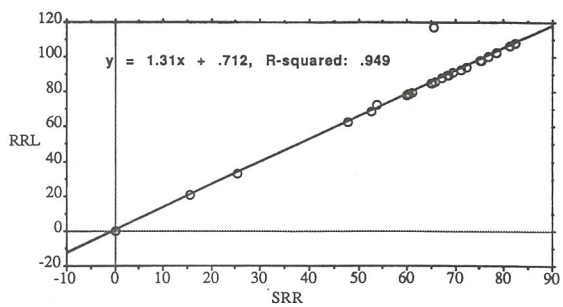

Fig. 4. Regression of RRL (relative resistance vs. an independent plot of L 285) on SRR (relative resistance based on comparison with L 285 in the same plot); indeterminate tropical lines.

Advanced cherry tomato breeding lines. The advanced cherry tomato breeding lines showed at best only moderate to low levels of BW resistance (Table 5). Results showed extremely high CV, rendering the value of the test rather dubious. Only one line showed statistically comparable resistance to the highly resistant accession, L 285.

Table 5. Bacterial wilt resistance of the best advanced cherry tomato breeding lines vs. checks, summer 1989.

Entry	SR (%)	RRL	RRB	Resistance to ToMV
L 285 (res check)	73.7 ab	100.0	89.1	+ / +
CLN 65-349D5-2-0 (res check)	82.7 a	112.2	100.0	$2^a/2^a$
CHT 40-96C-8-7-14-24	50.0 bc	67.8	60.5	$2^a/2^a$
CHT 40-96C-8-7-14-21	31.1 cd	42.6	37.6	$2^a/2^a$
CHT 40-96C-8-7-14-34	30.6 cd	41.5	37.0	$2^a/2^a$
L 390 (sus check)	0.0 d	0.0	0.0	+ / +
Mean of all lines	14.0			
CV %	103.1			

[z] $2^a/2^a$ = homozygous resistant for gene *Tm2*^{a}; + / + = susceptible.

Evaluation of Tropical Breeding Lines

Summary

A number of determinate tropical lines performed well in early summer 1989 general trials; the best ones, however, yielded from 30 to 49 t/ha. The heat-sensitive check cultivars, TK 70 and UC 82 yielded only 3 t/ha. The breeding lines also had less fruit cracking and carried resistance to tomato mosaic virus and varying levels of resistance to bacterial wilt. Among the best lines, CLN 698 also carried resistance to root knot nematode and had better fruit firmness and no fruit cracking.

In the general trial of indeterminate lines, the yields of four best lines ranged from 28 to 36 t/ha, significantly outyielding the heat-sensitive check cultivars, KY 301 and L 387 which yielded 2.6 and 5.4 t/ha, respectively. Three lines of the CLN 657-274 series had larger and firmer fruits with resistance to cracking.

Breeding lines developed after 1980 were markedly superior in yield and fruit size than traditional lines. The latest batch of nematode-resistant lines produced the largest fruits among various groups, although there appeared to be a slight yield reduction within the group with basically unchanged fruit setting ability. Further examination of yield components other than fruit-set is necessary to explain the reduction.

Among indeterminate tropical lines, the greatest gain in yield and fruit size was achieved in the latest batch of nematode-resistant lines despite the apparent reduction in fruit-setting ability. It appeared that dramatic increase in fruit size of the group more than offset the loss of heat tolerance.

Three multiple disease-resistant (ToMV, BW and NEM) determinate breeding lines outyielded the heat-tolerant checks in the summer PYT1. Two lines also carried very high levels of BW resistance and produced firmer and larger fruits.

The best multiple disease-resistant indeterminate lines gave only similar yields as the heat-tolerant check, CL 5915-206 in the PYT2. However, these lines had larger fruits without fruit cracking tendencies.

Introduction

The development of advanced tropical lines with greater resistance to diseases and improved horticultural characters was continued. In recent years, the stepwise combination into tropical lines of heat tolerance and resistance to three major diseases such as bacterial wilt, tomato mosaic virus and root knot nematode has been emphasized. In addition, selection for larger and firmer fruits, and resistance to fruit cracking was also carried out among the breeding populations.

Materials and Methods

Two general performance trials were conducted in the 1989 hot season. The first involved a comprehensive evaluation (general trial) of representative breeding lines from various phases* of the tomato program. This trial assessed the selection gains made from various characters needed for tropical adaptation and to utilize the information in designing future breeding strategies. The second group of test materials consisted of advanced determinate and indeterminate tropical lines carrying nematode resistance.

Details of the above trials were as follows:

Trials	Materials	Sown	Transplanted	Harvested
General (1)	35 determinate	21 April 1989	18 May 1989	24 July 14 - August 1989
General (2)	22 indeterminate	21 April 1989	18 May 1989	26 July - 7 August 1989
Preliminary (1)	22 determinate	16 May 1989	26 June 1989	14 September 1989
Preliminary (2)	15 indeterminate	26 May 1989	26 June 1989	4-15 September 1989

All trials used a randomized complete block design with two replications. Unit plots of determinate entries under both types of trials consisted of two single-row beds, 4.8-m long each and spaced 1.5 m apart; plants within the row were 0.4 m apart. For trials of the indeterminate entries, each plot consisted of a single two-row bed, 4.8 m long each and spaced 0.6 m apart within each bed; plants within the row were also spaced 0.4 m apart.

Both determinate and indeterminate tropical lines were supported with stakes to minimize fruit rot. Only two branches per plant were allowed to develop among the indeterminate entries. Their lateral shoots were pruned and only seven clusters were allowed to develop fruits.

Results and Discussion

General trials. In the general trial (1) of determinate lines, the best yielding tropical lines were those bred during 1980-88 (Groups III-IV), significantly outyielding all breeding lines bred before 1980 and the heat-sensitive check. These breeding lines are homozygous for the dominant gene, *Tm2*^{a}, for tomato mosaic virus resistance and carry varying levels of BW resistance. In addition, the Group IV lines, such as CLN 698-358-4-13, are also homozygous for the dominant gene, *Mi* conferring resistance to root knot nematode and have improved fruit size, firmer fruits, no fruit cracking and based on observations during the trial, have also some discernible resistance to black leaf mold.

Figure 5 shows the mean performances of traits of breeding lines with new resistances and other characters progressively added to them. It can be noted that breeding lines developed after 1980 (Groups III to IV) were superior in yield to the traditional lines. In addition, there was an evident selection gain for mean fruit size with the exception of Group IIIA, the first batch of ToMV-resistant breeding lines. This group was exclusively made up of breeding lines from one cross (CL 1131 series) and is not a diverse group by itself. Group IV, the nematode-resistant lines had the largest fruit size among breeding lines. However, this group registered a slight drop in marketable yield even though its fruit-setting ability was not visibly reduced relative to the other groups. A comparison of its yield components and the other group is necessary to explain the reduction in yield.

*The determinate lines were classified into several groups, namely: Group I-heat sensitive checks; Group II-lines carrying mainly heat tolerance (HT) and BW resistance (bred in 1975-1979); Group IIIA-lines of the CL1131 series, carrying HT, BW and ToMV resistance (bred in 1980-1983); Group IIIB-later batches of ToMV-resistant breeding lines with improved fruit size and, in a few instances, carrying the parthenocarpic gene, pat -2 (bred in 1984-1986); Group IV-new breeding lines carrying in addition to HT, BW and ToMV resistance, nematode resistance (bred in 1985-1988). Groupings among the indeterminate lines were as follows: Group I - comprised of local heat-sensitive check varieties; Group II breeding lines carrying HT, BW (IIA) and ToMV resistance (IIB); and Group III - breeding lines with nematode resistance added to HT, BW and ToMV resistance (IIIA = first batch; IIIB = later batch)

The best performing lines from the general trial (2) of indeterminate lines ranged in yield from 28.5 to 35.7 t/ha, significantly outyielding the heat-sensitive check cultivars, KY 301 and L 387 which yielded 2.6 and 5.4 t/ha, respectively. They also produced moderately firm to firm fruits with none or slight concentric or radial cracking. Furthermore, these lines carry resistance to both tomato mosaic virus and bacterial wilt; three lines also carry, in addition, resistance to root knot nematode and discernible resistance to bacterial leaf spot. However, all were visibly susceptible to black leaf mold.

The progressive changes in three horticultural characters among the indeterminate tropical breeding lines are graphically shown in Figure 6. The greatest gain in yield and fruit size was obtained in Group IIIB (Batch II of the nematode-resistant lines) even though there was an apparent reduction in fruit setting relative to Group IIIA (Batch I of the nematode-resistant lines). It appeared that dramatic increase in fruit size in Group IIIB was more than adequate to offset reduction in fruit-set. It was also apparent that high fruit-set, per se, was not a sufficient guarantee of high yield as in the case of Group IIIA which showed the best fruit-setting ability but produced fruits less than half the size of that of Group IIIB.

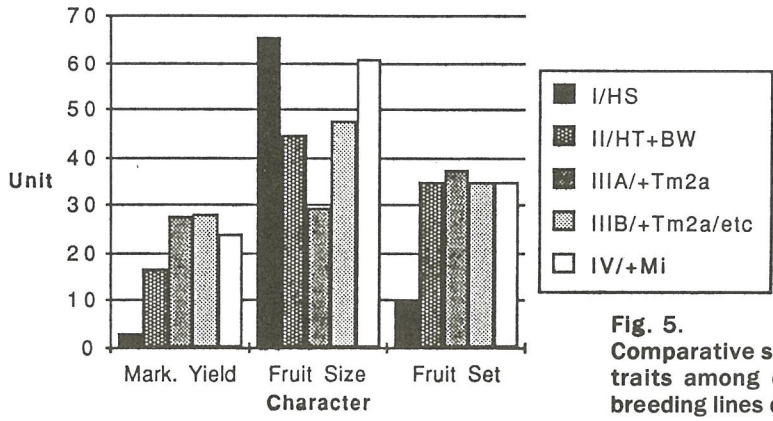

Fig. 5.
Comparative selection advances for various traits among determinate tropical tomato breeding lines developed in different periods.

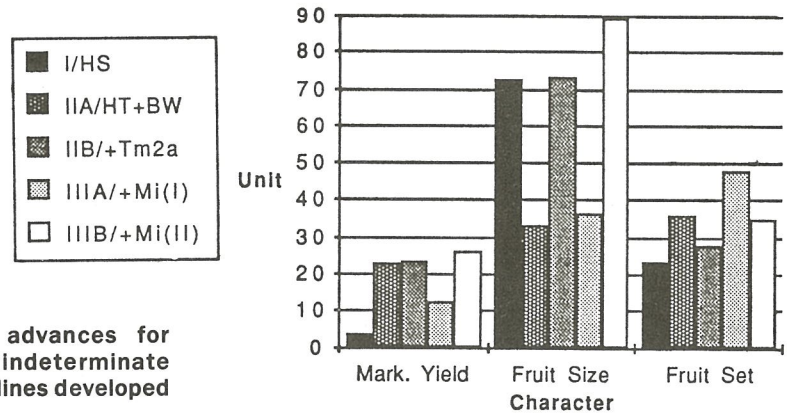

Fig. 6.
Comparative selection advances for various traits among indeterminate tropical tomato breeding lines developed in different periods.

Preliminary trials. Both preliminary trials (PYTs) were damaged by typhoon. Three nematode-resistant determinate lines performed relatively well in the summer 1989 PYTI (Table 6). Line, CLN 698-358-2-11-8 significantly outyielded the heat-tolerant checks, CL 5675 and CL 5915-153. Unfortunately, this line does not carry BW resistance as the other two listed in the table. Other advantages of the new lines over the checks are improved fruit firmness and larger fruits.

Table 7 shows the best nematode-resistant indeterminate lines compared to the heat-tolerant check, CL 5915-206 in the PYT2. These lines showed only comparable yield performance as the check. However, two selections, namely CLN 657-274-0-15-4 and CLN 657-274-0-15-0, had larger

and crack-resistant fruits compared to the check. The BW resistance levels of the new entries and the check appeared comparable.

Table 6. Yields and other horticultural characters of the best determinate tropical line in the PYT1, summer 1989.

Entry	Marketable yield (t/ha)	Fruit size (g)	Fruit set (%)	Cracking[z]	Firmness[y]	Resistance to[x]		
						ToMV	Nematode	BW survival rate (%)
CLN698BC$_1$F$_2$-358-2-11-8	15.8 a	36 c-e	37.0 a-d	SA	MF	$2^a/2^a$	*Mi/Mi*	27.7
CLN698BC$_1$F$_2$-358-4-13	13.6 ab	33 c-f	31.2 a-f	SA	MF	$2^a/2^a$	*Mi/Mi*	100.0
CLN475BC$_1$F$_2$-265-9-0	11.9 b-d	39 c-e	27.1 a-h	R	MF	$2^a/2^a$	*Mi/Mi*	100.0
CLN5675BC$_1$F$_2$-1-1-2-12 (ck)	11.3 b-d	18 g	41.0 a	N	MS	$2^a/2^a$	+/+	7.6
CL5915-153D$_4$-3-3-0-NS-1 (ck)	9.4 c-f	24 f-g	38.6 a-c	SLSA	MS	$2^a/2^a$	+/+	5.0
Mean of all entries	7.6	35	29.4	–	–	–	–	–
CV %	17.4	12.5	11.4	–	–	–	–	–

[z]SA = superficial abrasion, SL SA = slight superficial abrasion, R = radial cracks, N = no cracking. [y]MF = moderately firm, MS = moderately soft. [x]$2^a/2^a$ = homozygous resistant for gene *Tm2*^{a}; *Mi/Mi* = homozygous resistant for gene *Mi*; + / + = susceptible.

Table 7. Yields and other horticultural characters of the best indeterminate tropical lines in the PYT2, summer 1989.

Entry	Marketable yield (t/ha)	Fruit size (g)	Fruit set (%)	Cracking[z]	Firmness[y]	Resistance to[x]		
						ToMV	Nematode	BW survival rate (%)
CLN657BC$_1$F$_2$-274-0-15-4	9.6 b	101 a	23.1 ab	N	MF	$2^a/2^a$	*Mi/Mi*	82.2
CLN698BC$_1$F$_2$-585-0-17-9	8.9 bc	54 b-d	22.7 ab	N	MF	$2^a/2^a$	*Mi/Mi*	72.2
CLN657BC$_1$F$_2$-274-0-15-0	8.5 bc	89 ab	26.0 a	N	MF	$2^a/2^a$	*Mi/Mi*	95.5
CL5915-206D$_4$-2-2-0-4 (ck)	9.3 bc	58 b-d	25.0 a	VSLR/SA	MF	$2^a/2^a$	+/+	94.0
FMTT 22 (ck)	18.1 a	84 a-c	20.2 ab	VSLR	MF	2^a/+	+/+	67.0
Mean of all entries	6.8	67	17.2	–	–	–	–	–
CV %	43.5	25.8	17.7	–	–	–	–	–

[z]N = no cracking, VSLR/SA = very slight radial cracks and superficial abrasion. [y]MF = moderately firm. [x]$2^a/2^a$ = homozygous resistant for gene Tm-2^a; *Mi/Mi* = homozygous resistant for gene *Mi/Mi*; + / + = susceptible.

Evaluation of Fresh-market Tomato Breeding Lines

Summary

Six promising hybrids were selected for further testing from the observation trial in early summer 1989. The best ones ranged in yield from 41 to 54 t/ha greatly outyielding FMTT 22, the heat-tolerant check. These hybrids also carry resistance to tomato mosaic virus and root knot nematode and varying levels of resistance to bacterial wilt. They also showed less or no fruit cracking and moderately firm to very firm fruits. In addition, these new hybrids had uniform fruit sizes in each cluster.

A few entries outyielded the check cultivars in OYT II; however, this trial was damaged by a typhoon and needs to be reevaluated.

None of the large-fruited fresh market tomato hybrids outyielded the heat-tolerant check, FMTT 22 in the fall 1988 PYT.

The best large-fruited fresh market tomato hybrids in summer 1989 AYT yielded from 42 to 51 t/ha compared to only 29 t/ha for the heat-tolerant check, FMTT 22. The highest yielding hybrid was FMTT 138 which also showed better apparent resistance to the virus complex during that season and good foliage cover. However, it produced moderately soft fruits and did not carry nematode resistance.

Introduction

The search for fresh market tomato hybrids with the following characteristics was continued: heat tolerance, disease resistance (bacterial wilt, tomato mosaic virus and root knot nematode), firm fruits, dark green shoulder and pleasant fresh market taste.

Materials and Methods

Four trials were conducted in 1988 to 1989. Information on materials, planting dates and types of trials are given below.

Trials	Entries	Sown	Transplanted	Harvested
Observational 1	43	19 April 1989	18 May 1989	26 July-7 August 1989
Observational 2	68	21 June 1989	20 July 1989	18 September
Preliminary	34	4 October 1989	28 October 1989	28 February-22 March 1989
Advanced	12	19 April 1989	18 May 1989	19 July-7 August 1989

All observational trials (OYTs) were not replicated and generally involved a relatively large number of test materials. In contrast, the PYT and AYT were evaluated using a randomized complete block design with two and three replications, respectively. Unit plots of the OYT and the PYT consisted of a double-row bed, 4.0 m long each and spaced 0.6 m apart within one bed, with plants within the row spaced 0.4 m apart. For the AYT, plots consisted of four rows (two rows to a bed), with rows within the bed and plants within the row spaced 0.6 m and 0.4 m apart, respectively.

Results and Discussions

Observation trial. In the early summer observation trial on fresh market tomato hybrids, six entries outyielded the heat-tolerant check, FMTT 22 with marketable yields from 41 to 54 t/ha with larger or comparable fruit size, generally firmer fruits, with none or only slight cracks and relatively lower virus infection.

In OYT2, performance of all materials was generally poor because of typhoon damage. Despite this, the new hybrids yielded at least twice as much as FMTT 22 with comparable fruit size and in some cases, moderate to darker green shoulders.

Preliminary trial. None of the new hybrids outyielded the check FMTT 22 in the fall 1988 preliminary yield trial (Table 8). However, all significantly outyielded the local check cultivar, KY 301 and had moderately firmer and bigger fruits. Some also had relatively darker green shoulder than FMTT 22.

Table 8. Yields and other horticultural characters of the best fresh market tomato hybrids vs. check cultivars in the PYT, fall 1988.

Entry	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g/ft)	Cracking[z]	Firmness[y]	BLR[x]	Green shoulder	Resistance to	
								ToMV[w]	BW (%)[v]
FMTT 229	98.9 ab	54.8 d-i	158 a-d	N	MF	N	green	$2^a/2^a$	–
FMTT 110	98.2 ab	61.6 b-g	130 d-i	VSLR	MF	M	light green	$2^a/+$	13.2
FMTT 128	98.2 ab	61.6 b-g	148 a-f	VSLR	MF	VSL	light green	$2^a/+$	38.2
FMTT 227	93.6 a-c	55.8 d-i	137 c-h	SL-MR	MF	SL-M	green	$2^a/2^a$	–
FMTT 104	92.0 a-d	76.1 a	135 c-h	N	MF	SL	light green	$2^a/2^a$	100
FMTT 22 (ck)	102.0 ab	64.2 b-e	130 d-h	VSLR	MF	SL	light green	$2^a/+$	67
KY 301 (ck)	49.3 o	39.5 k-m	153 a-f	SLR	MS	SL	dark green	+/+	0
Mean of all entries	74.9	54.3	142	–	–	–	–	–	–
CV %	9.5	6.5	8.1	–	–	–	–	–	–

[z]N = none cracking; VSLR = very slight radial cracks; SL-MR = slight and moderately radial cracks; SLR = slight radial crack. [y]MF = moderate firm; MS = moderately soft. [x]BLR = blotchy ripening; N = none; M = moderate; VSL = very slight; SL = slight. [w]$2^a/2^a$ = homozygous resistant for gene *Tm2*^{a}; $2^a/+$ = heterozygous resistant; +/+ = susceptible. [v]BW(%) = survival rate in bacterial wilt test.

Advanced trial. The best relatively large-fruited fresh market hybrids are listed in Table 9. All new entries outyielded the heat-tolerant check, FMTT 22 and the local heat-sensitive check, KY 301 ranging in marketable yield from 42 to 51 t/ha. Fruits of the new hybrids were smaller though statistically similar to those of the checks and did not show any signs of cracks. However, with the exception of FMTT 105, the hybrids were apparently softer compared to that of FMTT 22.

Evaluation of New Cherry Tomato Breeding Lines and Hybrids

Summary

None of the cherry tomato lines outyielded the check cultivars, Girl's Sweet and Sugar Pearl in spring 1989 observation trial. However, the new lines had high soluble solids, more small fruits, less fruit cracks and resistance to powdery mildew.

Three new cherry tomato lines, namely CHT 265, CHT 309 and CHT 305 showed better heat tolerance than the check hybrids, Girl's Sweet and Sugar Pearl in summer 1989 observation trial. These also produced smaller but firmer fruits with less or no fruit cracks and showed resistance to black leaf mold and physiological wilting due to flooding; however, all hybrids succumbed to bacterial spot during the trial.

Four cherry tomato hybrids outyielded the check hybrids in fall 1988 PYT. The same hybrids also performed well during early summer 1988 preliminary trials, showing good levels of heat tolerance (yield range of 39 to 44 t/ha) with less fruit cracks, acceptable soluble solids, moderately firm fruits and good vine cover. Some entries also carried appreciable BW resistance.

The best cherry tomato hybrids in spring 1989 AYT had comparable yield and soluble solids as the check cultivars, Girl's Sweet and Sugar Pearl. However, they showed advantages over the checks in terms of reduced fruit cracking, tomato mosaic virus resistance and slight but visibly lower powdery mildew infection.

Introduction

As in 1988, research on development of cherry tomato genotypes with the following characteristics was continued: heat tolerance, disease resistance (bacterial wilt, tomato mosaic virus and nematode), firmness, tough skin, no fruit cracking and acceptable cherry type quality (especially high soluble solids brix range of 6-9°).

Materials and Methods

Information on entries, planting dates and type of cherry tomato trials conducted at different times in 1988-1989 are given below:

Trials	Entries	Sown	Transplanted	Harvested
Observational 1	44	19 January 1989	22 February 1989	8 May-18 June 1989
Observational 2	208	21 May 1989	30 June 1989	4-5 September 1989
Preliminary 1	16	8 September 1989	15 October 1988	23 December 1988-9 February 1989
Preliminary 2	16	19 April 1989	18 May 1989	11 July 1-August 1989
Advanced	10	12 January 1989	14 February 1989	25 April-9 June 1989

All observation trials were on two-row plot (within one 1.5-m bed) unreplicated system and designed to make general selection for entries which deserve further consideration. Each plot was 4 m long, with two rows within the bed spaced 0.7 m apart and within-row spacing of 40 cm. Oftentimes, observation trials involved a large set of entries that are evaluated for the first time.

The PYTs were replicated twice in a randomized complete block design. A unit plot was 6 m^2 and consisted of a two-row, 4 m long bed with rows in the bed spaced 0.7 m apart; plants within the row were spaced 40 cm apart.

Table 9. Yields and other horticultural characters of the best F_1 FMTs vs. check cultivars in the AYT, summer 1989.

Entry	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g/ft)	Crack-ing	Firm-ness[y]	UFS[x]	Other traits[w]			Resistance to		
							BLM	BLS	Other viruses (%)	ToMV[u]	BW[t] (%)	NEM[s]
FMTT 138	50.9 a	42.7 a	74 e-g	N	MS	3	7.0 b	5.7 b	1.7 c	$2^a/2^a$	–	+ / +
FMTT 115	50.3 a	48.2 a	60 g	N	MS	3	7.0 b	5.7 b	5.0 c	$2^a/2^a$	–	+ / +
FMTT 105	48.3 a	40.5 ab	82 de	N	MF	1	8.0 b	6.3 b	14.2 a	$2^a/2^a$	–	*Mi* / +
FMTT 95	47.9 a	43.3 a	92 cd	N	MS	5	6.7 c	4.7 c	5.0 c	$2^a/2^a$	97.2	*Mi* / +
FMTT 94	47.1 a	40.8 ab	68 fg	N	MS	3	6.3 c	5.0 b	9.2 a	$2^a/2^a$	77.4	+ / +
FMTT 114	42.4 ab	47.9 a	73 e-g	N	S	5	6.7 c	5.7 b	14.2 a	$2^a/2^a$	97.5	*Mi* / +
FMTT 22 (HT ck)	28.8 c	24.5 cd	95 b-d	SLRC	MF	5	7.7 b	5.3 b	19.2 a	2^a / +	67.0	+ / +
KY 301 (HS ck)	3.7 d	11.2 e	106 b	SVR	MS	5	9.0 a	7.3 a	26.7 a	+ / +	0	+ / +
Mean of all entries	34.8	32.5	86	–	–	–	7.3	5.8	12.4			
CV %	16.7	8.6	8.7	–	–	–	7.3	18.9	82.2			

[z]N = no cracking; SLRC = slight radial and concentric cracks; SVR = severe radial crack. [y]MS = moderately soft; MF = moderately firm, S = soft. [x]UFS = uniform fruit shape; Rating scale of 1 = irregular; 3 = moderately irregular; and 5 = regular. [w]Rating scale of 1 = none to 10 = severe. [v]Other viruses (%) = complex of unknown viruses. [u]$2^a/2^a$ = homozygous resistant for gene *Tm2*^{a}; 2^a / + = heterozygous resistant; + / + = susceptible. [t]BW(%) = survival rate in bacterial wilt test. [s]*Mi* / + = heterozygous resistant for gene *Mi*; + / + = susceptible.

The advanced trial was planted in a randomized complete block design with three replications. Each plot consisted of two 2-row beds (or a total of 4 rows), each row 4 m long and spaced 70 cm apart within the bed with plants within each row spaced 40 cm apart.

Results and Discussion

Observational trials. None of the new cherry tomato breeding lines outyielded the check cultivars, Girl's Sweet and Sugar Pearl in spring 1989 observation trial but they had higher soluble solids (range of 5.8-6.7) and smaller fruits (range of 14-18 g) than check cultivars. The new lines also showed less fruit cracking tendencies and some discernible resistances to powdery mildew.

The yields of the best cherry tomato hybrids in summer 1989 OYT2 ranged from 11.1 to 16.4 t/ha, outyielding the check hybrids, Girl's Sweet and Sugar Pearl which yielded 8-9 t/ha. The hybrids also produced moderately firm fruits with slight fruit cracks. These also carried resistance to tomato mosaic virus, and based on observations during the trial, resistances to black leaf mold and physiological wilting due to flooding; however, all hybrids were apparently highly susceptible to bacterial spot.

In the preliminary trial conducted in fall 1988, the yields of four cherry tomato hybrids (CHT 105, 103, 104 and 92) ranged from 76-86 t/ha outyielding Girl's sweet and Sugar Pearl. These produced moderately firm fruits with slight or no cracks. Another advantage of these hybrids over the checks was their resistance (in heterozygous form) to tomato mosaic virus.

The four cherry tomato hybrids in early summer 1989 PYT exhibited good levels of heat tolerance and yield ranging from 39-44 t/ha. In contrast, checks Girl's Sweet and Sugar Pearl yielded 29 and 23 t/ha, respectively. The hybrids also had less fruit cracking tendencies (checks had severe radial cracking) and good vine cover. Entries such as CHT 104 and CHT 105 also carried some levels of BW resistance.

The best cherry tomato hybrids with comparable performance as the check hybrids, Girl's Sweet and Sugar Pearl in spring 1989 AYT are listed in Table 11. The following advantages of the hybrids over the checks were noted: less fruit cracking, tomato mosaic virus resistance and slight but different reactions to powdery mildew. Soluble solids of entries was comparable to that of the check hybrids.

Table 10. Yield and horticultural characters of F_1 cherry tomato vs. check cultivars in the advanced yield trial, spring 1989.

Entry	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g)	Cracking[z]	Firmness[y]	Brix°	Other traits[w]		Resistance to	
							PM	BLS	ToMV[w]	BW[v] (%)
CHT 105	51.4 b	96	28 bc	VSLR	MF	5.6 bc	6.0	2	$2^a/+$	63 b-f
CHT 104	49.6 bc	93	29 bc	SL-MR	MF	5.9 ab	6.5	2	$2^a/+$	74 b-d
CHT 77	43.7 b-d	94	30 b	VSLR	F	5.4 c-e	6.0	2	$2^a/+$	–
CHT 103	41.8 cd	93	26 cd	VSLR	MF	5.7 bc	6.5	2	$2^a/+$	37 e-n
Girl's Sweet (ck)	51.4 b	96	30 b	SVR,C	F	5.5 cd	9.0	2	+/+	–
Sugar Pearl (ck)	45.3 b-d	96	24 d	VSVR	MF	6.1 a	8.5	2	+/+	–
Mean of all entries	45.3	94	32	–	–	5.5	–	–		24
CV %	10.4	5.1	4.9	–	–	3.8	–	–		59.3

[z]VSLR = very slight radial crack; SL-MR = slight to moderately crack; SVR,C = severe radial and concentric cracks; VSVR = very severe radial crack. [y]MF = moderately firm; F = firm. [x]Rating scale of 1 = none to 10 = severe; PM = powdery mildew; BLS = bacterial spot. [w]$2^a/+$ = heterozygous resistant for gene *Tm2*^{a}; +/+ = susceptible. [v]BW(%) = survival rate in BW test.

Evaluation of New Processing Tomato Hybrids

Summary

The best new hybrids in the late summer and fall 1988 OYTs showed higher marketable yields, better maturity and improved fruit firmness than the check cultivars. However, most had inferior fruit size and soluble solids.

Three hybrids showed comparable heat tolerance as the heat tolerant check, TN-3 in the late summer of 1988 PYT. PT 4225, PT 4287, PT 4289 and PT 4300 of the new high yielding hybrids appeared promising because of their firmer fruits and good vine cover.

PT 4297 was outstanding in fall 1988, third batch in PYT, with good concentrated maturity, firmness and vine cover.

The best performing hybrids in the spring of 1989, fourth batch, also showed the same desirable characteristics as in the late summer and fall season PYT except for soluble solid content which generally tended to be lower because of the high soil moisture and temperature condition during the harvest period. The soluble solids of the selected hybrids were always comparable, however, with that of the normally high solids check like TK 70. As in other trials, PT 4225, PT 4287, PT 4289 and PT 4300 were prominent among best entries.

In general, four hybrids namely, PT 4225, PT 4287, PT 4289 and PT 4300 performed consistently well in the late summer, fall and spring croppings.

PT 4121 and PT 4165, both outstanding entries in the late summer of 1988 advanced trial, not only outyielded the heat-tolerant check TN-3 but also had better concentrated maturity, fruit firmness (especially PT 4121), larger fruits, better vine cover and vine compactness.

With the exception of selections from the spring 1989, fourth batch, most selected hybrids had higher pedicel retention rate than the check cultivars.

Introduction

In 1989, the search for processing tomato genotypes with heat tolerance (for late summer and spring season planting), disease resistance (bacterial wilt, tomato mosaic virus and nematode), high concentrated yield of firm fruits (for mechanical harvesting) and acceptable processing quality was continued. Some hybrids were advanced to various stages.

Materials and Methods

Details of trials conducted at different times in 1988-1989 are given below.

Type of trial	Entries	Sown	Transplanted	Harvested
Observational 1	118	26 July 1988	30 August 1989	1 December 1988-4 January 1989
Observational 2	122	13 September 1988	13 October 1988	31 January-13 March 1989
Preliminary 1	18	26 July 1988	30 August 1988	1 December 1988-4 January 1989
Preliminary 2	21	13 September 1988	13 October 1988	31 January-13 March 1989
Preliminary 3	24	13 September 1988	13 October 1988	31 January-13 March 1989
Preliminary 4	22	9 December 1988	15 January 1989	25 April-8 May 1989
Preliminary 5	18	9 December 1989	15 January 1989	25 April-8 May 1989
Advanced	8	26 July 1989	30 August 1989	1 December 1988-4 January 1989

All observation trials were made up of single-row, unreplicated plots and designed primarily to make general selection for entries which deserve further consideration. Each plot consisted of a single 4-m long bed, set 1.5 m apart from the adjacent beds, spaced 40 cm within rows.

The preliminary trial was replicated twice in a randomized complete block design. A unit plot was 12 m^2, consisting of two beds, 4 m long each, set 1.5 m from adjoining beds spaced 40 cm within rows.

The advanced trials were planted in a randomized complete block with three replications, each plot consisting of four 4-m long beds, set 1.5 m apart with plants spaced 40 cm within rows.

Results and Discussion

Observation trials. The new processing hybrids showed comparable heat tolerance as TN-3 in the late summer planting with better concentration of maturity (for final yield) and moderately firm fruits and resistance to ToMV and nematode. However, these generally had smaller fruits, especially the check, TK 18.

Overall, the best entries in late summer trial were PT 4441 and PT 4452 because of their concentrated maturity, moderately firm to firm fruits, compact and good vine cover, and soluble solids and color comparable to those of the checks. PT 4459 had potentially high soluble solids that is combined with acceptable yield and fruit color and will be particularly re-examined for these attributes. Again, the new hybrids have the added advantage of having ToMV and nematode resistance.

Very high yields were obtained in the fall 1988 OYT. The best yielding entries were PT 4446, PT 4454 and PT 4441, with yields ranging from 147-150 t/ha. These entries also produced relatively firm fruits, though still softer compared to the fruits of Tainan No. 2 with soluble solids comparable to those of the check cultivars and good to excellent vine cover.

Preliminary Trials. Overall, the best entries in the individual PYTs were:

- **Late summer 1988 trial, first Batch —** PT 4225, PT 4287 and PT 4289 which had acceptable levels of heat-tolerance as the heat tolerant check, TN-3 greatly outyielded the local check cultivar, TK 18 and produced moderately firm to firm fruit, with good vine cover; however, the soluble solids of these entries was generally lower than TK 70. Entry like PT 4289 and PT 4300 also showed high levels of BW resistance.

- **Fall 1988 trial, second batch —** PT 4300, PT 4309 and PT 4287 with comparable final and first harvest marketable yield as the check varieties TN-3 and TN-2 but outyielded TK 70. These entries also showed improved firmness and good to excellent vine cover and vine compactness. Only PT 4287 had soluble solids comparable to the check cultivars.

- **Fall 1988 trial, third batch —** PT4297 showed the highest final and first marketable yield. Only PT 4284 had soluble solids comparable to the checks. The new hybrids also showed improved fruit firmness compared to TN-3 and TK 70.

- **Spring 1989 trial, fourth batch —** Batch-PT 4223, PT 4287 and PT 4225 gave final and first harvest marketable yield range of 82-85 t/ha and 61-68 t/ha, respectively. Soluble solids of materials including the checks such as TN-2 and TK 70 in this trial were generally low. The selected entries compared favorably with the check cultivars in soluble solids.

- **Spring 1989 trial, fifth batch —** Three hybrids outyielded the check cultivar TK 70 and showed firmer fruits with comparable soluble solids as the checks. However, these hybrids had relatively high pedicel retention rates.

Advanced trial. PT 4121 and PT 4165 selected earlier from the 1987 PYTs were both outstanding in the late summer 1989 advanced yield trial (Table 12). Both hybrids outyielded the heat-tolerant check TN-3. Other advantages of the new entries, particularly PT 4121 over TN-3 had better fruit firmness, larger fruits and good vine cover. However, most entries had lower soluble solids than the check cultivar, TK 18, except PT 4172, PT 4026 and PT 4165.

International Distribution and Testing

In 1989, a total of 2,907 seed packets were distributed to 141 cooperators in 47 countries. Cooperators continuously tested new genetic materials from the tomato improvement program. Promising results were obtained by cooperators in several trials. One cultivar was officially released in 1989.

Table 11. Yields and other horticultural characters of the best processing hybrids vs check cultivars in the advanced yield trial, late summer 1989.

Entry	Marketable yield (t/ha)		Fruit size	Fruit set	Brix°	pH	Acidity	Hunter	Firm-	Vine	Vine	Resistance to	
	Final	First harvest	(g)	(%)				(a/b)	ness[z]	cover[y]	comp[x]	ToMV[w]	BW[v] (%)
PT 4121	98.7 a	35.9 b	102 b	49 ab	4.00 c	4.26 b-d	0.257 b	2.55 b	MF	G	F-G	$2^a/+$	69 a-d
PT 4165	97.7 a	29.9 c	103 b	43 bc	4.60 ab	4.27 bc	0.259 b	2.42 b	MS	E	F	$2^a/+$	93 a-e
PT 4071	86.5 ab	21.7 d	68 d	53 a	4.23 bc	4.18 e	0.273 b	2.55 b	MS	F	G	$2^a/+$	–
PT 4026	83.3 ab	24.8 cd	86 c	48 ab	4.73 a	4.16 c	0.345 a	2.54 b	MS	F-G	F-G	$2^a/+$	90 a-g
PT 4172	77.5 bc	50.4 a	80 c	36 c	4.86 a	4.21 c-e	0.291 b	2.52 b	MS	F	F	$2^a/+$	95 a-d
TN-3 (ck)	77.8 bc	21.4 d	67 d	54 a	4.17 c	4.20 de	0.271 b	2.52 b	MS	F	F	$2^a/+$	–
BL 444 (ck)	66.2 cd	4.5 f	87 c	50 ab	4.03 c	4.28 b	0.291 b	2.51 b	F	G-E	E	+/+	–
TK 18 (ck)	52.6 d	12.6 e	135 a	42 c	5.00 a	4.36 a	0.276 b	2.70 a	MS	F-G	F	+/+	0 r
Mean of all entries	80	25.2	91	47	4.45	4.24	0.287	2.54	–	–	–	–	71
CV %	11.2	12.3	5.5	5.8	5.1	0.82	8.6	2.8	–	–	–	–	19.0

[z]F = firm: MF = moderately firm. [y]F = fair cover; G = good; E = excellent. [x]F = fair compact; G = good; E = excellent. [w]$2^a/+$ = heterozygous resistant for gene *Tm2*^{a}; +/+ = susceptible. [v]BW(%) = survival rate in BW test.

Cultivars Released

One tropical fresh market hybrid was released to tomato farmers in Taiwan by Taichung DAIS, Taiwan in July 1989. This entry, FMTT 22 was named Taichung ASVEG 4. The special desirable attributes that were reportedly found in this material are: moderate level of heat tolerance; resistance to bacterial wilt; resistance to tomato mosaic virus; resistance to fruit cracking; moderately firm and large fruits; acceptable green shoulder color; deep-globe shape; and highly productive at 500 m above sea level during the hot and humid season.

As of December 1989, there were 63 lines of AVRDC tomato germplasm released worldwide in 24 countries.

Feedbacks from Cooperators

Kampuchea. Dr. Brent Rowell reported that PT 870 and PT 3027 gave relatively higher yields (26 and 19 t/ha, respectively) than the local check (12 t/ha) in the 1987-1988 dry season trials. In the 1988-1989 dry season, PT 3027 with 14 t/ha significantly outyielded the local check (7 t/ha). Of particular importance was the comparatively low virus (mostly yellow leaf curl virus) infection of the AVRDC materials compared to the local check (range of 12-21% among AVRDC entries vs. 33% in the local check). Relative resistance to leaf curl virus is a very important trait for successful tomato production during the dry season in the area.

Philippines. East-West Seed Company reported the outstanding performance of a series of cherry hybrids in a recent trial. The best entry was CHT 104, yielding 69 t/ha with minimal foliage and fruit diseases and with very uniform fruit sizes per cluster, averaging 31 g/fruit. Moreover, this hybrid was considered to have good storage potential.

Somalia. Dr. Ali Kambal reported that VC-13-2-2P, an introduction from the Philippines was particularly outstanding in two successive seasons with very minimal leaf curl virus infection and has now been recommended for on-farm trials. Sufficient seeds had been provided for multiplication and on-farm trials in 1989-90.

Sri Lanka. The Department of Agriculture at Peradeniya reported that two or three heat-resistant lines (not identified in the correspondence) developed by AVRDC were ready for release in 1989. More seeds of the tropical lines had been requested for verification trials.

Swaziland. Mr. S. Matsebula of Malkerns Research Station reported that CL 5915-153D4-3-3-0 and CLN 65-349D5-2-0 had higher fruit-setting rates and outyielded the check cultivar, Manapal in a trial in 1988 at Malkerns. However, the fruits were small.

Tanzania. Mr. Gabriel H.R. Rugalema of Sokoine University of Agriculture at Morogoro reported that CL 143 outyielded Roma VF, the most widely grown cultivar in the country.

Turkey. Mr. K. Hosoi of Kagome Company, Ltd. evaluated a number of AVRDC fresh market tomato hybrids and selected FMTT 114 and FMTT 22 for their high adaptability. However, consumers do not prefer the dark green shoulder of these hybrids.

Tomato Entomology

Evaluation of Breeding Lines for Tomato Fruitworm Resistance

Summary

Eleven families derived from a cross between tomato fruitworm (*Heliothis armigera*) resistant *Lycopersicon hirsutum* f *glabratum* and susceptible but high yielding *L. esculentum* were screened in BC_3F_5 progeny for resistance to tomato fruitworm. In addition to tomato fruitworm damage, the lines were also observed for larger fruits and higher yields. Five less damaged breeding lines with yields from 68 to 74 t/ha and fruit size ranging from 36 to 59 g/fruit were selected for distribution to national programs and further improvement by crossing with tomato fruitworm resistant *L. pennellii*.

Introduction

Tomato fruitworm (TFW), *Heliothis armigera* Huebner (Lepidoptera: Noctuidae), is a polyphagous insect that attacks tomato and several other economically important crops in Southeast Asia. The female adults lay eggs on the foliage and the larvae, after initial feeding on the leaves, move to the fruit and bore inside. In 1980, AVRDC confirmed the TFW resistance in two *Lycopersicon hirsutum* f *glabratum* accessions. AVRDC crossed this accession with high yielding breeding lines carrying desirable horticultural characteristics. During subsequent seasons, AVRDC evaluated the progeny for the TFW resistance and made three backcrosses to the recurrent parent. In late 1988, the BC_3F_6 population was screened for fruitworm resistance; fruit yields and fruit size were also evaluated.

Materials and Methods

Eleven families were selected from BC_3F_5 population based on the high fruitworm resistance and big fruit size. These lines were tested against the susceptible parent CL1591-5-0-1-2-0 and two high yielding but TFW susceptible checks. One-month-old seedlings of each entry were planted in 5 × 3 m plot in two 5-m long rows set 1.5 m apart. Entries were arranged in a randomized complete block design with three replications. Starting at flowering stage of the earliest flowering entry, and at intervals thereafter, a large number of laboratory reared TFWs were released to increase TFW population and allow infestation of the fruits. The crop was grown following the standard cultural practices such as fertilizer application, weeding, fungicide spray for disease control, and irrigation when needed. Starting three months after transplanting when the first batch of fruits were ready for harvest, damage or healthy fruits was recorded and the percent of fruit damaged was calculated. Fruits that were infested whether green as well as ripe were plucked and left in empty areas in the field with the purpose that the larvae feeding inside will pupate and this will increase the fruitworm population. The ripe fruits were harvested and marketable ones were weighed to record the yield. Several ripe fruits from each entry were weighed and the weight per fruit was calculated.

The TFW damage and the total marketable fruit yield data were analyzed by ANOVA and means were compared by DMRT.

Results and Discussion

Results of TFW damage to tomato, marketable yield, and fruit size are summarized in Table 1. Three breeding lines which have fairly high yields from 68 to 74 t/ha had the lowest fruit damage in each of the three observations. Their fruits are small, about half the size of susceptible high yielding checks. Five entries were selected as improved germplasm that can be distributed to national cooperators. There was no significant correlation between fruit size and TFW damage. The selected entries were genuinely less susceptible than the susceptible cultivars. Certain level of correlation was found in fruit size and yield. Since resistant materials have smaller fruits compared to the susceptible, these may not be readily acceptable by farmers. AVRDC is presently working on the improvement of fruit size of these lines using *L. pennellii* as the source of resistance.

Table 1. Fruitworm damage, marketable yield and fruit size of selected tomato breeding lines.[z]

Breeding line/cultivar	% fruits damaged			Marketable yield t/ha	Fruit size g/fruit
	24 Jan. 1989	16. Feb. 1989	9 March 1989		
CL5352BC3F3-(3-3)BC3F3-BC3F5-BC3F6	17.7 abc	2.0 b	2.3 d	67.9 bc	45.7
CL5352BC3F3-(3-3)BC3F4-14-BC3F5-BC3F6	14.9 abc	2.8 ab	3.5 cd	79.1 abc	37.9
CL5352BC3F3-(3-3)BC3F4-17-BC3F5-BC3F6	16.3 abc	3.6 ab	4.5 cd	70.6 abc	56.8
CL5352BC3F3-(3-3)BC3F4-26-BC3F5-BC3F6	6.2 c	2.2 b	2.6 d	71.1 abc	41.7
CL5352BC3F3-(3-4)BC3F4-54-BC3F5-BC3F6	8.5 abc	2.9 ab	2.6 d	68.5 bc	37.5
CL5352BC3F3-(3-4)BC3F4-74-BC3F5-BC3F6	10.3 abc	3.6 ab	2.0 d	74.0 abc	35.7
CL5352BC3F3-(3-4)BC3F4-90-BC3F5-BC3F6	18.2 abc	4.6 ab	2.5 d	63.6 bc	49.9
CL5352BC3F3-(3-4)BC3F4-94-BC3F5-BC3F6	30.9 a	3.5 ab	3.9 cd	61.3 c	45.1
CL5352BC3F3-(3-7)BC3F4-111-BC3F5-BC3F6	18.5 abc	3.3 ab	4.0 cd	70.6 abc	59.1
CL5352BC3F3-(8-3)BC3F4-255-BC3F5-BC3F6	10.4 abc	2.7 ab	5.9 bcd	32.7 d	45.0
CL5352BC3F3-(21-2)BC3F4-707-BC3F5-BC3F6	10.3 abc	11.9 a	2.1 d	60.2 c	23.5
CL1591-5-0-1-2-0	18.9 abc	6.2 ab	7.3 abc	80.9 ab	80.4
TK70	30.6 ab	9.0 ab	10.2 a	67.5 bc	100.8
PT4121	17.2 abc	6.5 ab	9.6 ab	87.7 a	100.1

[z]Planting date: 18 October 1988. Sampling (harvest) dates: 24 Jan, 16 Feb., and 9 March 1989. Data are means of three replicates. Means in columns followed by the same letter are not significantly different by DMRT at 5% probability level.
Entry numbers 3, 4, 5, 6, and 9 are selected for testing and distribution to national programs.

Tomato Pathology

Control of *Pseudomonas solanacearum* by Soil Amendment

Summary

L-390, a highly susceptible check had 50% survival rate in untreated soil and 100% in amended soil at 35 days after transplanting in pots in the greenhouse. Population of bacteria was reduced to less than 10% of the initial population in amended plots under field conditions. Plant survival increased with soil amendment.

Introduction

There are published reports of how S-H mixture, a soil amendment, controls some soil-borne diseases. The amendment has seven constituents, of which two were found necessary for the control of bacterial wilt in tomato under greenhouse studies (Hsu and Chang 1989)[1]. These two ingredients are mineral ash (slag product of steel production) and urea.

In addition to certain amendments, soil moisture affects the population of bacteria. *Pseudomonas solanacearum* survived longer under soil moisture conditions close to 100% field capacity (Akiew 1985)[2]. This study aimed to determine the effects of soil amendment on the population of *P. solanacearum* and evaluate if amendment can increase the survival period of tomato.

Materials and Methods

Laboratory Test. A soil sample was obtained from the bacterial wilt nursery on 14 July 1989. The soil was mixed thoroughly and populations were detected on a modified SM-1 selective medium by dilution plating (Tsai et al. 1985)[3]. Soil moisture was recorded.

A soil amendment consisting of mineral ash from the China Steel Company in Kaohsiung and urea from AVRDC was mixed at a ratio of 98.3:1.7% mineral ash to urea. The mixture was added to the soil on a weight to weight basis at 0.2, 0.6 and 1.0% for a total weight of 500 g. Each of the 500 g soil mixtures was placed in 1 L beakers and sealed with a plastic bag.

During a 40-day period, four samples each of 10 g were removed from the beakers and mixed with 90 ml water then serially diluted (10^{-1}, 10^{-2}, 10^{-3} and 10^{-4}) before a 0.1 ml suspension was removed, plated and smeared on modified SM-1. These plates were incubated at 32°C for 48 h. Colonies from plates (with 20 to 200 colonies) were counted. The populations were calculated based on the dry weight of 1 g of soil. These numbers were converted to the $\log_{10}$ before analysis.

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[1] Hsu, S. T. and M. L. Chang. 1989. Effect of soil amendments on survival of *Pseudomonas solanacearum*. Plant Prot. Bull. 31:21-33.

[2] Akiew, E. B. 1985. Influence of soil moisture and temperature on the persistence of *Pseudomonas solanacearum*. pp. 77-79. In Bacterial Wilt Diseases in Asia and the South Pacific. G. J. Persley, ed. ACIAR Proceedings No. 13, 145 p.

[3] Tsai, J. W., S. T. Hsu, and L. C. Chen. 1985. Bacteriocin-producing strains of *Pseudomonas solanacearum* and their effect on development of bacterial wilt of tomato. Plant Prot. Bull. 27:267-278.

Greenhouse test. Samples of field soil were collected from the bacterial wilt disease nursery and thoroughly mixed. The initial populations of bacteria and soil moisture were determined as described in the laboratory experiment.

After sampling, the soil was divided into two. Total weight of each subsample was taken and a 1% amendment consisting of mineral ash and urea (98:2%) was added to one of the subsamples. This was mixed and then both subsamples were subdivided into 30, 3-kg portions and placed in plastic bags for seven days.

The populations and soil moisture were checked at seven days. The soil was then transferred to 17.5-cm diameter clay pots, 13.5 cm in height. Tomato, L-390 (HS), CL-143-0-10-3-0-1-10 (MR = CL-143-) and L-285 (HR) at five to seven leaf stage were transplanted into the pots. One plant of each line was planted to a pot, so there were ten each with and without soil amendment. The experimental design was completely randomized. Plant mortalities were recorded every seven days.

Field test. On 17 May, L-390 was seeded and inoculated on 23 June and 5 July. The beds were worked and reformed on 13 July. Twenty-four experimental units, 1 × 4 m raised bed, were divided into four replications in a randomized complete block design. Each block was split and main plots were either not treated or treated with soil amendment of 10.8 kg/bed at the rate of 18 t/ha. The soil was tilled immediately after application to mix the amendment to an approximate depth of 20 cm. Tomato transplants L-390, L-285 and CL-143 were used in subplots and randomly planted in beds at a density of 10 plants/bed on 19 July.

Within each plot, three soil samples were removed with a 2.2-cm diameter probe to a depth of 20 cm and pooled to make one sample. The first sampling was done 21 June. Sampling interval was seven days in two months. Populations of bacteria and soil moisture were determined in each plot.

Plants were scored twice per week for wilt symptoms. Wilted plants were removed from the field and basal sections of the plants were washed, cut and placed in a plastic bag. One ml of sterile water was added and the stems were macerated until sufficient sap was obtained. A loop of the sap suspension was removed, streaked directly on modified SM-1 medium and incubated for 48 h to identify the presence of *P. solanacearum*.

Data from bacterial populations were transformed to $\log_{10}$. Initial population before adding soil amendment was used to zero. Any decrease or increase in populations was based on a percentage of the initial population. Plant survival (%) was calculated on a per plot basis following this equation: [total number of infected plants/total plants] × 100.

Results and Discussion

Laboratory test. The initial population before adding soil amendment was 2.5×10^5 cfu/g of dry soil. The population gradually declined throughout the experiment in all treatments (Fig. 1). The population decreased most in 1% amended soil and remained less in seven days after treatment than in all other treatments. The LD_{50} (lethal dose for 50% of the population) for 1% amended soil occurred before 21 days, whereas other treatments did not reach the LD_{50} after 40 days. The population decline (0.2 and 0.6%) in amended soil was greater than in nonamended soil. The population after 40 days in 1% amended soil was less than 100 times that of any other treatment.

Greenhouse test. The initial population of bacteria was 3×10^4 cfu/g of dry soil. The population declined in the check to 7×10^3 and in 1% amended soil to 4×10^2 cfu/g of dry soil after one week. Plants of L-390, L-285 and CL-143 transplanted into the amended soil survived longer than in nonamended soil (Table 1). Survival for L-390 was 50% in nonamended soil and 100% in amended soil at 35 days after transplanting. There was 80% survival in amended soil and none in nonamended soil at 54 days.

Field test. Soil population of bacteria was 1×10^6 cfu/g of dry soil at the onset of the experiment (Fig. 2). The population fluctuated by weeks and after 21 days declined to 2.4×10^4 cfu/g of dry soil. After adding the amendment, the population declined rapidly in amended plots over time and after 63 days the population was reduced to one tenth of that in the nonamended plots. The distribution of the population in the field plots was initially at random, but after amendment

Table 1. Occurrence of bacterial wilt on three tomato lines grown in soil wilt amendment compared to untreated plots.

Line	Treatment[z]	Survival (%)[y]		
		8/25	9/15	10/3
L-390	+	100	100	80
L-390	–	90	50	0
CL-143-	+	100	100	100
CL-143-	–	100	100	90
L-285	+	100	100	100
L-285	–	100	100	100

[z]+ = With 1% soil amendment, = no soil amendment. [y]Numbers are based on 10 plants (replication) for each line.

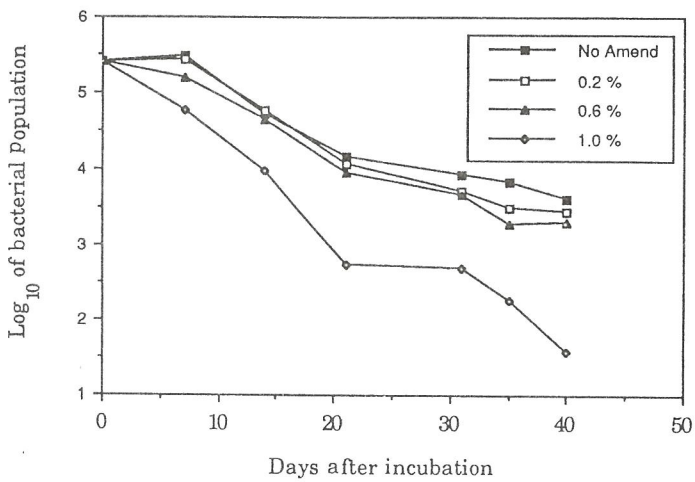

Fig. 1.
Log_{10} colony-forming units (cfu) per gram of dry soil of *Pseudomonas solanacearum* zero to 40 days in nontreated, or with 0.2, 0.6 or 1% amendment added to the soil.

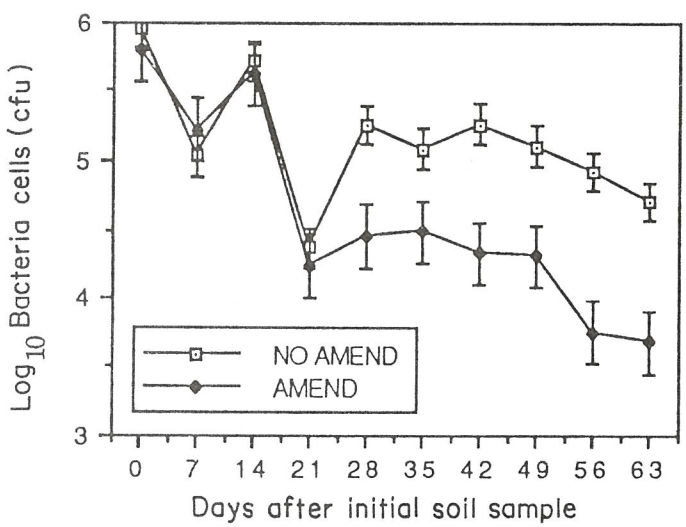

Fig. 2.
Log_{10} populations of *Pseudomonas solanacearum* in field plots with and without amendment added 23 days after the onset of the experiment.

application the population distribution was regular and followed the layout of the plots (Fig. 3). Comparing the populations within lines, untreated plots always had fewer bacteria, except at 14 days after application when the population in plots planted to CL-143 was higher in amended plots (Fig. 4). The population in untreated plots tended to decrease more in L-285 compared to the other lines.

Plant survival was greater in amended soil. For L-390, the susceptible line, survival was less than 50% for plants in nonamended soil and 83% for plants in amended soil at 34 days after transplanting (Fig. 5). After 47 days, survival in nonamended soil was 20% compared to 65% in amended soil. Throughout the season, CL-143 had an average of 5% more plants in soil-amended than in nonamended plots; at 64 days after transplanting 94% of the plants survived in amended and 85% in nonamended plots. L-285 had the highest percentage survival. At 64 days after transplanting, 95% of the plants survived in amended plots versus 88% in nonamended plots.

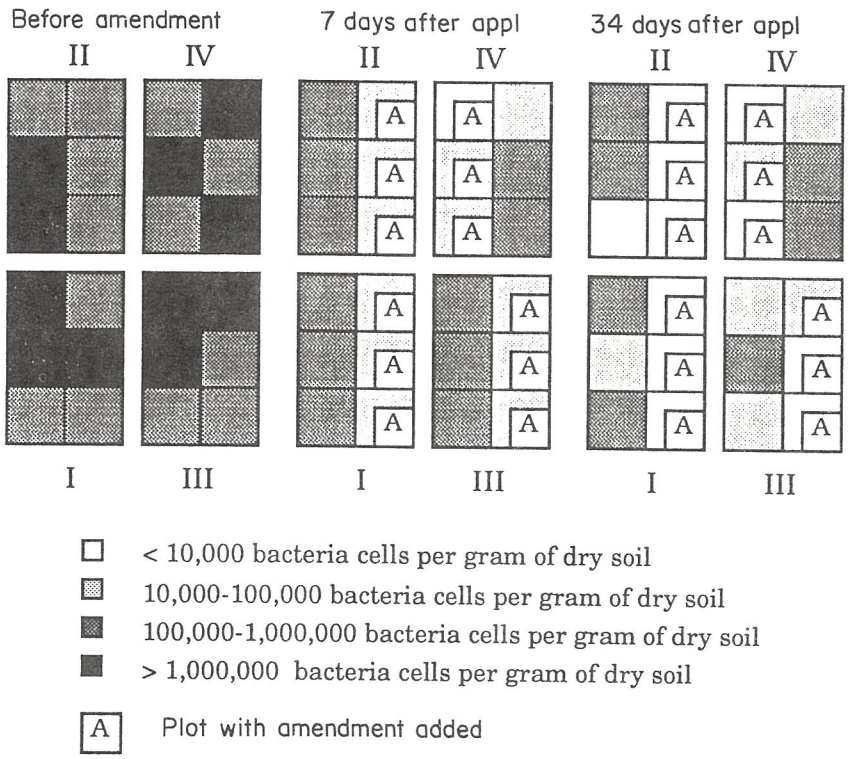

Fig. 3. Distribution of *Pseudomonas solanacearum* in the field plots with and without soil amendment

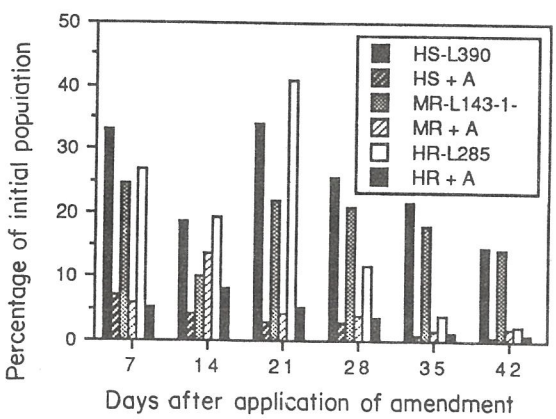

Fig. 4. Percentage of the initial population of *Pseudomonas solanacearum* in plots with and without amendment in three tomato lines.

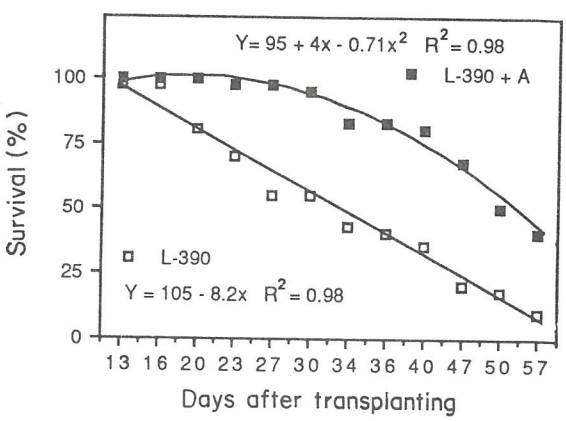

Fig. 5. Survival of L-390 in plots with and without soil amendment (A) 57 days after transplanting.

The mechanism that caused the reduction of bacterial populations with the use of soil amendment is not known. However, because of the beneficial effect of the soil amendment on plant survival, more research is needed to verify this phenomenon over seasons and environments.

Effects of *Pseudomonas solanacearum* on Inoculated Seeds

Summary

Seed germination of L-285 (HR), CL-143 (MR), or L390 (HS) was not affected by inoculum concentration of *Pseudomonas solanacearum*. Increased inoculum reduced the root and stem lengths, number of upright stems and normal seedling growth. Seeds of L-390 to CL-143 soaked in inoculum had less clear-cut differences but seeds placed on top of cheesecloth with inoculum had greater differences. Total length of seedling was one of the variables measured that had consistent differences among the three lines tested.

Introduction

There have been few reports on quick and easy screening techniques for evaluating resistance to bacterial wilt in tomato. When many lines need to be screened, fast and reliable techniques are necessary to advance breeding lines resistant to bacterial wilt.

AVRDC and other research centers working on tomato improvement for the tropics have screened for bacterial wilt resistance using inoculation methods like clipping plants with infected blades or by infiltrating stems. The clip method is faster and easier but inconsistent for differentiating resistant lines. Infiltration of stems was useful but time-consuming. In 1986, AVRDC developed a disease nursery in the field that met the advancement and selection of resistant lines. Other than inoculating the wilt nursery and screening for resistance, there has been no research conducted on *Pseudomonas solanacearum* since 1985.

Because bacterial wilt is still a limiting factor in tomato production throughout and beyond the Southeast Asian region and also because resistant lines developed in site-specific locations are not always universally resistant, it is imperative that AVRDC continue research on evaluating resistance to understand the host, pathogen and environmental interactions. This study aimed to develop a quick *in vitro* inoculation technique to evaluate resistance and provide ways to study basic root-pathogen interactions.

Materials and Methods

Seed soak. Ten tomato seeds of each line [L-285 (HR), CL-143-0-10-3-0-1-10 = CL-143-(MR) and L-390 (HS)] with four replications were soaked in 10 ml of a suspension of bacteria (isolate TBW-87) for 30 min at concentrations of 10^3, 10^4, 10^5, 10^6 and 10^7 cfu/ml, along with a soak using sterile water.

After soaking, the seeds were removed and placed on five layers of moist cheesecloth (3 ml sterile water) inside of 125 ml beakers. The beakers were covered with a lid from a petri dish and then completely randomized on the laboratory bench (25-34°C) under indirect light. Observations were made daily and data were recorded in eight days. Quantitative data on germination, length of hypocotyl, erectness of stem, cotyledon expansion, length of rootlet, appearance and dry weight of seedlings were recorded.

Cheesecloth soak. This experiment is identical to seed soaking, except that 3 ml of bacterial suspension was added to the cheesecloth in beakers and the seeds were not soaked. Bacterial concentrations at 67.5, 125, 250, 500, and 1000 cfu/ml were added to the cheesecloth inside beakers. Ten seeds of the three lines were placed on top of the cheesecloth, covered with plastic and incubated at 28°C under 12-12 light-dark conditions. Data on germination, length of root and stem, erectness of stem, and wet weight of the seedlings after seven days were recorded.

Results and Discussion

Seed soak. Seed germination was not affected by inoculum concentration. There was a reduction in root and shoot length, stem erectness and appearance of root hairs compared to noninoculated seed (Table 2). In general as the concentration of inoculum increased, the growth parameters of the seedlings decreased. None of the variables measured clearly showed the differences between MR and HS as more often CL143 had closer values to L-390 than L-285.

Cheesecloth soak. There were no differences in seed germination related to inoculum concentration for any of the three lines. As bacterial concentrations increased, the length of root, stem and total length all decreased, but the rate of decrease was different. A clear difference over concentration was observed on the total length of seedling (shoot + root length) (Fig 6). When

Table 2. Effects of soaking seeds in three concentrations of *Pseudomonas solanacearum* on seedling growth, stem erectness and total seedling length of tomato.[z]

	Seedling growth (%)		
Concentration[y]	L-285	CL-143-	L-390
10^4	80	23	0
10^5	77	23	7
10^6	7	0	0
	Stem erectness (%)		
Concentration	L-285	CL-143-	L-390
10^4	63	23	27
10^5	40	20	3
10^6	7	0	0
	Seedling length (% of control)		
Concentration	L-285	CL-143-	L-390
10^4	80	87	87
10^5	80	52	53
10^6	43	36	27

[z]Each number is the mean of 10 seedlings for each of three replications. [y]Colony forming units of bacteria per ml.

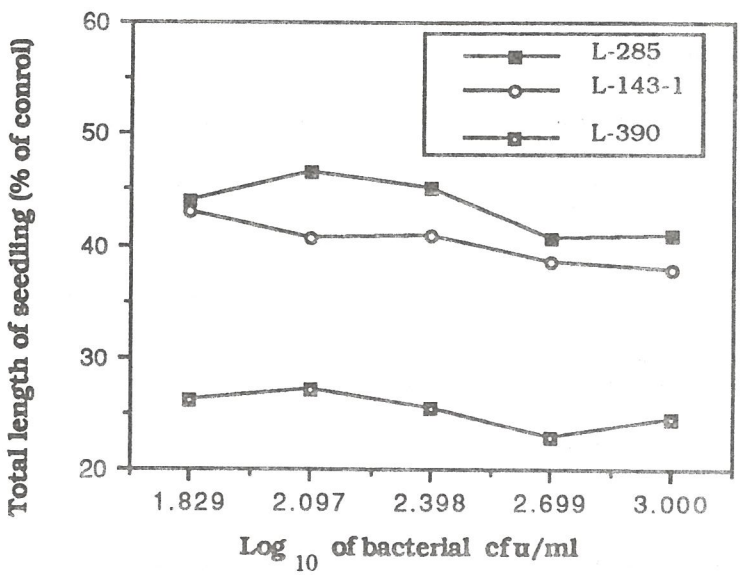

Fig. 6. Percentage of total length of noninoculated plants of seedlings from three lines of tomato inoculated with *Pseudomonas solanacearum* over a range of concentrations.

taken as a percentage of the control, L-285 was greater by 40% of the total length, while CL-143-1 was less by 40% at higher concentrations and L-285 was always below 30% of the control regardless of concentration.

Factors such as light, temperature, and seed soaking time influenced the results. More studies are planned to determine what measurements need assessment to make this technique more effective. To do this, more lines will be tested to correlate results from the laboratory and field. Ideally this technique should utilize an easy-to-measure quantitative variable so that many seeds of test lines can be assessed. This screening technique can be completed in seven days, and can easily test different strains. Basic studies on the infection process and the mechanism(s) of resistance can be investigated using this technique.

Evaluation of Black Leaf Mold on Selected Accessions

Summary

Tomato accessions, L 1352 and L 1558, had consistently and comparatively low levels of black leaf mold infection compared to 37 other highly resistant accessions reported previously. The fungus failed to sporulate on L 1558 in one of the trials.

Introduction

Black leaf mold, caused by *Pseudocercospora fuligena*, is an important disease of tomato grown in warm, humid conditions in some locations. The pathogen infects leaves at any growth stage and causes leaf dryness and withering. Fungicides sprayed throughout the season provide some control of the disease. In 1986, 5,318 accessions were screened for resistance. Thirty-nine accessions were reported highly resistant and 4,446 susceptible. Ten of these 39 accessions were used as parents in the AVRDC breeding program to incorporate resistance to this disease.

This study reconfirmed the resistance levels in 39 accessions formerly reported as highly resistant and to specifically evaluate those accessions that were used in the breeding program for resistance to black leaf mold.

Materials and Methods

Confirmation of resistant lines. Nineteen-day old seedlings of the 38 (out of 39) reportedly resistant accessions and 43 susceptible accessions were evaluated initially. Plants were inoculated by atomization with a conidial suspension (1×10^3) using a backpack sprayer on 10 August 1989. The conidia were collected from 10-day-old colonies grown on PDA at 28°C under a 12/12 hour light/dark regime. After inoculation, six seedlings from each accession were kept at random inside a growth room set at 28°C and 90 + 10% relative humidity. The foliage was kept moist with a sprinkler irrigation system. The rest of the seedlings (20 to 40/accession) were placed in plastic chambers located outside the greenhouse. The relative humidity in these chambers (55-98%) was kept higher than the outside humidity by flooding water below the flats. The temperature fluctuated between 23 and 37°C.

Each plant in the growth room was evaluated 15 days after inoculation by recording the percent of foliage infected (1 to 100%) and rating the degree of sporulation on a 1 to 3 scale where 1 = no visible sporulation, 2 = light sporulation and 3 = heavy sporulation. The plants in the chambers outside were evaluated 7, 14 and 21 days after inoculation. The percent of foliage infected on each accession was recorded as a group.

Reconfirmation of resistance. Seeds of the 39 accessions and two susceptible lines were planted on 6 July. These were inoculated on 28 July with a conidial suspension obtained from washing infected leaves with water. Seedlings were inoculated as previously described and placed inside the growth room and evaluated 16 days after inoculation by recording the percent of foliage infected per plant. Sporulation was also recorded.

Evaluation of selected accessions for breeding. Seeds of 10 accessions and two known susceptible breeding lines were planted on 19 July. These were inoculated on 10 August with inoculum collected from infected leaves in the field. Plants were incubated in the growth room. Disease evaluation was made on 25 August and rated as previously described. This experiment was repeated, however, the plants were incubated in plastic chambers outside the greenhouse.

Results and Discussion

Confirmation of resistance. The average severity of black leaf mold was 71% (Table 3). There were five accessions with <2 standard deviation (SD) from the mean and 6 with 2 SD from the mean. The average sporulation was 2.7. All accessions that had values of <1 SD below the mean had corresponding sporulation ratings below the mean. Accession 1558 had no sporulation. Disease severity in the plastic chambers ranged from 20 to 90% with an average of 67%. Fifteen lines had severity ratings of <1 SD below the mean.

Table 3. Disease severity and relative ranking of tomato accessions inoculated with *Pseudocercospora fuligena*.

Acc. no.	*Lycopersicon*[u] spp.	Trial 1[z]		Trial 2[y]		Trial 3[x]		Trial 4[w]	Trial 5[w]
		Sev. (%)	RR[v]	Sev. (%)	RR	Sev. (%)	RR	Sev. (%)	Sev. (%)
733	Lh	27	4	50	9	1	1	–	–
1065	Lh	38	6	90	69	9	3	–	–
1352	Le	24	1	20	1	14	5	–	–
1558	Le	25	2	30	2	6	2	–	–
1688	Lp	56	14	30	3	80	37	–	–
1731*	Le	55	13	90	74	52	28	46	93
1777*	Le	26	3	90	70	24	9	–	–
2851*	Le	77	39	80	57	45	16	50	78
2926*	Le	43	9	90	77	65	29	66	88
3050*	Le	37	5	30	5	41	12	53	89
4089*	Le	77	41	80	64	60	24	58	91
4569*	Le	85	69	70	47	39	11	78	89
4765*	Le	90	81	70	48	75	34	69	83
4815*	Le	87	75	50	15	68	31	68	89
4930*	Le	76	37	80	69	43	15	67	97
5184*	Le	78	48	70	50	61	26	68	92
Mean		71		67		49		63	89
S.D.		16		17		24		9	5
n[t]	81	81		12		12			

[z]Mean severity values from 6 plants (reps) and 80 accessions that were incubated under controlled conditions. [y]Same entries as in trial one. Severity values from 20-40 plants per accession (no replication) kept in plastic chambers outside the greenhouse. [x]Trial 3 had 39 reported resistant accessions and two susceptible lines. Severity values are means of three replications from plants incubated under controlled conditions. [w]Trial 4 and 5 are the accessions selected for the breeding program; means include two breeding lines CL 5915-1 and CLN 95-28 with severity ratings of 69 and 61% in Trial 4, and 92 and 88 in Trial 5, respectively. [v]Relative ranking (RR) of accession in that trial. [u]Le = *L. esculentum*; Lh = *L. hirsutum*; Lp = *L. pimpinellifolium* [t]Number of entries per trial. *Accessions selected for the breeding program.

Reconfirmation of resistance. Trial 3 had the lowest mean severity rating of all the trials (49%). The relative ranking (RR) of accessions 733, 1065, 1352 and 1558 were similar to those in Trial 1. None of the accessions selected as breeding lines had severity values <1 SD below the mean and most had values above the mean.

Evaluation of selected accessions for breeding. Mean severities for Trials 4 and 5 were 63 and 89%, respectively. All accessions had high severity values which corresponded to the higher values from the previous three trials. In these tests, there were no accessions selected for resistant breeding purposes that had consistently low severity values, although 3050 had a better relative ranking than the other nine accessions used in breeding for resistance.

In 1987, an experiment used mycelium (1 plate/liter) for inoculation which resulted in lower infection as shown by the scale used (HR = <5% to MS = 15-30%). In these tests the average severity was >49%. The 39 lines reported resistant (< 5% infected tissue) had average severity ratings in these tests of 67 and 49% in two different trials. Some of the differences in the results from the 1986 report and this report could be due to fungal isolates, mycelial versus conidial inoculation and variations in environmental conditions. These experiments show that screening for resistance must be done under defined environmental conditions because disease assessed under less than optimum conditions oftentimes leads to erroneous results.

Because the severity values and relative ranking of accessions changed between trials, those lines that had values <1 SD from the mean will be tested again and quantitative measurements will be taken on the sporulation level.

Evaluation for Resistance to *Sclerotium rolfsii*

Summary

Most accessions and breeding lines of tomato had very low percentage of plants survival inoculation with *Sclerotium rolfsii*. In general, accession of *L. peruvianum* had more surviving plants (20%) than other *Lycopersicon* spp.

Introduction

There are no reports of *Lycopersicon* spp. resistance to *Sclerotium rolfsii*. Sclerotium blight is serious especially under hot and wet weather, causing plant mortality at any growth stage. The pathogen is ubiquitous and attacks most dicotyledonous plants. The fungus is difficult to control. So far, fumigating the soil is the most effective control method but it is costly and oftentimes not applicable. This experiment evaluated *Lycopersicon* spp. for resistance to *Sclerotium rolfsii*.

Materials and Methods

The fungus was isolated on PDA from infected tomato at AVRDC in April 1989. The inoculum was increased on sterilized rice grains. After 21 growing days, three infected kernels were removed and placed adjacent to the base of 21-day-old plants beneath the soil.

Forty-eight seedlings of 50 accessions planted in 6-cm plastic pots were inoculated and incubated inside a screenhouse. For Trial 2, accessions that had higher percentage survival were retested and 10 breeding lines and two accessions of *L. piperotum* were added. Seeds were sown in plastic pots with 12 plants per entry and four replications. After inoculation, plants were kept under high relative humidity (>80%) and at 28°C. Data were recorded seven days after inoculation converted to percentage survival.

Results and Discussion

The range of survival was from 0 to 50% in the first test (Table 4). Five of the top seven accessions belong to *L. peruvianum*. *L. glandulosum* had the highest survival rate of 21% in Trial 2.

Although survival of each accession in each trial was different, there seems to be a trend for some of the accessions to be less susceptible. The lines that had the highest survival rate will be further evaluated.

Table 4. Evaluation of tomato accessions and breeding lines for resistance to *Sclerotium rolfsii*.

Accession/ Breeding Line	*Lycopersicon* spp.	Trial 1[z] Survival (%)	Trial 2[y] RR[x]	Survival (%)	RR
887	*L. peruvianum*	50	1	15	6
672	*L. peruvianum*	33	2	15	5
1033	*L. glandulosum*	32	3	21	1
888	*L. peruvianum*	30	4	4	23
669	*L. peruvianum*	27	5	6	17
735	*L. peruvianum*	25	6	20	2
734	*L. peruvianum*	25	7	9	14
139	*L. pimpinellifolium*	–5[w]	–	17	4
140	*L. pimpinellifolium*	–	–	19	3
BL 433	*L. esculentum*	–	–	15	7
Average		13		9	
S.D.		10		6	
n[v]		50		27	

[z]Means are from 48 plants/accession with no replications. [y]Means are from 12 plants/accession for each of 4 replications. [x]Relative ranking (RR) of accession based on survival. [w]Not tested. [v]Numbers of lines tested in each trial.

Survey on Viruses in the Philippines

Summary

In 1983, a virus survey was conducted in the Philippines, in which tomato samples were tested for five viruses. To gain information on other viruses, 60 tomato samples were collected in 1988 from three locations and tested for the presence of 10 viruses. Seventy-eight percent of the samples were found virus-infected; 72% of the samples contained cucumber mosaic virus (CMV), followed by tomato mosaic virus (ToMV), 58%; alfalfa mosaic virus (AMV), 35%; tomato spotted wilt virus (TSWV), 33%; potato virus Y (PVY), 17% and potato virus (PVX), 3%. Other viruses were not detected. A high incidence of tomato mosaic virus (ToMV) and CMV on tomato was also found in surveys in other Southeast Asian countries.

Introduction

In 1983, a survey on tomato viruses was conducted in the Philippines. The samples were tested only for the presence of ToMV, PVY, CMV, PVX and tobacco leaf curl virus (TLCV). In the spring of 1989, while conducting a survey on pepper viruses in this country, samples were also taken from tomato to gain additional information on important viruses on this crop.

Materials and Methods

Sixty samples were collected from three locations in Luzon island. The samples were dehydrated over $CaCl_2$ before testing at AVRDC. A DAS ELISA test was performed using antisera to TSWV, PVX, PVY, tobacco etch virus (TEV), AMV, ToMV, CMV, (PMMV), tobacco veinbanding virus and pepper veinal mottle virus (PVMV).

Results

Forty-seven (78%) of the 60 samples were found to be virus-infected; 72% of the samples contained CMV. ToMV was the second most frequent virus (58%), followed by AMV (35%), tobacco veinbanding virus (32%), TSWV (33%), PVY (17%) and PVX (3%). Other viruses were not detected.

New Natural Host of Tobacco Vein Banding Mosaic Virus

Summary

Electron microscope and serological tests were conducted to characterize several potyvirus isolates previously recovered from tomato. Ultrathin sectioning of infected cells revealed virus particles in tightly packed aggregates associated with cylindrical inclusions of the pinwheel, scroll and laminated aggregate type. Immunosorbent electron microscopy using antisera to 32 potyviruses revealed close relationships of the isolates only with groundnut eyespot virus.

In DAS ELISA tests, antiserum to the unknown tomato isolates was found to react positively with tobacco veinbanding mosaic virus recently obtained from the Taiwan Tobacco Research Institute. However, the physical properties (TIP, LIV and DEP) of the tomato virus differed from those of tobacco vein banding virus. The mild symptoms on tomato and the types of cytoplasmic inclusion bodies are also almost identical to tobacco veinal mottle virus (TVMV) reported only on tobacco in the United States.

Introduction

In previous tomato virus surveys, several potyvirus isolates recovered could not be exactly characterized. They did not react with PVY and TEV, the two most common potyviruses on tomato elsewhere. The host range of the isolates was found to be confined in the Solanaceae, but excluding *Capsicum* spp. None of the virus isolates was seed-transmitted. Yield was reduced when infection occurred up to 36 days after sowing. These isolates were suspected to be a new virus. More electron microscope and serological investigations were conducted to further characterize the virus.

Materials and Methods

Systemically infected leaves of *N. tabacum* White Burley were embedded in EPON and examined in a Zeiss EM 10C electron microscope.

Serology ISEM tests were performed. Titers of reactions (= reciprocal dilution end point of decoration reaction) were determined using two dilution series of antisera.

DAS ELISA tests were conducted using antisera of potyviruses (chili veinal mottle virus (CVMV), pepper veinal mottle virus (PVMV), pepper mottle virus (PeMV), Peru tomato virus (PTV) and TVMV) known to infect solanaceous crops. All antisera were produced at AVRDC.

Results and Discussion

Electron microscopy Ultrathin sections of infected cells often contained virus particles in tightly packed aggregates where the particle ends formed one plane or monolayers often associated with tonoplast membranes. The particles were perpendicular to the membrane (Fig. 1a) and were also associated with conspicuous cylindrical inclusions with their long axis predominantly parallel to the pinwheel axes. The pinwheel plates (Fig. 1b) formed scrolls and laminated aggregates (Fig. 1a) and structures resembling short curved laminated aggregates.

In serology tests using 39 antisera to 32 potyviruses, the isolates were found related with only seven potyviruses, i.e. groundnut eyespot (GESV), eggplant severe mottle (ESMV), eggplant green mosaic (EGMV), telfairia mosaic (TeMV), yam mosaic (YMV), zucchini yellow mosaic (ZYMV) and a soybean isolate of peanut stripe virus (PStV). However, decoration titers of isolate T 697 with these seven antisera indicated a relatively close relationship only with GESV antiserum, having a titer of 1:1600. The homologous antiserum to isolate T 697 had a homologous titer of 1:3200. The titers obtained with the other antisera were 1:400 for TeMV, 1:100 for ZYMV (Italy isolate) and YMV, and 1:50 for PStV soybean isolate and EGMV. Since the GESV antigen could not be obtained, its exact serological relationship with T 697 could not be clearly determined.

No serological reaction was detected by ISEM tests with antisera to these 22 viruses: amaranthus leaf mottle, bean common mosaic (BCMV), bean yellow mosaic (BYMV), beet mosaic, celery mosaic,

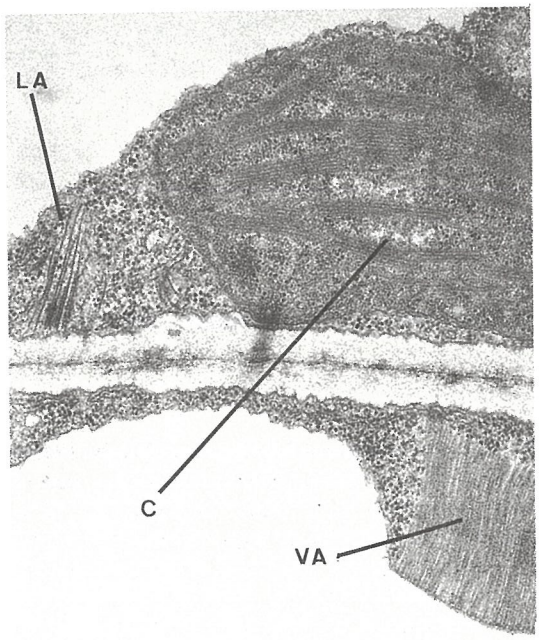

Fig. 6a. Ultrathin section of tomato leaf tissue infected with isolate 697 (32.550X) (LA = laminated aggregates; VA = virus aggregates; C = chloroplast).

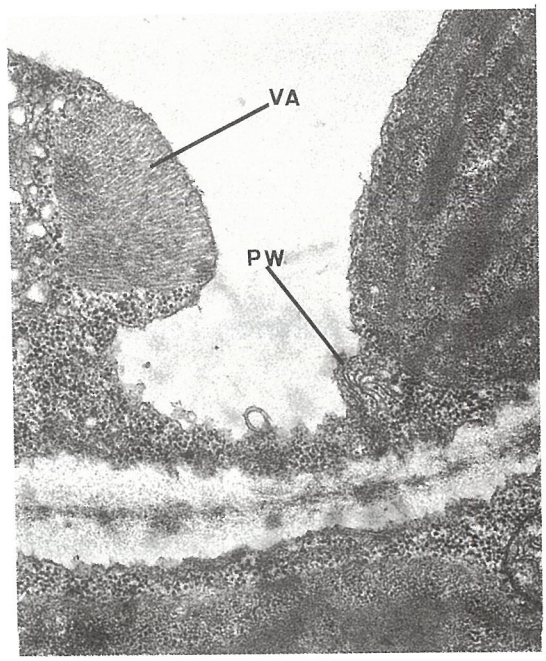

Fig. 6b. Ultrathin section of tomato leaf (32.500X) tissue infected with isolate T 697 (PW = pinwheel; VA = virus aggregates).

pea leaf roll mosaic, peanut mottle, pepper mild mosaic, PeMV, PVMV, PTV, potato virus A, PVY, soybean mosaic, sugarcane mosaic, sweet potato feathery mottle, TEV, turnip mosaic, watermelon mosaic-2, wild potato mosaic and ZYMV, Berlin isolate.

In DAS ELISA tests, isolates T 697, 1082, 1077 and 704 did not react with immunoglobulins of CVMV, PVMV, PeMV and PTV. However, a strong positive reaction (A405 > 2) was obtained with antiserum to an isolate of tobacco vein banding mosaic virus obtained from the Taiwan Tobacco Research Institute. The strong serological relationships with TVMV suggest that the isolates T 697, 1082, 1077 and 704 are identical with, or a strain of, TVMV which is widespread and destructive in Taiwan.

The tomato isolate, however, seems to differ slightly from TVMV in having a thermal inactivation point (TIP) of 55-60 compared to 60-65° for TVMV, a longevity *in vitro* (LIV) (25°C) of 15 days compared to 4-5 days for TVMV and a dilution end point (DEP) of 10^{-3}-10^{-4} compared to 10^{-4}-10^{-5} for TVMV. The mild symptoms in tomato, i.e. the presence of pinwheel inclusions, scrolls and laminated aggregates, which characterizes the Taiwan tomato isolate T 697 was also similar to tobacco veinal mottle virus. The relationships of TVMV with the Taiwan tobacco vein banding mosaic virus need further investigation.

Tomato Physiology

Effects of Solution Temperature on Hydroponically Grown Tomato

Summary

FMTT-3 plants were grown hydroponically for 60 days under three solution temperatures. Plants grown under 18°C solution temperature had the highest total dry matter content and dry matter accumulation in the fruit. More but smaller fruits were formed at 18°C. The root system at 32°C solution temperature had the least membrane thermostability (as determined by electrolytes leakage) and oxidizing activity (as determined by the oxidation of alpha-naphthylamine) at later growth stage. High membrane thermostability and oxidizing activity may facilitate water and nutrient uptake. In this connection, the root system immersed in solution had higher membrane thermostability and oxidizing activity than the root system exposed in the air. The solution may serve as buffer against extreme temperature fluctuations. Furthermore, the peduncle of the 18°C solution had higher phosphorus and potassium in the later growth stage. High phosphorus and potassium in the peduncle may be conducive to the dry matter partition of the fruit.

Introduction

During flooding, soil oxygen is depleted. Consequently, growth of most flood-sensitive vegetables is seriously affected. Damage of flooding on the plant is usually aggravated by high soil temperature due to decreased oxygen solubility and increased oxygen demand for root respiration. In this connection, culture of certain vegetables in hydroponic systems poses problems under hot summer conditions. Plants depend on gross structural and metabolic adaptations to flooding. This experiment investigated the effect of solution temperature on the root system and growth of tomato plant.

Materials and Methods

Seeds of FMTT-3 were sown on 10 March 1989 in small plastic pots (ID 6.5 cm and height 7.5) containing smoldered rice hulls. Pots planted with one seedling each were placed in polystyrene container (25 cm × 54 cm × 34 cm) using AVRDC's nutrient solution. Nutrient solution was kept at 1 cm above the bottom of plastic pots at the time pots were placed in the container. The level of nutrient solution was lowered down to about 10 cm from bottom of the pots. Thereupon, the level of nutrient solution was kept at 9-11 cm from bottom of the pots by replenishing the nutrient solution regularly.

The containers were grouped into three to maintain nutrient solutions at 18°, 25° and 32°C by thermostated water heaters. Nine plants for each temperature treatment were sampled 20, 40, and 60 days after transplanting.

Samples were measured for: 1) fresh and dry weights of different plant parts, 2) fresh and dry weights of root systems exposed to air and immersed in solution, 3) root cellular thermopermeability of aerially-exposed and immersed parts of the root system through electrolyte leakage at 25° and 100°C, 4) root oxidizing activity of aerially-exposed and immersed parts of the root system by alpha-naphthylamine method, and 5) total NPK content in leaf, petiole, stem and peduncle. Dissolved oxygen concentration, pH, and electrical conductivity of nutrient solutions were also monitored once a week. Due to greater water demand at later stage, electrical conductivities of solutions were substantially

increased, pH and dissolved oxygen decreased (Fig. 1). These may be related to turning brown of the root system 60 days after transplanting.

Results and Discussion

Nutrient solution temperatures seemed to affect the total production and distribution of dry matter to the fruit. The lower the nutrient solution temperature, the higher was the total dry matter produced and more dry matter was distributed to the shoot and fruit (Fig. 2). Increased dry matter in the fruit was due to an increase in the number of fruits under low solution temperatures (Table 1). Fruit size was smaller under low solution temperatures because of competition for dry matter among fruits under low solution temperatures.

Conductivity of electrolytes leakage could be employed to evaluate the membrane thermostability of the root system after various temperature treatments. Results indicated that tissue membrane of both aerially-exposed solution-immersed roots under high solution temperature, especially at later stages, was less stable than that of under low solution temperature (Fig. 3). Furthermore, membrane of solution-immersed root system was more stable than the aerially-exposed root system.

The root system's oxidizing activities could be measured by oxidation of alpha-naphthylamine. Root system from low solution temperatures had higher oxidizing activities especially at later stage than that from high solution temperatures (Fig. 4). High oxidizing activity in the root system may indicate efficient water and nutrient uptake. Furthermore, the oxidizing activity of the solution-immersed root system was higher than that of the root system exposed to air. It appeared that solution immersion provides protection to the root system against extreme temperatures.

Table 1. Reproductive characteristics of FMTT-3 grown under three nutrient-solution temperatures.

Days after initial temp treatment	°C	No. of flowers /plant	Fruit fresh wt. (g/plant)	No. of fruits /plant
20	18	28.7	28.9	5.9
	25	22.3	31.0	7.9
	32	27.9	24.8	7.5
40	18	48.9	48.4	16.8 a[z]
	25	53.3	61.3	16.8 a
	32	49.7	60.5	13.6 b
60	18	85.9	29.9	44.9 a
	25	78.1	34.3	33.7 b
	32	70.9	38.3	29.0 b

[z]Mean separation within the same day of sampling by DMRT at 5% probability level.

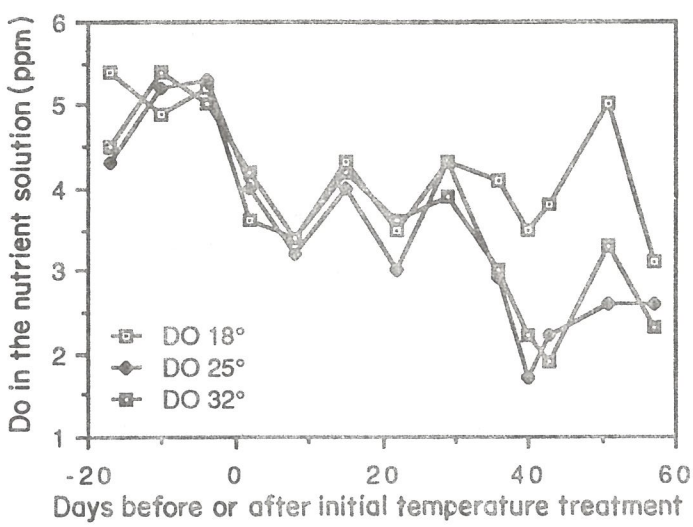

Fig. 1.
Changes of dissolved oxygen of nutrient solutions maintained in three nutrient-solution temperatures.

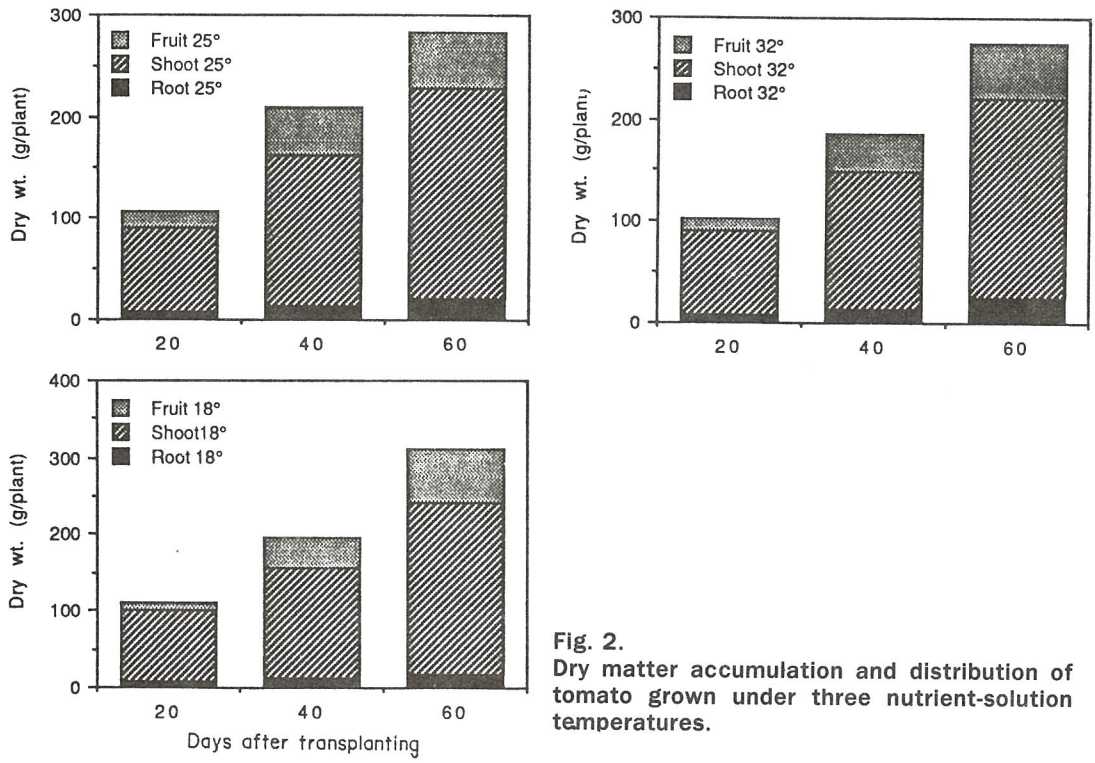

Fig. 2.
Dry matter accumulation and distribution of tomato grown under three nutrient-solution temperatures.

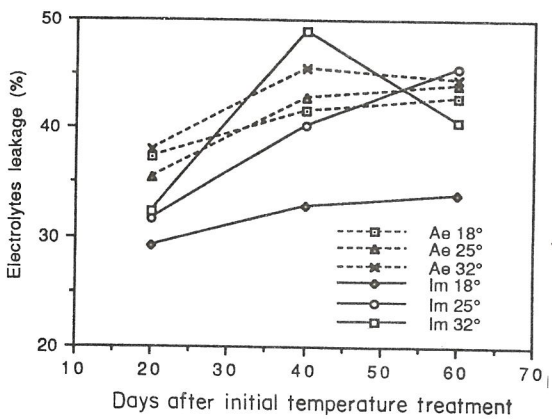

Fig. 3 Changes of oxidizing activities of the aerially-exposed (Ae) and solution-immersed (Im) root systems of tomato grown in three nutrient-solution temperatures.

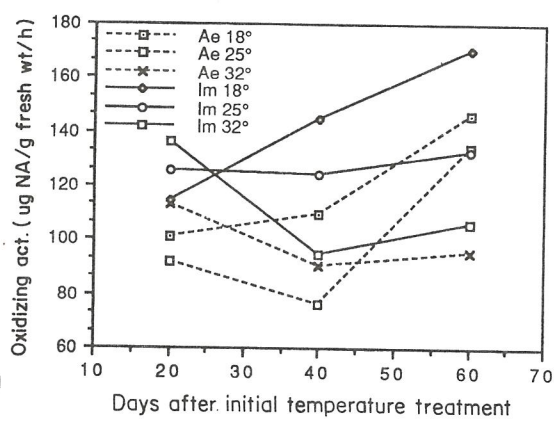

Fig. 4 Mean crop growth rate ($g/m^2/day$) of two tomato varieties grown in hot and cool seasons and applied with CPA.

There were no significant differences in nitrogen, phosphorus and potassium content in the leaf, petiole and stem among three nutrient-solution temperatures. However, phosphorus and potassium in the peduncle were higher in low solution temperatures than in high solution temperatures (Table 2). High phosphorus and potassium in the peduncle may be related to a large dry matter partition to the fruit.

Table 2. NPK content in the peduncle of FMTT 3 grown under three nutrient-solution temperatures.

Days after initial temp treatment	°C	N	P	K
20	18	2.4	0.8	3.4
	25	2.3	1.0	3.7
	32	2.0	0.7	4.2
40	18	2.1	0.8	3.1
	25	2.2	0.8	3.0
	32	2.4	0.6	2.7
60	18	2.1	1.2 a[z]	3.4 a
	25	2.1	1.0 ab	3.3 ab
	32	2.0	0.9 b	3.1 b

[z]Mean separation within the same day of sampling by DMRT at 5% probability level.

Growth Analysis of Tomato Applied with a Growth Regulator

Summary

Para-chlorophenoxy acetic acid (CPA) application at anthesis decreased the flowering and the number of fruits of CL5915-206 and FMTT3 but increased the fruit size in both hot and cool seasons. FMTT3 had bigger fruits and higher fruit yields than CL5915-206 in the corresponding treatment in the same season. CPA application at anthesis or two weeks after anthesis increased fruit yields in the hot season but not in the cool season. Plants applied with CPA at anthesis produced less but larger fruits without seeds, whereas plants applied with CPA two weeks after anthesis produced smaller fruits with some seeds. CL5915-206 under high temperature condition had high rates of natural parthenocarpy without CPA. CPA application increased harvest index in the hot season. High sugar/starch ratio in peduncle of tomato grown under high temperature conditions might be related to early ripening.

Introduction

High temperature reduces fruit-set and prevents assimilate distribution to the fruit. Furthermore, it usually decreases fruit size of the heat tolerant tomato. High temperature disturbs the balance of endogenous hormones between vegetative and generative parts of tomato causing the reduced diversion of assimilates to the plant's generative parts. Earlier, it was demonstrated that application of para-chlorophenoxy acetic acid (CPA) increased tomato fruit-set and yields under high temperature conditions. The study examined the effect of CPA on dry matter distribution of tomato in relation to fruit size under hot and cool growing conditions.

Materials and Methods

Seeds of FMTT3 (indeterminate type and heat tolerant with medium size fruits) and CL5915-206D_4-2-2-0 (indeterminate type and heat tolerant with medium size fruits) were sown on 20 April and 1 September 1988, respectively. Seedlings were transplanted to the field on 16 May, and 5 October 1988, respectively. Plants were pruned leaving only two stems in every plant. CPA at 100 ppm in 0.1% Tween 20 was applied to the first to eighth clusters at the time each of them reached first anthesis or two weeks after anthesis. The control cluster was treated with 0.1% Tween 20 only. There were six treatments (three growth regulator applications × two varieties), arranged in a randomized complete block design with four replicates. Each replicate (plot) was 1.5 × 12.0 m with two rows spaced 40 cm (intrarow) × 60 cm (interrow). Four plants in each replicate were randomly sampled at the time of transplanting, and 3, 6, 9, 11 and 13 weeks after transplanting in the hot season. In the cool season, plants were sampled at the time of transplanting, and 3, 6,

9, 12, 15, 18 and 21 weeks after transplanting. Samples were measured in terms of plant height, leaf area, and fresh and dry weights of different parts. Days to first anthesis and first harvest of each cluster were also recorded. Plot sections were reserved to investigate the yield and yield component. Harvested fruits were randomly selected to determine fruit color rating, acidity and soluble solids. Petioles and peduncles were also investigated for sugar and starch content. Means of maximum and minimum temperatures from field planting to final harvest were 31.2°C and 24.3°C in the hot season, and 23.9° and 14.9°C, respectively.

Results and Discussion

CPA application reduced the flower and the number of fruits in both hot and cool seasons (Table 3). Extent of reduction was higher with CPA application at anthesis stage than that at 14 days after anthesis. More flowers but lesser fruits were produced in the hot than in the cool season. Fruit-set in cool season was about two to three times higher than that in hot season. However, CPA increased fruit-set in the hot season, about twice the control but slightly decreased in the cool season when CPA was applied at anthesis. Consequently, fruit yield in the cool season, although higher than that in the hot season was reduced by CPA at anthesis. Regarding fruit-set and number of fruits in the same season, CL5915 and FMTT3 with same treatment were comparable. However, FMTT3 had higher fruit yields than CL5915 in both seasons.

The fruit was bigger by 50% in the cool than in the hot season and that of FMTT3 was almost twice as large as that of CL5915 with corresponding treatment in the hot season (Table 4). CPA applied at anthesis significantly increased the fruit size in both seasons, and carpel number except in cool season of CL5915-206. Increased fruit size by CPA application at anthesis was due to increase in the size of the ovary. The preferential diversion of assimilates for the development of the ovary would also limit assimilates available for subsequent fruit-setting. CPA applied at anthesis increased more parthenocarpy than when applied at two weeks after anthesis (Table 4). This suggested that additional auxins at anthesis could supplement endogenous auxins to extract more assimilates for fruit development. It is possible that additional auxins at anthesis increase the size of cell in the ovary.

Both vegetative and total dry matter productions were restricted in the hot season, whether with or without CPA application (Table 5). Total dry matter greatly reduced (40 to 50% of cool season) in the

Table 3. Growth characteristics of tomato plants grown in the hot and cool seasons and applied with CPA.

Entry	Treatment	No. of flowers /plant		No. of fruits /plant		Fruit set (%)		Fruit yield (g/plant)	
		Hot	Cool	Hot	Cool	Hot	Cool	Hot	Cool
CL 5915-206	Control	122 a[z]	79 a	9.4 b	52.5 a	9.0 b	66.4 a	418 c	4950 a
	CPA-0	63 c	58 b	8.8 b	26.5 c	17.4 a	45.9 b	739 b	3694 b
	CPA-14	97 b	68 ab	18.7 a	39.5 b	21.5 a	58.5 a	904 a	4581 a
FMTT 3	Control	88 a	73	4.7 c	45.1 a	8.9 b	62.9 a	516 c	6289 a
	CPA-0	45 b	53	6.7 b	23.5 b	16.7 a	45.4 b	977 b	5185 b
	CPA-14	80 a	69	14.2 a	36.2 a	16.7 a	53.3 ab	1187 a	6504 a

[z]Mean separation within the same entry and season by DMRT at 5% probability level.

Table 4. Fruit characteristics of tomato grown in the hot and cool seasons and applied with CPA.

Entry	Treatment	Fruit size (g/plant)		No. of carpels /fruit		Parthenocarpy (%)	
		Hot	Cool	Hot	Cool	Hot	Cool
CL 5915-206	Control	44 b[z]	98 b	3.9 b	4.5	59 c	7 c
	CPA-0	83 a	141 a	4.4 a	4.2	100 a	79 a
	CPA-14	48 b	119 b	4.1 b	5.3	80 b	14 b
FMTT 3	Control	109 b	129 b	4.3 b	4.5 b	16 c	5 c
	CPA-0	146 a	232 a	4.9 a	4.9 a	99 a	88 a
	CPA-14	84 c	156 b	4.2 b	4.8 a	63 b	18 b

[z]Mean separation within the same entry and season by DMRT at 5% probability level.

hot season. Results indicated that high temperatures blocked both vegetative and reproductive growth in tomato plants, but with greater effects on reproductive growth. CPA application enhanced fruit-set, thus the preferential partition of assimilates to fruit instead of increasing total dry matter production. Harvest indices in both entries with same treatments were comparable in the same season. However, vegetative and total dry matter productions of FMTT 3 either in the cool or hot season were higher than those of CL 5915. High dry matter production in FMTT 3 could have induced bigger fruit size and higher fruit yields (Tables 3 and 4).

Based on crop growth rate (CGR), rapid dry matter accumulation occurred at three to nine weeks after transplanting (Fig. 5). During this period of growth, CGR of CL5915 at 7 to 14 $g/m^2/day$ was about 70% of FMTT3 of corresponding treatments. Tomato plants started to senesce and no further increase in CGR was observed nine weeks after transplanting in the hot season. It was probable that high temperatures impeded photosynthesis by disrupting membrane stability and/or increasing respiration, resulting in a limited assimilation for further growth. High dry matter production in the cool season could be accounted for by maintaining high CGR throughout long periods of growth. CPA application appeared to have no effect on CGR. Net assimilation rates (NAR) of both entries in hot season were 1.0 to 2.5- fold of NAR in the cool season before senescence (Fig. 6). Therefore, high CGR in cool season was more likely due to an increased leaf area, about double that of hot season during the first nine weeks of growth, instead of an increased NAR. Leaf area ratio declined at six weeks after transplanting in the hot season (Fig. 7).

NAR was increased by CPA application at anthesis during three to six weeks after transplanting (Fig. 7). It is possible that CPA application created sink strength in the developing fruit, thus stimulated NAR for rapid fruit increment at early stages of fruit development in hot season. High soluble sugar content/starch ratio in the peduncle in hot season supported the increased NAR, thus providing more assimilates for bigger fruit increment. However, increased NAR in hot season was negligible for total dry matter accumulation. Large fruit obviously depended on steady supply of assimilates.

Table 5. Vegetative and total dry weights (g/plant) and harvest index (%) of tomato grown in cool and hot seasons and treated with CPA.

Entry	Treatment	Vegetive dry wt. (g/plant)		Total dry wt. (g/plant)		Harvest index (%)	
		Hot	Cool	Hot	Cool	Hot	Cool
CL 5915-206	Control	82	112	96	289	14 b	61
	CPA-0	74	106	118	246	36 a	57
	CPA-14	69	117	104	290	34 a	59
FMTT 3	Control	116 a[z]	160	139	386	16 b	58
	CPA-0	97 b	179	144	392	33 a	55
	CPA-14	110 ab	136	158	336	30 a	59

[z]Mean separation within the same entry and sampling by DMRT at 5% probability level.

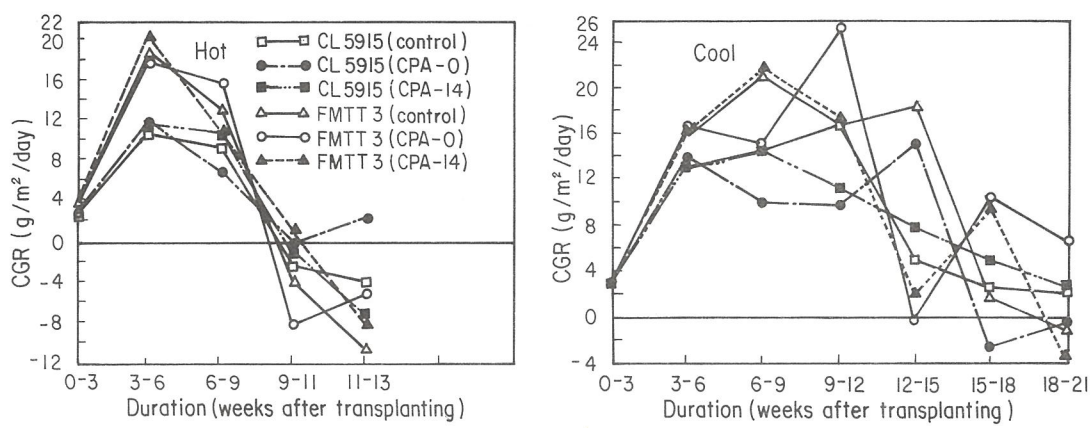

Fig. 5. Mean crop growth rate ($g/m^2/day$) of two tomato varieties grown in the hot and cool seasons and treated with CPA.

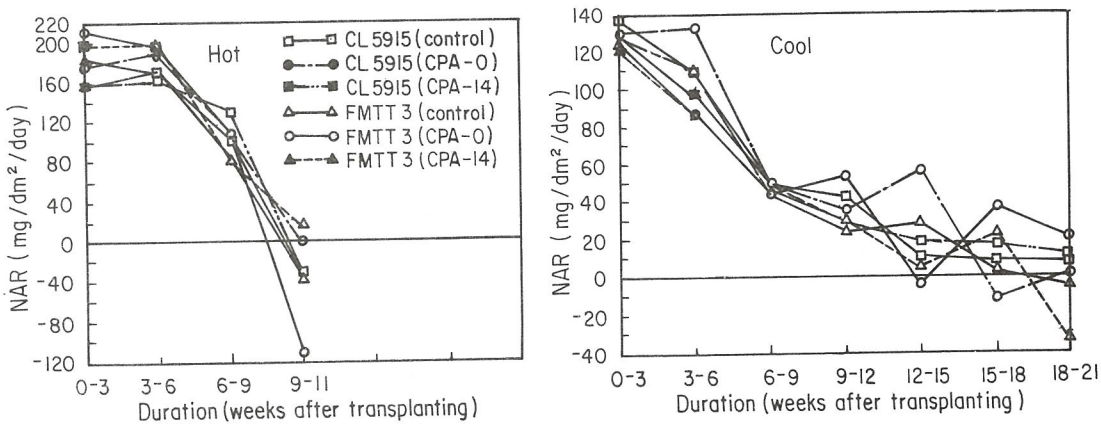

Fig. 6. Mean net assimilation rate (mg/dm^2/day) of two tomato varieties grown in the hot and cool seasons and treated with CPA.

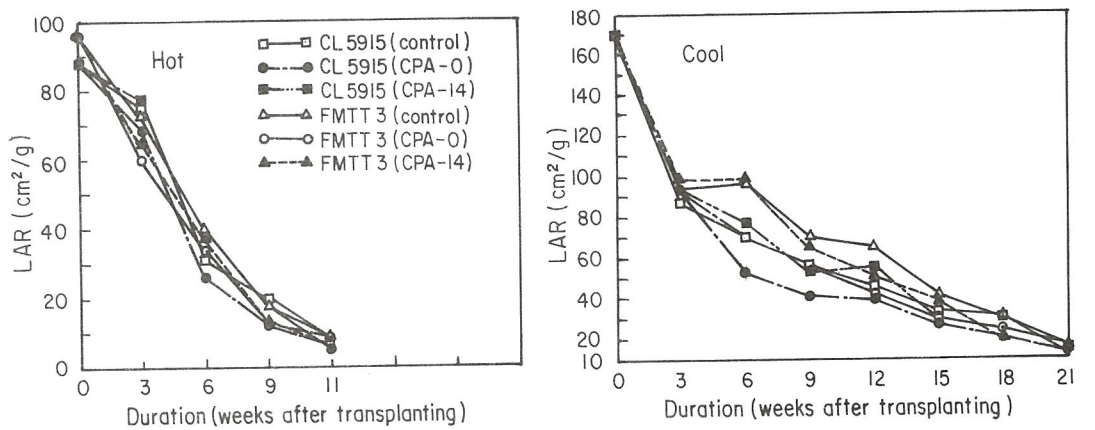

Fig. 7. Leaf area ratio (cm^2/g) of two tomato varieties grown in the hot and cool seasons and treated with CPA.

Production Systems Program

Chemistry

Determination of Pepper Fruit Capsaicin Content By Near Infrared Reflectance Spectroscopy

Summary

The possibility of using near infrared reflectance spectroscopy (NIRS) as a fast screening technique for capsaicin determination was studied. Prediction statistics showed the accuracy of NIRS in estimating the capsaicin in pepper fruit. The coefficient of determination (R^2) and standard error of prediction (SEP) between NIRS and HPLC method was 0.91 and 0.85, respectively. Good linear relationship between routine colorimetric procedure and NIRS was also observed. NIRS, calibrated with colorimetric method may overestimate the capsaicin content in pepper fruit due to lack of specificity of colorimetric method used.

Introduction

Capsaicin constitutes the pungency in hot pepper fruit. Determination of capsaicin in pepper fruit has gained the interest of those involved in pepper breeding and processing. There have been many methods proposed for determining capsaicin and they varied from organoleptic evaluation to applications of sophisticated instruments. Most of these methods, however, require time-consuming sample clean-up procedures. A few methods are reported for fast estimation of the relative pungency of pepper fruit. These methods, however, often require solvent extraction and lack precision.

The possibility of estimating capsaicin by near infrared reflectance spectroscopy (NIRS) was studied. Due to its minimum requirement of sample preparation and fast analytical procedure, the NIRS may offer a quick alternative method of determining over 100 samples a day by one technician. Other constituents such as sugar and pigment could also be determined simultaneously using the same sample and equipment.

Materials and Methods

Sample preparation. Fresh pepper fruits were dehydrated in a hot air dryer at 45°C for four days. After removing the seeds, the dried samples were ground into fine powder in a high speed centrifuge mill (FRITSCH Co.). The capsaicin was extracted from the powder then analyzed and determined by NIRS.

Colorimetric method. Capsaicin of pepper in powder form was extracted with acetone in a temperature controlled shaker for four hours. The extract was filtered and capsaicin in the liquid phase was determined based on the color reaction of capsaicin and ammonium vanadate. The optical density at 725 nm was measured at 10 min after addition of HCl solution. Analytical grade capsaicin was used for preparation of the standard curve.

High Performance Liquid Chromatograph (HPLC) method. Capsaicin extracts were filtered through No. 41 Whatman filter paper and acetone was allowed to evaporate at 55°C.The residue was redissolved in ethanol and the volume was adjusted to 10 ml.

HPLC assay was performed isocratically on a Merck Lichrosorb RP-18 column (5 μm) under room temperature. The mobile phase was a mixture of methanol and water at a ratio of 35/65 (v/v). The flow rate was kept at 1 ml/min. Capsaicin and dihydrocapsaicin in pepper fruit can be successfully separated under this condition and detected at 229 nm (Fig. 1). The total content of these two compounds was used to express the capsaicin content of pepper fruit.

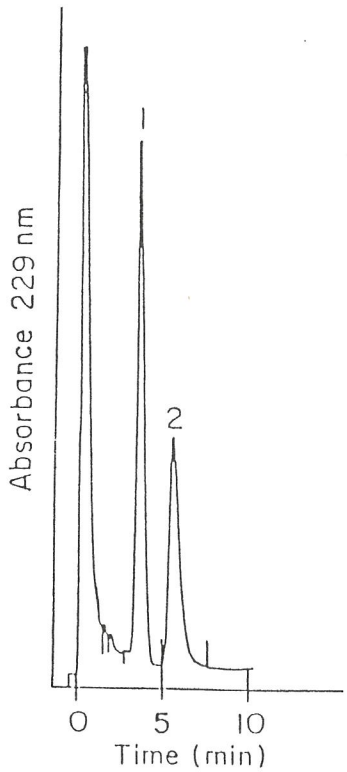

Fig. 1. HPLC chromatogram of capsaicin in hot pepper.

All chemicals used are reagent grade. The standard of capsaicin and dihydrocapsaicin was purchased from Sigma Co. Solvent of mobile phase was of HPLC grade.

Results and Discussion

Preliminary test. NIRS has been useful in estimating the macro-composition contents such as protein, fat, fiber and sugar. The application of NIRS for micro-composition determination is still limited because of possible interference from other components. Based on the reported spectrum of capsaicin at near infrared region, carbohydrates were identified as potential interference in capsaicin determination by NIRS. A preliminary study was conducted to test the possibility of predicting capsaicin in pepper fruit using a Technicon InfraAlyzer 400 spectroscope. The colorimetric method was used to calibrate NIRS. Prediction statistics are summarized in Table 1.

The high correlation coefficient and low standard error of prediction suggested that an acceptable prediction of capsaicin content in pepper fruit using an InfraAlyzer 400 spectroscope can be achieved.

Calibration with HPLC method. NIRS is a secondary analytical technique which relies on a reference to a primary manual analysis. Any inaccuracies in the primary method are also reflected in the NIRS. The colorimetric method, although much simpler, is not very specific. Nonpungent compounds with similar chemical structure as capsaicin may interfere with the results of colorimetric analysis. A HPLC method therefore aims to improve the accuracy of NIRS prediction.

As described earlier, detection of capsaicin in the HPLC system was carried out at 229 nm. This spectrum was not the maximum absorption of capsaicin in the UV region. Sensitivity test revealed a good linear relationship between capsaicin content and peak area in the range of 0.05 to 0.35 μg. This sensitivity is sufficient for analyzing pepper fruit.

The regression line of capsaicin content determined by HPLC and prediction by NIRS is as shown in Table 1. The R^2 and SEP of the regression equation was 0.91 and 0.85 respectively. The slope and intercept of the regression equation were very close to the theoretical values (slope = 1.09; intercept = 0.21).

The capsaicin content determined by HPLC was much lower than that determined by colorimetric method. The difference in capsaicin content (D value) across a sample of 29 pepper fruits had a

Table 1. Prediction of capsaicin in pepper fruit calibrated by colorimetric and HPLC methods.

Method	No. of filter	Calibration test			
		Slope	Intercept	SEP	R^2
Colorimetric	5	1.03	0.48	0.96(28)[z]	0.93
HPLC	5	1.09	0.21	0.85(32)	0.91

[z]Value in parentheses is the number of samples.

range of 0.041 to 9.316 mg/100g with a mean value of 1.651 mg/100g. This result suggested that there could be other interfering compounds involved in the determination of capsaicin by colorimetric method. The use of HPLC as reference method can improve the accuracy of NIRS prediction.

Selected wavelengths and coefficients (F value) of regression equation for capsaicin determination by Technicon InfraAlyzer 400 are listed in Table 2. All filters selected are in the region between 1700 and 2300 nm. These results conformed with the other findings that capsaicin has a very strong absorption at 1752 nm and weak bands at 1950 to 2200 nm region. The interference of carbohydrate on capsaicin prediction was not observed. Sample sets of different genotypes harvested at different seasons will be tested further to confirm the reliability of NIRS prediction.

The accuracy of prediction as expressed by R^2 and SEP was found slightly lower than reported values which use the second derivatives of absorption at five wavelengths. However, the prediction statistics obtained were within the acceptable range for screening purposes considering the 18% coefficient of variation (CV) in capsaicin content of field replications of the same variety.

Conclusion

The NIRS was found as an acceptable screening technique for quantitative analysis of capsaicin content in pepper fruit. HPLC is recommended as a manual method. Since samples used were harvested from the same season, additional testing will be conducted to examine its reliability.

Table 2. Wavelength and F values[z] for capsaicin prediction by NIRS.

Filter No.	Wavelength (nm)	F value
F 0	–	-7.303
F 6	2230	268.039
F 10	2180	-476.557
F 12	1818	1031.192
F 14	2100	-4226.823
F 15	1759	-4266.823
F 17	1734	3212.634

[z]Coefficients of regression equation.

Effects of Methionine on Mungbean Sprout Properties

Summary

The effect of applying methionine in soaking water for mungbean sprout production was investigated. Methionine treatment enhanced the length of hypocotyls of V2010 but not the diameter and root length. Treatments under different concentrations showed that the effect of methionine leveled off above 1250 ppm.

Introduction

Yield and quality are two major concerns in mungbean sprout production. Although there are no standards for sprout quality, the most desirable mungbean sprouts have short roots with hypocotyls longer than 4 cm and 2 mm in diameter. Sprouts should have reasonable keeping quality, prevent water loss and maintain crispness. Methods for the production of short roots and plumb hypocotyls have been extensively studied. Some are not economically feasible while others are adopted for commercial production.

The production of sprout noodles, which are hypocotyls of mungbean sprouts without cotyledons is gaining popularity. The quality requires the commodity to have long and straight hypocotyls with relatively larger diameter. The length of the hypocotyls should be uniform which makes it easier to cut off the cotyledon. Large-seeded varieties may provide better quality but the yield could be lower. To date, major research has focused on how to produce quality sprouts coupled with good yield.

AVRDC previously demonstrated the effect of methionine on sprout properties which varied depending on varieties used. Methionine treatment increased the sprout length of V2010 but not the diameter of hypocotyls. Experiments were conducted to identify the optimum methionine concentration to achieve beneficial effects.

Materials and Methods

Seeds of mungbean accession V2010 were obtained from trials of On-station Testing. Seeds were passed through sieves to remove too large and too small ones.

Sprouting. The sprouting process was carried out by a home-designed sprouting machine. Water, after aeration for 3-4 h was supplied automatically every 4 h to wash the sprouts. No temperature control device was installed in the system thus temperature regulation depended entirely on the air conditioner in the room. Presoaking was carried out under room temperature for 6 h before placing the seeds into the sprouting machine. The amount of seeds used for each treatment was 50 g and mean values of 30 sprouts were used to express hypocotyl length and diameter, and root length.

Methionine determination. Seeds or sprouts of mungbean were homogenized in Waring blender with water and then centrifuged for 10 min. The extracts were transferred into a test tube followed by 3 ml methionine free medium (basal medium : amino acid medium = 2 : 1), and inoculated with *Streptococcus zymogenes*. The optical density of the solution at 580 nm was examined after incubation at 37°C for 48 h. The amount of methionine content was calculated from the standard curve of L-methionine.

Results and Discussion

The yield and properties of sprouts produced from seeds treated with methionine solution at different concentrations are presented in Table 3. Mungbean seeds treated with methionine at higher concentrations produced longer hypocotyls. This effect levelled off when methionine concentration reached 1250 ppm. No significant effect was observed on root length nor thickness of hypocotyl. As a result, the sprout yield increased from 368.6 g/50 g seeds for check to 402.9 g/50 g seeds when treated with 1500 ppm methionine solution. Treatments were not replicated due to limitation of the available facility.

A replicated experiment was conducted to study the effect of methionine on yield and sprout properties. The concentration of methionine used was 1500 ppm. Methionine treatment increased the length of hypocotyls from 6.4 to 7.8 cm and sprout yield by 16.8% (Table 4). However, the sprouts had longer roots. This result confirms the previous observation that the effects of methionine are different from the effects of ethylene. Its effects are more pronounced on the length of hypocotyls than thickness.

Methionine content of mungbean seeds after treatment was examined. The amount of methionine absorbed by the seeds was not linear to its concentration in the solution.

Methionine treatment will improve the nutritional quality of the sprouts. Methionine content of sprouts produced from methionine-treated seeds at different concentrations is shown in Table 5.

Table 3. Effects of various methionine concentrations on properties of mungbean sprouts.

Properties	Methionine Concentration						
	0	250	500	750	1000	1250	1500(ppm)
Hypocotyl length (cm)	7.2 e[z]	7.2 e	7.6 cde	7.5 de	7.7 cd	8.5 a	8.3 ab
Hypocotyl diameter (mm)	3.4 ab	3.5 a	3.3 bc	3.3 bc	3.4 bc	3.3 c	3.4 abc
Root length (cm)	2.2 a	2.3 a	2.7 a	2.8 a	2.8 a	2.3 a	2.6 a
Sprout yield (g/50 g seed)	368.6	363.5	387.5	376.1	385.5	378.7	402.9

[z]Any two values not followed by the same letter are significantly different at 5% level.

Table 4. Effects of methionine treatment on properties of mungbean sprouts.

Properties	Wo/M[z]	W/M[z]
Hypocotyl length (cm)	6.4	7.8[y]
Hypocotyl diameter (mm)	3.5	3.4 ns
Root Length (cm)	2.6	2.8[y]
Sprout yield (g/50g seed)	326.5	281.4[y]

[z]Wo/M: without methionine; W/M: with 1500 ppm methionine. [y]Highly significant by T test. ns: not significant.

Table 5. Methionine content of sprouts produced from methionine-treated seeds at different concentrations.

L-Methionine content	Methionine Concentration					
	250	500	750	1000	1250	1500 (ppm)
Sprouts	0.5[z]	0.8	0.7	6.7	12.1	15.3

[z]Unit: L-methionine μg/g sprout.

Composition Analysis of Vegetable Soybean

Summary

The near infrared reflectance spectroscopy (NIRS) was found reliable in determining the moisture, protein, fat, fiber, starch, sugar and ash in vegetable soybean. Gas chromatographic analysis suggested that most volatiles in vegetable soybean are so called beany flavor compounds. The major volatiles identified are n-hexanal,1-octen-3-ol-furfural and trans-2-cis-4-decandienal.

Free amino acid content was higher in immature vegetable soybean seed than in mature ones. Glutamic acid is the dominant free amino acid and contributes 0.38% of the total fresh weight. Apart from sugar, this amino acid may make a significant contribution to the eating quality of vegetable soybean.

Introduction

Vegetable soybean is a traditional vegetable of the Orient. It has generated much interest recently as a processed commodity for export to Japan. To assure the market quality of processed vegetable soybean, it is necessary to better understand the quality-related composition and develop evaluation methods for varietal improvement and quality control.

Near infrared reflectance spectroscopy (NIRS) is deemed potentially useful to estimate the macro-compositions of vegetable soybean. The prediction procedure has been improved to obtain more reliable and accurate results. The performance of NIRS for analysis of protein, fat, fiber, sugar, starch and ash is presented in this report.

Sugar, amino acid and volatile compounds are suspected to be associated with the eating quality of vegetable soybean. The major volatile compounds and free amino acids of three major vegetable soybean varieties were identified. Their individual sugar content is under investigation.

Materials and Methods

Vegetable soybean. The samples were harvested from yield trials on AVRDC fields. The graded pods were first blanched in boiling water for 90 seconds. After precooling in tap water, the samples were quickly frozen under -40°C and kept in the freezer until further preparation.

Preparation of vegetable soybean powder samples. After removing from the shells, seeds were dehydrated at 45°C for 72 h in a hot air oven and then ground into fine powder in a high speed centrifuge mill passing through a 0.5 mm screen. The samples in powder form were analyzed for their free amino acids.

Volatile extraction. About 400 g of thawed seeds were ground with 2 liters distilled water and the slurry was extracted for 2 h in a Likens-Nickerson apparatus. Glass-distilled n-pentane

and diethyl ether (1:1) were used as the extracting solvent, and ethyl acetate was added as an internal standard. The volatile extracts were dried with anhydrous $NaSO_4$ and concentrated to a minimum volume using a distillation apparatus. The concentrate was transferred into a capillary tube and sealed for further GC analysis.

Volatile compound separation and identification. The analysis was carried out with a Hitachi G-3000 gas chromatograph equipped with a flame ionization detector. A 50 m × 0.2 mm fused silica column filled with Carbowax-20 M was used for separation. Oven temperature was held at 50°C for 5 min then programmed to 200°C at 2°C/min and kept at 200°C for 30 min. The injector and detector temperature was 250°C. Nitrogen was used at a flow rate of 5 ml/min. The volatile compounds were identified by Hewlett-Packard 5985B system gas chromatography-mass spectroscopy (GC-MS).

Determination of soluble amino nitrogen. One gram powder was extracted with 80% ethanol at 80°C for 2 h. The ethanol was allowed to evaporate at 80°C. The residue was diluted to 25 ml with distilled water and kept in the refrigerator for HPLC analysis. Liquid chromatographic analysis was carried out in Waters model 440 equipped with 1254 nm UV detector. Waters C_{18} reverse phase column was used for separation and was kept at 38°C. The solvent system was programmed as follows:

Time (min)	Flow rate (ml/min)	%A[z]	%B[z]	Curve type
initial	1.0	100	0	–
10.0	1.0	54	46	5
10.5	1.0	0	100	6
11.5	1.0	0	100	6
12.0	1.0	0	100	6
12.5	1.5	100	0	6
20.0	1.5	100	0	6
20.5	1.0	100	0	6

[z]A, B solution purchased from Waters Co.
A solution: 19 g sodium acetate and 0.5 ml triethylamine were dissolved in 1 liter distilled water and adjusted to pH 6.4. Sixty ml acetonitrile (CH_3CN) was poured into the solution after filtration. B solution: CH_3CN : water = 6 : 4 The amino acid content was calculated with the standard amino acids.

Results and Discussion

Applications of NIRS for composition analysis. Two sets of samples were analyzed manually for their major compositions including moisture, protein, fat, fiber, ash, sugar and starch. One set was used to ascertain the NIRS and the other set to verify the accuracy of the prediction. The prediction statistics of calibration equations are presented in Table 6. The number of filters required varied from 3 for moisture to 6 for starch and fiber. The correlation coefficients (R^2) for prediction were all above 0.95 and all standard errors of prediction (SEP) were very low. The accuracy of the

Table 6. Prediction statistics of calibration equation for major compositions of vegetable soybean.

Constituent	No. of filter	Content range (%)	R^2 of cal. curve	SEP of cal. curve
Moisture	3	4.4-10.3	0.99(48)[z]	0.19(30)
Protein	4	32.2-42.7	0.98(31)	0.43(30)
Oil	5	15.6-21.8	0.99(63)	0.19(38)
Sugar	5	5.3-11.7	0.99(31)	0.33(38)
Starch	6	5.7-9.9	0.95(34)	0.52(35)
Fiber	6	3.4-4.6	0.97(50)	0.35(34)
Ash	5	4.0-5.6	0.96(46)	0.16(43)

[z]Values in parentheses indicate the number of samples.

prediction was found better than that reported last year. This result suggested that blanching is an essential step for sample preparation especially for sugar and starch analysis.

Free amino acids in vegetable soybean. Vegetable soybean is an immature grain of soybean. It is generally harvested at R_7 growth stage. The content of free amino acids in immature seed can be much higher than in mature ones. The total amino nitrogen of three vegetable soybean cultivars, Ryokkoh (305), Tzurunoko (205) and Kaohsiung Selection No. 1 (292) at different stages of maturity is compared in Table 7. Free amino nitrogen content in young vegetable soybean seeds was three times higher than that of mature seeds of the same variety.

Table 7. Soluble amino nitrogen content of three vegetable soybean varieties at various maturities.

Variety	Soluble amino nitrogen[z] Maturity (%)			
	60	80	100	Soybean
292	0.2106	0.0936	0.1168	0.039
205	0.1436	0.1779	0.0961	0.038
305	0.1178	0.1281	0.0954	0.045

[z]Unit: % on dry weight basis.

Glutamic acid was dominant in three varieties. This single amino acid contributes more than 10% of total free amino acid in vegetable soybean. The calculated concentration of glutamic acid was over 0.38% of fresh weight of vegetable soybean seed. The contribution of this amino acid to the overall taste of vegetable soybean can be very significant. Line KS No. 1 had the lowest total amino nitrogen and glutamic acid which could be related to unpalatability of this variety.

Flavor compounds of vegetable soybean. The flavor compounds of soybean milk are mainly products of peroxidation of unsaturated fatty acids. Lipoxygenase has been identified as the most important enzyme involved in this process. Since oil content of vegetable soybean is as high as the grain soybean on dry weight base, it is suspected that the mild flavor of vegetable soybean might be caused by the same group of compounds. The volatiles of vegetable (305) and grain soybeans (305 and AGS 129) were separated by gas chromatography and identified by mass spectroscopy. The lower concentration of these volatiles in vegetable soybean is understandable since the pods were blanched to inactivate the enzymes including lipoxygenase. Major volatiles identified in vegetable soybean are n-hexanal, 1-octen-3-ol-furfural, trans-2-cis-4-decandienal. They are known as beany flavor compounds. The two compounds, amyl alcohol and benzaldehyde are not commonly found in soybean milk. The significance of these two compounds in relation to flavor of vegetable soybean merits further investigation.

The gas chromatograms of vegetable soybean varieties, namely, 205, 305 and 292 were compared. The patterns of these three chromatograms were similar but concentrations of each compound differed. Variety 292 had lower volatiles than the other two varieties. This result confirms the claim of Japanese traders that variety 292 does not provide sufficient flavor. Measuring total peak area could be a useful method to estimate the flavor of vegetable soybean. The relationship between volatiles and lipoxygenase activities is under investigation.

Hardness of Vegetable Soybean

Summary

The texture of vegetable soybean can be ascertained by the seed hardness at first bite. Regression studies demonstrate that the physical properties can be predicted by near infrared reflectance spectroscopy (NIRS). The coefficient of determination (R^2) and standard error of prediction (SEP) observed between the hardness of cooked beans measured by rheometer and predicted by NIRS were

0.81 and 0.38, respectively. The R^2 and SEP between hardness of cooked beans and predicted values by NIRS using uncooked beans was found to be 0.91 and 0.24. This result suggested that hardness of vegetable soybean can be estimated simultaneously with chemical compositions by NIRS using the same samples.

Introduction

Texture is an important attribute of food quality. A considerable amount of research has been undertaken to develop methods to evaluate food texture. Measuring the force-deformation curve is frequently used as an index of physical properties. This method has measured several well-defined physical properties which can be related to sensory characteristics of food. However, this method is relatively time-consuming and several measurements are required to overcome the variations of individual food samples. The determination of chemical composition of food is suggested as another means to determine food texture.This method requires grinding of relatively large samples into uniform mixture before analysis. This approach requires one to know which compositions are major attributes to overall texture properties.

The near infrared reflectance spectroscopy (NIRS) has been demonstrated as a useful instrument to estimate the chemical composition of food. As a secondary analytical method, the NIRS requires a set of analytical results of a primary reference method to establish a calibration equation. The filters selected and coefficients of the calibration equations are often the results of statistical calculation. Assuming that the texture of certain food is the result of its chemical composition, one may be able to estimate its texture by NIRS through statistical treatments of measured physical properties and reflectance of selected filters. Studies were carried out this year at AVRDC using vegetable soybean seeds as test materials.

Materials and Methods

Ten seeds in each cooked sample were measured by rheometer (FUDOH NRM-2010J-CW) using an adapter No. 3 (0.8) and pressing the plunger 5 mm into the seed. Both upward speed of sample stand and pen speed of plotter (FUDOH FR-801) were 5 cm/min. The sample was put into a seed holder to prevent seed removal when the adapter touched the seed. Bean hardness is expressed by the pressure force to break the seed.

The NIRS system consists of a Technicon InfraAlyzer 400 interfaced with an IBM compatible PC with IACAL package for data processing.

Results and Discussion

Physical property of vegetable soybean. The texture of vegetable soybean is characterized by its cohesiveness and brittleness. The mechanical property of seed hardness was selected to represent seed texture in this study.

There are several factors which may affect the texture properties of vegetable soybean seeds. Effects of maturity (Table 8) and cooking time were studied. Significant effects of both maturity and cooking time were observed. This indicated that consistency on harvesting samples at fixed maturity stage and condition of sample preparation are important during the assessment process.

Table 8. Hardness of cooked seeds of three vegetable soybean varieties harvested at different maturities.

Variety	Hardness (g) Maturity[z]		
	60%	80%	100%
205	[y]2565 b	2628 b	3297 a
292	2494 b	3118 a	3654 a
305	2917 a	2713 b	2811 b

[z]Percent of pod, in which its seed size reaches full potential. [y]Mean value of 10 measurements.

Prediction of hardness by NIRS. Two experiments were conducted to assess the accuracy of predicting the hardness of vegetable soybean seeds by NIRS. In the first experiment, seeds were separated into 25 groups based on their hardness measured by rheometer. After drying and grinding into fine powder, the sample set was analyzed by NIRS for establishment of calibration equation. The calibration equation obtained was:

$$\text{Hardness} = 3.516 + 861.50 \log_1/R_5 - 787.01 \log_1/R_{12} - 2140.29 \log_1/R_{13} + 1323.33 \log_1/R_{17} - 151.47 \log_1/R_{18}$$

A near-perfect linear relationship was established between hardness measured by rheometer and hardness calculated by the calibration equation. The correlation coefficient (R^2) was 0.98. This result suggested that NIRS can be an alternative technique to estimate the hardness of vegetable soybean. Five filters were selected in predicting the hardness of vegetable soybean.The selected wavelengths suggested that compositions of carbohydrates such as starch and cellulose, and -SH group of protein may play a major role in determining the texture of vegetable soybean. A low coefficient of determination ($R^2 = 0.81$) was observed when one uses the calibration equation directly.

Ordinary dehydrated powder samples, without cooking, were used in the second experiment. Another independent sample set was applied to test the reliability of the calibration equation. The prediction statistics are summarized in Table 9. The R^2 value of 0.91 was obtained by this approach. Considering that there is variation in hardness among individual seeds of the same sample, this technique seems acceptable as a rapid screening technique to estimate the hardness of vegetable soybean. This technique may permit estimation of hardness simultaneously with the analysis of protein, fat, fiber, sugar, starch and ash which may improve laboratory efficiency.

Table 9. Prediction statistics of calibration equation for hardness of vegetable soybean.

No. of filters	Calibration test			
	Slope	Intercept	SEP	R^2
5	0.94	0.14	0.24 (38)[z]	0.91

[z]Value in parentheses indicates the number of samples.

Crop Management

Plant Density Trial for Vegetable Soybean

Summary

Results revealed that wider spacing reduced plant height, number of branches, dry weight and leaf area. The optimum density for AGS 292, G 9053 and G 10134 was 26-27 plants/m^2 (15 × 50 cm) in spring and autumn. The pod quality such as percent of graded pods, pod color, sugar content was not affected by plant density. Lower yield in G 10134 was attributed to poor quality of pods (percent of graded pods) in autumn.

Introduction

Vegetable soybean G 10134 has good eating quality but is unpopular compared to G 9053 or AGS 292 due to its low pod yield. Information on low pod yield and the potential to increase the yield using higher plant population is not clear. Previous trials showed that close spacing 10 × 50 cm^2 produced highest grade pods in spring, but the effect might be different in autumn. The response of yield components and percent of graded pods to plant spacing in different varieties were not known. This study aimed to determine the effect of plant density on growth, yield and its components and pod quality of three vegetable soybean varieties in spring and autumn.

Materials and Methods

Three soybean cultivars were planted on 14 September 1988 and 22 February 1989. AGS 292 (Kaohsiung Sel. No. 1), G 9053 (Tzurunoko) and G 10134 (Tainung 305, Ryokkoh) were used as main plots and planted at spacings 10 × 50 cm, 15 × 50 cm, 20 × 50 cm and 25 × 50 cm as subplots. The experiments were arranged in a split-plot design with three replications. Soybean seeds, 4-5 per hill were sown in 4 × 5 m plots and seedlings were thinned to two plants per hill. Before hand seeding, the plots received 40 N + 50 P_2O_5 + 70 K_2O kg/ha of fertilizers and 20 t/ha of compost. Plants were sidedressed with 40 N kg/ha at R_1-R_2 stage.

Results and Discussion

Flower initiation and development of vegetable soybean was not influenced by plant density either in autumn or spring. G 10134 flowered earlier than two other varieties in autumn, but all formed pods at the same time. Flower and pod formation was later in spring than in autumn because soybean development was delayed by low temperatures and longer days in spring.

Growth analysis was conducted in each season (Tables 1 and 2). No significant differences were found among varieties in plant height, number of nodes in the main stem, leaf dry weight and leaf area. The number of nodes was not affected by plant density, but wider spacing increased the number of branches, plant dry weight, leaf area and decreased plant height in both spring and autumn. Increased plant density produced significantly larger leaf area index (Table 3) and consequently more light was intercepted by the plant canopy.

Table 1. Growth analysis of vegetable soybean at different spacings, autumn 1988.[z]

Treatment	Plant height	No. of nodes	No. of branches	Dry wt. (g/plant)					Leaf area (cm)	Harvest[y] index
				Stem	Petiole	Leaf	Pod	Total		
Main										**treatment**
AGS 292	32.2 a	8.8 a	2.6 a	2.5 b	1.4 a	4.1 b	12.6 b	20.5 b	972 a	60.3 a
G 9053	31.8 a	8.8 a	3.1 a	2.9 ab	2.2 a	4.3 ab	11.4 b	20.8 b	1088 a	53.8 b
G 10134	31.6 a	8.5 a	1.9 b	3.5 a	2.1 a	4.9 a	19.9 a	30.4 a	1027 a	54.9 b
Sub-treatment										
10 × 50	35.0 a	8.7 a	1.7 c	2.4 c	1.5 c	3.3 d	11.0 c	18.2 c	803 c	54.5 b
15 × 50	32.5 ab	8.8 a	2.2 b	2.7 bc	1.7 bc	3.9 c	13.0 bc	21.3 c	934 c	56.0 b
20 × 50	29.9 b	8.6 a	2.9 a	3.1 b	2.0 ab	4.9 b	15.2 b	25.2 b	1106 b	56.3 b
25 × 50	30.2 b	8.7 a	3.3 a	3.6 a	2.3 a	5.6 a	19.3 a	30.9 a	1274 a	58.7 a

[z]Means in each vertical column followed by the same letter are not significantly different at 5% probability level by DMRT. [y]Based on fresh weight of the top part.

Table 2. Growth analysis of vegetable soybean at different spacings, spring 1989.[z]

Treatment	Plant height	No. of nodes	No. of branches	Dry wt. (g/plant)					Leaf area (cm)
				Stem	Petiole	Leaf	Pod	Total	
Main treatment									
AGS 292	36.4 a	8.8 a	2.2 ab	3.6 a	1.7 b	5.6 a	13.0 b	23.9 b	1016 a
G 9053	38.5 a	9.0 a	2.9 a	4.8 a	3.0 a	5.4 a	16.2 a	29.4 a	1069 a
G 10134	40.7 a	8.5 a	1.1 b	4.8 a	2.4 ab	5.3 a	12.3 b	24.8 b	877 a
Sub-treatment									
10 × 50	46.0 a	8.8 a	1.1 c	3.4 b	1.5 c	3.4 c	10.0 c	18.3 c	754 c
15 × 50	38.9 b	8.8 a	1.8 b	3.9 b	2.1 b	4.5 b	13.2 b	23.7 b	886 bc
20 × 50	35.3 bc	8.7 a	2.6 a	4.9 a	2.9 a	6.6 a	15.3 ab	29.7 a	1058 b
25 × 50	34.0 c	8.7 a	2.9 a	5.4 a	3.0 a	7.2 a	16.8 a	32.5 a	1250 a

[z]Means in each vertical column followed by the same letter are not significantly different at 5% probability level by DMRT.

Table 3. Leaf area index and light interception ratio of vegetable soybean at later growth as affected by plant density and variety in two seasons.[z]

Treatment	LAI		Light interception ratio (%)	
	Autumn	Spring	Autumn	Spring
Main treatment				
AGS 292	2.4 a	2.4 a	92.5 a	79.6 b
G 9053	2.5 a	2.6 a	92.4 a	87.3 a
G 10134	2.5 a	2.1 a	90.6 a	88.2 a
Sub-treatment				
10 × 50	3.2 a	3.0 a	95.7 a	88.2 a
15 × 50	2.5 b	2.4 b	93.4 ab	89.0 a
20 × 50	2.2 bc	2.1 bc	91.1 b	83.4 b
25 × 50	2.0 c	2.0 c	87.2 c	79.5 b

[z]Means within a column followed by the same letter are not significantly different at 5% probability level by DMRT.

Significant differences in graded pod yield per unit area were found among treatments in both trials (Tables 4 and 5). In autumn 1988, AGS 292 yielded more than G 10134, while G 9053 was not significantly different from the two. Both AGS 292 and G 9053 had higher yield than G 10134 in spring. Plants in wider spacing formed more pods than those in narrower spacing. Yields from 10 × 50 cm and 15 × 50 cm spacings were significantly higher than those from 25 × 50 cm in both spring and autumn. There were no significant interactions between variety and spacing except in the number of plants per m^2, plant dry weight per m^2, light interception ratio, leaf area index at a later growth stage and number of pods per plant in autumn, and leaf area index at harvest in spring. The grading ratio was lower in G 10134 than in AGS 292 and G 9053. Grading ratio and pod color were not affected by plant spacing (Table 6). Information on duration of harvest as influenced by plant density and variety will help improve production. The dry matter accumulation of pod and plant

Table 4. Yield and yield components of vegetable soybean as affected by plant density and variety, autumn 1988.[z]

Treatment	Plant no. /m^2	Plant dry wt. g/m^2	Graded pod yield t/ha	Pod wt. g/plant	Pod no. /plant	Graded pod wt. g/plant	Grading ratio %
Main treatment							
AGS 292	25.4 a	486 b	6.91 a	48.7 a	22.4 a	25.6 a	62.3 a
G 9053	25.7 a	480 b	6.34 ab	48.8 a	22.1 a	28.0 a	60.9 a
G 10134	24.3 b	713 a	4.96 b	48.4 a	20.4 a	22.2 b	50.3 b
Sub treatment							
10 × 50	38.3 a	685 a	6.26 ab	31.6 d	14.4 d	16.6 d	56.8 a
15 × 50	26.8 b	568 b	6.55 a	45.3 c	20.4 c	21.3 c	59.4 a
20 × 50	19.7 c	495 c	5.96 bc	55.1 b	24.7 b	28.4 b	58.7 a
25 × 50	15.9 d	491 c	5.52 c	62.5 a	27.1 a	34.8 a	56.4 a

[z]Means within a column followed by the same letter are not significantly different at 5% probability level by DMRT.

Table 5. Yield and yield components of vegetable soybean as affected by plant density and variety, autumn 1988.[z]

Treatment	Plant no. /m^2	Plant dry wt. g/m^2	Graded pod yield t/ha	Pod wt. g/plant	Pod no. /plant	Grading ratio %	Harvest index	
							D[y]	F[x]
Main treatment								
AGS 292	26.0 a	576 b	5.6 a	48.4 a	21.5 a	48.6 b	55.1 a	55.5 a
G 9053	25.9 a	700 a	6.2 a	48.0 a	20.6 a	56.2 a	55.6 a	53.3 ab
G 10134	25.7 a	601 b	4.7 b	41.9 b	16.3 b	50.8 b	49.6 a	47.6 b
Sub treatment								
10 × 50	40.0 a	734 a	5.9 a	31.4 d	13.9 c	48.4 a	54.7 ab	52.4 a
15 × 50	27.5 b	651 ab	5.9 a	44.4 c	19.0 b	51.0 a	55.7 a	54.2 a
20 × 50	20.1 c	596 bc	5.4 ab	51.7 b	21.9 a	54.5 a	51.3 b	50.6 a
25 × 50	16.0 d	522 c	4.8 b	56.9 a	23.0 a	53.5 a	51.9 ab	51.3 a

[z]Means within a column followed by the same letter are not significantly different at 5% probability level by DMRT. [y]Based on dry weight of the top part. [x]Based on fresh weight of the top part.

Table 6. Pod color and seed components of different vegetable soybean varieties and plant densities, spring and autumn.[z]

Treatment	Color	Dry matter	Oil	Protein	Sugar	Starch	Fiber
			Autumn				
Variety (Main plot)							
AGS 292	4.4 a	32.8 a	20.1 a	37.3 a	11.0 a	8.9 a	4.2 a
G 9053	4.2 ab	32.7 a	19.7 a	43.3 a	10.2 a	8.7 a	3.9 a
G 10134	3.9 b						
Spacing (Subplot)							
10 × 50	4.3 a	33.3 a	20.0 a	38.1 a	10.1 a	9.0 a	4.0 a
15 × 50	4.1 a	33.1 a	19.7 a	40.7 a	11.3 a	8.7 a	4.2 a
20 × 50	4.2 a	32.3 a	20.0 a	37.3 a	10.5 a	8.6 a	4.2 a
25 x 50	4.1 a	32.6 a	19.9 a	41.9 a	10.8 a	8.9 a	4.1 a
			Spring				
Variety (Main plot)							
AGS 292	3.7 b	32.8 c	18.4 b	41.1 b	11.5 a	9.4 a	4.3 a
G 9053	4.2 a	34.4 b	19.0 ab	42.5 a	9.4 b	9.4 a	4.2 a
G 10134	4.2 a	35.9 a	19.7 a	42.7 a	8.6 c	9.7 a	4.5 a
Spacing (Subplot)							
10 x 50	4.1 a	34.5 a	19.2 a	41.9 a	9.7 a	9.7 a	4.3 a
15 x 50	4.1 a	34.4 a	19.1 a	42.2 a	9.8 a	9.6 a	4.3 a
20 x 50	4.1 a	34.5 a	19.0 a	42.2 a	9.9 a	9.4 a	4.3 a
25 x 50	4.0 a	34.0 a	18.8 a	42.1 a	10.0 a	9.4 a	4.5 a

[z]Means within a column followed by the same letter are not significantly different at 5% probability level by DMRT.

of G 101134 was higher than that of AGS 292 and G 9053 in autumn, but the harvest index (based on fresh weight of top parts) of G 10134 was lower than that of AGS 292 because of low water content in pods of G 10134. The less graded pod weight produced by G 10134 resulted in its lower graded pod yield per unit area.

It can be concluded therefore that the partitioning ratio of photosynthetic assimilate to the pod was poor in G 10134 which resulted in fewer pods and pod weight and the lower graded pod yield of G 10134.

Improvement of Harvest Efficiency of Processing Tomato

Summary

This study dealt with the use of growth regulators and simple mechanical harvesters for efficient harvesting of processing tomato. Ethrel promoted uniform maturity, and in combination with the harvester resulted in greater harvest efficiency.

Introduction

The use of mechanical harvesters for processing tomato is well adopted in developing countries. Some developing countries face greater labor shortage and higher labor cost problems. Previous trials showed that ethrel was the most effective growth regulator to enhance ripening of tomato. Two uniformly-maturing processing tomato varieties were evaluated under various cultural management practices (spacing, plant population, rate of fertilizer application) and ethrel treatments.

Materials and Methods

Two identical experiments were conducted on 7 October and 15 November 1988. The experiments were arranged in a split-plot design with subtreatments arranged in a randomized complete block design and replicated three times.

The main treatments were varieties and subtreatments were cultivation and harvesting methods. The subtreatments are presented in Table 7. The first trial was harvested on 10, 17, 24 January and 9 February 1989. The second trial was harvested on 17 and 27 March 1989.

The first and second subtreatments were sprayed with ethrel (39.5%, diluted 400 times) when 30% of the fruits turned red. Two weeks after spraying of ethrel, plants of the first treatment were cut one day before shaking the fruits into the harvester, whereas the fruits of the second treatment were manually harvested. The fruits of the third treatment were also manually harvested, but several times. All treatments were mulched with polyethylene sheets.

Table 7. Subtreatments utilized in harvesting once-over processing tomato.[z]

Subplot (no.)	Spacing (cm)	Plant/hill (no.)	Fertilizer (kg/ha)	Ethrel application 2 weeks before harvest	Harvest
1	150 × 30 cm	2	50N:100P_2O_5:50K_2O all as Basal	Yes	by harvester once-over
2	150 × 30	2	50N:100P_2O_5:50K_2O all as Basal	Yes	by hand once-over
3	150 × 40	1	150N:150P_2O_5:150K_2O 1/2 Basal, 1/2 Sidedressing	No	by hand several times

[z]Main plot: cultivar PT 4121 and UC 82.

Results and Discussion

Ethrel treatments received lower amounts of fertilizer (50 N : 100 P_2O_5 : 50 K_2O kg/ha), had narrower spacing (30 cm within rows), and higher populations (44,000 plants/ha). These factors limited

the plants' vegetative growth. The ethrel treatments showed a more uniform maturity rate (20-30%) than the traditional management check in both experiments. At harvesting, ethrel once-over treatments had significantly different effects compared with traditional management check. Ethrel plus harvester treatment saved the most amount of labor (Tables 8 and 9). Both ethrel treatments had a significantly higher unit hour harvest output than the traditional treatment (Table 8) while only ethrel plus machine harvester had a significantly different harvest efficiency than the other two treatments (Table 9).

Marketable fruit yield. Traditional management practices showed a significantly higher yield than ethrel treatments, especially ethrel plus mechanical harvesting. This was mainly due to more fertilizers applied and partly because of over maturity which caused some fruits to rot. Ethrel treatments exhibited different nonmarketable fruit weights compared to the check (traditional treatment) in both trials. Ethrel treatments gave greener fruits but had a shorter growing period (10 to 21 days) than the traditional practices.

The use of a mechanical harvester was found more efficient than manual harvesting. No differences were observed in harvest efficiency between two ethrel treatments because the operator was not familiar with the machine.

pH, Brix and acidity. There were no significant differences in fruit pH, Brix and acidity among the three subplot treatments.

The harvester utilized was a very simple machine. However, it still seems useful for the small farmer. The plate of the machine should be modified to roll the fruits faster and the teeth of the conveying belt should be broadened to easily catch the big fruits.

The variety UC 82 had the jointless gene and was easy to shake off the vine. PT 4121 had joints and was not easy to pick or shake off, thus it required more labor at harvest than UC 82.

Measurement of Direct Heat Injury to Roots of Seven Vegetable Species

Summary

Root systems of Chinese cabbage, soybean, mungbean, sweet potato, sweet pepper, hot pepper and tomato plants were measured for membrane thermostability after incubation at 25°, 35°, 40°, 45°, 50° and 60°C for 30 min. Membrane leakiness increased with increasing temperatures. About 50% heat injury occurred at 47.7 ± 0.5°, 48.7 ± 0.5°, 49.0 ± 0.5°, 50.5 ± 0.5°, 51.2 ± 0.5° and 54.7 ± 0.5°C in roots of tomato, Chinese cabbage, soybean, mungbean, sweet pepper, hot pepper and sweet potato, respectively. Intact roots of sweet potato appeared to withstand direct heat injury. Roots of soybean slightly withstood heat, whereas roots of tomato and Chinese cabbage were most sensitive.

Introduction

Soil temperatures higher than air temperatures are due primarily to the effects of direct or reflected solar radiation hitting soil surface. Similarly, solar radiation would raise temperatures in pots or hydroponics with container sidewalls, designs and colors which promote radiation absorption. Soil temperatures in polyethylene mulched-raised beds in excess of 50°C have been reported, although such extreme temperatures normally persist for less than 1 hour each day. Fast and extreme temperature fluctuations reduced plant growth or caused plant mortality. Root mortality caused by short exposures to these extremes may be due to direct injury from loss of membrane integrity. This injury can be detected immediately at the cellular level. Electrolyte leakage techniques have been employed to determine the temperatures resulting in direct injury to cell membranes of certain plant roots.

Based on electrolyte leakage techniques, AVRDC previously reported that vegetable species and genotypes within species differ in heat tolerance. This research was initiated to determine the temperature

Table 8. Comparison between manual harvesting and mechanical harvesting of processing tomato.[z]

Treatment	Harvest labor (min/m^2)	Fruit weight harvested (kg/h)	Marketable fruit (t/ha)	Non-marketable fruit (t/ha)	Green fruit (t/ha)	Days to flowering	pH at harvest	Brix	Acidity
Main treatments									
PT 4121	4.8 a[y]	134.8 a	82.6 a	2.8 a	8.5 a	19.8 a	4.30 a	3.9 a	0.24 a
UC 82	3.2 b	144.5 a	63.9 b	1.4 b	6.6 a	14.3 b	4.31 a	3.0 b	0.19 b
Subtreatments									
Ethrel, mechanical harvesting	2.03 c	175.5 a	51.0 b	3.1 a	4.9 b	18.0 a	4.33 a	3.5 a	0.20 a
Ethrel, manual harvesting	4.03 b	143.9 a	76.6 ab	2.2 b	12.2 a	18.2 a	4.31 a	3.4 a	0.22 a
Traditional management and harvest	6.04 a	99.6 b	92.3 a	1.0 c	5.5 b	15.0 b	4.27 a	3.5 a	0.22 a

[z]Date transplanted: 7 October 1988; Date harvested: 10, 17, 24 January and 9 February 1989. [y]Means within main or subtreatment (within a column) followed by the same letter are not significantly different at 5% probability level by DMRT.

Table 9. Comparison between manual harvesting and mechanical harvesting of processing tomato.[z]

Treatment	Harvest labor (min/m^2)	Fruit weight harvested (kg/h)	Marketable fruit (t/ha)	Non-marketable fruit (t/ha)	Green fruit (t/ha)	Days to flowering	pH at harvest	Brix	Acidity
Main treatments									
PT 4121	6.7 a[y]	107.3 a	88.4 a	2.7 a	5.5 a	31 a	4.2 a	4.4 a	0.3 a
UC 82	4.8 a	144.1 a	79.6 b	1.7 b	3.3 a	30 a	4.3 a	4.1 a	0.3 a
Subtreatments									
Ethrel, machine harvest	3.0 c	219.6 a	80.6 b	1.2 b	4.8 ab	31 a	4.3 a	4.2 a	0.3 a
Ethrel, hand harvest	6.2 b	80.6 b	75.0 c	1.5 b	5.7 a	31 a	4.3 a	4.4 a	0.3 a
Traditional management and harvest	8.1 a	77.0 b	96.3 a	3.9 a	2.6 b	30 b	4.3 a	4.1 a	0.3 a

[z]Date transplanted, November 15, 1988, Date harvested, 17 and 27 March 1989. [y]Means within main or subtreatment (within a column) followed by the same letter are not significantly different at 5% probability level by DMRT.

causing direct heat injury to root systems of seven vegetables. It is imperative to determine the maximum temperature at which root systems will survive for a short time so that cultural practices or hydroponics aimed at reducing maximum soil or container medium temperatures can be evaluated. Electrolyte leakage techniques were employed to measure membrane thermostability of intact root systems of seven vegetable species.

Materials and Methods

Seeds of Chinese cabbage (B-40), hot pepper (Passion), mungbean (VC 1973A), soybean (AGS 292), sweet pepper (Blue Star) and tomato (EMTT-3), and cuttings of sweet potato (CN 1489-89) were planted in small plastic pots with smoldered rice hulls as growing medium. Seedlings were grown in the greenhouse until they were randomly selected, 21 to 41 days after planting, to determine the heat response in the root system.

Plants were removed from the pots. Root systems were washed with tap water to remove the rice hulls followed by deionized water. Root systems attached to the shoot were placed in test tubes with 2 ml of deionized water and immersed in a water bath for 30 min at 25°, 35°, 40°, 45°, 50° and 60°C. Shoots were extended from the test tubes above the water bath. There were four plants per temperature treatment in each of four replicates.

About 0.5 g samples of actively growing roots of temperature-treated plants were cut into 10 mm sections, placed in test tubes with 10 ml of deionized water in test tubes (2 × 15 cm), and incubated at 25°C for 20 min. Electrical conductivity of each solution was then measured by a YSI Model Conductance Meter immediately. Roots were subjected to boiling point at 100°C for 30 min and allowed to cool at 25°C before conductivity readings were taken again. Heat injury was expressed as the percentage of solution conductivity between the two measurements.

Results and Discussion

Percentage of electrolyte leakage from intact roots plotted against treatment temperatures revealed sigmoidal relationships among seven vegetable species. Shapes of individual response curves were similar among seven vegetable species. Electrolyte leakage rapidly increased from 45° to 60° in all vegetables. At 50°C direct heat injury, roots of seven vegetables except sweet potato resulted in 50% injury. Within 25° to 45°C, intact roots of sweet potato appeared most effective to withstand direct heat injury. Roots of soybean displayed an intermediate response while roots of Chinese cabbage were most sensitive.

Temperatures resulting in 50% injury are usually expressed as the critical point on the response curve. This point would therefore be useful in comparing among species of genotypes. Direct extrapolation on the response curve drawn through the array of points showed that critical points are: 54.7 ± 0.5°, 51.2 ± 0.5°, 50.5 ± 0.5°, 50.0 ± 0.5°, 49.0 ± 0.5°, 48.7 ± 0.5° and 47.7 ± 0.5°C for sweet potato, hot pepper, sweet pepper, mungbean, soybean, Chinese cabbage and tomato, respectively.

Electrolyte leakage measurement was an effective means to determine the end of intact roots. Temperatures which caused direct injury appeared highest in Chinese cabbage and the lowest in sweet potato. Relative heat tolerance of the root systems followed the ranking based on field performance. Cultural practices aimed at reducing or eliminating heat injury to roots with raised bed and mulching or containerized roots must at least keep the daily maximum root temperatures below 50°C, depending upon species. However, longer exposures to root temperatures slightly below these critical temperatures could reduce growth for most vegetables except sweet potato and soybean.

Cropping Systems

Collection and Testing of New Vegetables

Summary

A total of 606 crop varieties were collected in 1989. Observation trials for broccoli, eggplant, onion and spinach and advanced yield trials of broccoli and eggplant were conducted during 1989. Fifteen entries of broccoli, 15 of eggplant, 18 of onion and 15 of spinach were selected based on their yield potential and other horticultural characteristics for inclusion in the advanced yield trials for further confirmation. Broccoli entries, BR 13 and No. 441, and eggplant, F 100 and Nite King, performed consistently well in these trials. The major production constraints observed were diamondback moth (*Plutella xylostella*) and black rot (*Xanthomonas campestris* pv. *campestris*) on broccoli; bacterial wilt (*Pseudomonas solanacearum*) on eggplant; purple leaf spot (*Alternaria porri*) and bolting on onion; and downy mildew (*Peronospora spinaciae*), Sclerotinia rot (*Sclerotinia sclerotiorum*), and flowering for spinach.

Introduction

This study aimed to gather more information on tropical vegetables for AVRDC's nutrition garden project, bilateral programs and cooperators. The second set of new vegetables was selected in 1986. Commercially available cultivars of these crops were evaluated under tropical environments. A total of 606 varieties were collected in 1989 (Table 1). Observation trials for broccoli, carrot, cucumber, eggplant, lettuce, and spinach were conducted. However, trials for cucumber and carrot were damaged by heavy rain in August.

Table 1. Collection of new vegetable crops.

Vegetables received	Scientific name	No. of varieties
Broccoli	*Brassica oleracea* var. *italica*	49
Carrot	*Daucus sativa*	83
Cucumber	*Cucumis sativus*	84
Eggplant	*Solanum melongena*	34
Hyacinth bean	*Dolichos lablab*	4
Kangkong	*Ipomoea aquatica*	24
Leaf amaranth	*Amaranthus* spp.	12
Leaf lettuce	*Lactuca sativa*	112
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*	69
Spinach	*Spinaciae oleracea*	56
Yardlong bean	*Vigna unguiculata* var. *sesquipedalis*	16
Total		606

Materials and Methods

Varieties of broccoli (48), eggplant (34), onion (62) and spinach (53), respectively were evaluated for their performance in autumn 1988. Trials were laid out in a randomized complete block design with two replications. The spacing was 75 × 50, 150 × 50, 20 × 10 and 30 × 20 cm, for broccoli, eggplant, onion and spinach, respectively. Fifteen varieties each of broccoli and eggplant were selected for preliminary yield trials in late spring and summer 1989, respectively.

Results and Discussion

Broccoli. Varieties of broccoli performed better in autumn than in late spring 1988 with mean yield of 12.4 and 7.4 t/ha, respectively. This was mainly attributed to differences in temperature; the average daily mean air temperature was 20.5 and 25.0°C in autumn and late spring, respectively. Among 48 entries, 26 had similarly varying yields from 16.7 to 12.5 t/ha. However, there were significant differences in growth duration (from 51 to 92 days) among entries. The 15 highest yielders are listed in Table 2.

A set of 15 varieties were selected for the advanced trial in spring 1989 based on their high yield potential and early maturity. Their growth durations were similar (from 48 to 55 days). BR 13 and No. 441 performed better than others (Table 3). No. 441 performed consistently well in all yield

Table 2. Yield and horticultural characters of broccoli varieties, autumn 1988.[z]

Acc. no.	Entry	Yield (t/ha)	Days to maturity	Mean head wt. (g)	Leaf weight (g)	Head length (cm)	Head width (cm)
1	Calabrese 90 days	13.7 a-e	92	525	1816	27.4	12.0
2	Comet F_1 364	13.9 a-e	51	521	856	23.9	13.9
3	Ramoso di Calabria Precoce	13.9 a-e	78	599	1757	26.6	11.2
4	Ramoso Calabria Mezzo Precoce	14.7 a-d	78	588	1876	27.2	12.3
5	Ramoso Calabrese Tardivo	15.2 a-c	79	610	1745	26.6	10.2
13	No. 443	13.5 a-e	54	496	785	26.4	12.9
14	No. 441	16.0 ab	52	600	717	25.5	12.1
18	Dandy Early	13.7 a-e	51	523	617	25.8	13.5
24	AVX 8009	13.8 a-e	61	519	1331	25.4	11.1
26	SG1 (F_1)	15.1 a-c	59	567	1042	26.1	11.3
34	Green Goliath	13.6 a-e	54	521	725	24.5	12.9
38	PSX 17883	13.8 a-e	65	557	1080	25.9	12.0
39	Hybrid Pirate	16.7 a	85	701	1600	25.8	13.7
42	Ultra Green	16.1 ab	58	668	632	25.1	11.6
45	2-L green (F_1)	15.3 a-c	64	575	894	26.3	12.0

[z]Planted on 5 Oct. 1988. Harvested on 14 Dec. 1988 – 11 Jan. 1989. Entries: 48

Table 3. Yield and horticultural characters of broccoli varieties, spring 1989.[z]

Acc. no.	Entry	Yield (t/ha)	Days to maturity	Mean head wt. (g)	Leaf weight (g)	Head length (cm)	Head width (cm)	Non-flowering (%)
2	Comet 364	5.6 fg	55	273	742	24.3	10.9	17.9
11	Sprinter	3.6 h	55	271	897	22.8	9.1	29.2
12	39913-556	7.6 de	55	314	540	24.9	10.6	8.3
13	No. 443	3.7 gh	55	268	708	25.0	8.3	26.3
14	No. 441	10.4 ab	48	425	789	24.3	11.4	7.1
18	Dandy Early	9.6 bc	55	430	556	24.6	11.4	7.1
19	No. 02-067	8.07 c-e	48	410	805	25.4	12.8	11.3
20	Moragod CT 31	7.1 ef	55	373	966	24.7	11.9	16.7
21	Toro CT 21	9.3 b-d	48	386	797	26.0	11.6	1.3
28	Stolto	9.5 b-d	48	388	773	25.6	12.6	0
32	BR #13	12.2 a	55	509	976	24.9	13.2	4.2
33	BR #5	8.8 b-e	55	359	645	24.7	11.5	1.3
40	YS 6163	9.0 b-e	46	351	788	25.3	12.9	1.3
42	Ultra Green	9.6 bc	55	371	698	24.4	11.2	2.9
49	Green King	8.4 c-e	55	376	815	24.7	11.7	5.4
LSD 0.05		2.0	2.3	97	193	1.1	2.3	

[z]Planted on 12 April 1989.

trials (even in late spring 1988). BR 13 was also the best yielder in late spring 1988. The major biotic constraints were diamondback moth and black rot.

Eggplant. The average yield (51.2 t/ha) of 34 eggplant varieties in autumn was lower than that (61.0 t/ha) in summer. The average daily mean air temperature was 19.3 and 26.8°C, in autumn and spring trials, respectively. F 100 and Galine Hybrid-F 1 performed well among entries in spring (Table 4). There were no significant differences in days to maturity among 15 highest yielding varieties. Their growth durations were in the middle group and significantly different from either the late (122 days) or early (97 days) maturing entries. Their fruit sizes varied from 131 to 577 g per fruit (Table 4).

Based on high yield potential and quality and taste, 15 varieties were selected for inclusion in the advanced trial in summer 1989. F 100 and Nite King were the best yielders among entries. F 100 performed best among entries in all trials. Both trials suffered from bacterial wilt infection.

Table 4. Yield and horticultural characters of eggplant varieties.

Acc. no.	Entry	Yield (t/ha)	Days to maturity	Size (g)	Fruit color	Shape
	Autumn 1988[z]					
3	No. 29 (F_1)	63.8 b-f	112	443	Dark purple	Round
8	Fontana F_1	58.4 c-g	117	488	Dark purple	Short oval
10	Ingfrat	68.8 b-d	117	452	Dark purple	Round
13	Black Beauty	61.3 b-g	113	577	Dark purple	Short oval
14	Agora	73.6 b	113	444	Dark purple	Short oval
17	Soma F_1	59.2 c-f	111	449	Dark purple	Short oval
18	Bonesa F_1	60.8 b-g	112	444	Dark purple	Short oval
19	Solara F_1 RS	70.3 bc	113	331	Dark purple	Semi long
20	Murena F_1	74.4 b	108	363	Dark purple	Short oval
23	5223-2	65.9 b-e	108	437	Dark purple	Round
24	Hybrid Epic	67.2 b-e	111	335	Dark purple	Short oval
25	F-100	99.9 a	114	461	Dark purple	Short oval
26	Hybrid Nite King	66.4 b-e	108	250	Dark purple	Round
28	Hybrid Easter Egg	56.7 c-g	109	131	White	Round
30	Galine Hybrid F_1	93.7 a	111	463	Dark purple	Short oval
	Summer 1989[y]					
1	Onita	17.4 gh	81	133	Dark purple	Semi long
5	Terong Ungan Bulat	33.2 ef	79	146	Purple	Oval
8	Fontana	44.5 b-d	80	384	Dark purple	Short oval
11	CT Chao Praya	14.1 h	88	48	Light green	Oval
12	Florida Market	39.7 c-e	83	354	Dark purple	Short oval
13	Black Beauty	41.7 b-e	80	426	Dark purple	Short oval
19	Solara	38.1 c-f	78	233	Dark purple	Semi long
22	Ma 83004	38.3 c-f	80	218	Dark purple	Short oval
25	F 100	63.0 a	77	332	Dark purple	Short oval
26	Nite King	52.5 ab	78	392	Dark purple	Oval
28	Easter Egg	27.4 fg	75	82	White	Oval
31	Masu Eggplant	34.6 d-f	81	91	Dark purple	Long
32	Pingtung Long	46.1 bc	78	119	Purple	Long
33	Birde	43.1 b-e	78	80	White light purple	Long
34	Farmer's Long	35.2 c-f	78	78	Purple	Long
LSD 0.05			4.5	57		

[z]Planted on 5 Oct. 1988. Harvested on 5 Dec. 1988 16 Mar. 1989. [y]Planted on 30 May 1989. Harvested on 18 July-31 Aug. 1989.

Onion. There were 62 entries in the autumn trial. The average mean air temperature was 19.6°C. There were great variations in yields among entries even among 24 highest yielding varieties (Table 5). All best yielders, namely, NIZ 1003, PSX 680, Superlex, XPH 3325 and Granex 429 had relatively large bulbs. XPH 3325 had a relatively high rate of bolting but had firm bulbs. Trials suffered from purple leaf spot and bolting.

Spinach. There were 53 entries in the autumn trial. The average mean temperature was 18.1°C. The mean yield was 15 t/ha. About 23 entries had higher yields. The 15 highest yielders are listed in Table 6 with Carpo Hybrid F_1 and XPH 1501 (F_1) on top. There were significant differences in growth duration among all entries, varying from 47 to 60 days. Downy mildew and Sclerotinia rot were the most serious diseases observed. Some entries bore flowers.

Table 5. Yield and horticultural characters of onion varieties, autumn 1988.[z]

Acc. no.	Entry	Yield (t/ha)	Days to maturity	Mean bulb size (g)	Bulb skin color	% of bolting	Brix	Firmness[y]	Fruit shape
15	Superlex	86.3	135	332	Brown	0	5.6	3.6	Granex
16	Extrema	17.7	135	128	Brown	0	5.4	4.2	Flat
20	Early Texas Yellow Grano 502	15.7	196	392	Pink	0	7.0	7.0	Globe
23	Hybrid Yellow Granex	66.5	135	333	Brown	0	6.0	4.9	Flattened globe
24	AVX 1011	26.6	148	266	Brown	0	6.5	4.2	Globe
26	Granex 429	76.4	148	405	Brown	0	6.0	5.6	Globe
27	XPH 3325	79.8	148	353	Brown	8.3	9.5	6.3	Flattened globe
31	Texamo	38.6	135	193	Brown	0	6.0	3.5	Globe
38	Texas Yellow Grano	62.2	142	400	Brown	14.8	11.5	4.0	Globe
39	Texas Grano	60.2	156	361	Brown	4.8	9.5	4.3	Globe
40	PSX 680	87.4	142	353	Brown	0	11.5	4.2	Flattened globe
41	Granex Y PRR	76.3	148	359	Brown	0	8.5	3.8	Semi globe
42	PSX 1029	66.7	148	348	Brown	0	8.5	3.1	Globe
47	NIZ 1003	96.7	148	497	Brown	0	4.0	3.7	Globe
48	NIZ 1016	52.4	148	324	Brown	1.4	8.0	3.0	Globe
49	Evita (NIZ 1006)	36.9	166	397	Brown	0	8.5	2.8	Deep globe
52	4-LC 3-3	70.3	148	367	Brown	0.6	4.5	2.5	Globe
53	4-Lg 7-3	40.5	156	338	Brown	0.8	4.5	5.8	Globe
54	4-Lg 7-4	61.8	148	309	Brown	0	6.0	5.0	Globe
58	Henry's Special	65.2	135	318	Brown	0	8.0	4.3	Globe
59	Gold Rush	51.8	135	255	Brown	0	8.0	5.5	Flattened globe
60	Red Comonander	53.5	135	208	Red	3.2	10.5	5.0	Granex
61	Tainan #1	61.6	135	212	Brown	5.6	6.0	5.3	Globe
62	Tainung #3	56.5	142	228	Brown	0.7	9.5	4.9	Granex

[z]Planted on 20 Oct. 1988. Harvested on 3 Mar-3 May 1989. Entries: 62. [y]Firmness is expressed as the deformation distance (mm) when pressure reaches 500 g/cm^2.

Table 6. Yield and horticultural characters of spinach varieties, autumn 1988.[z]

Acc. no.	Entry	Yield (t/ha)	Days to maturity	Leaf no.	Mean (g)	Leaf[y] color	Plant[x] type
5	Matador	17.0 a-g	56	17.7	224	2	4
9	Orient	20.0 a-f	49	21.6	143	2	2
11	Torai	21.3 a-d	49	10.3	166	2	2
14	Dertate Dingegnoli	19.8 a-f	52	12.6	164	3	3
16	Rox eye (F_1)	20.2 a-e	51	8.2	158	2	2
19	Carpo Hybrid F_1	23.5 a	52	13.4	157	2	3
26	XPH 1510 (F_1)	23.2 ab	49	15.6	162	2	3
32	Miko (SG 514)	17.8 a-g	52	12.8	119	2	4
34	SG 520 F_1	17.7 a-g	49	12.9	110	2	3
35	OE 3188 F_1	19.7 a-f	52	11.9	144	3	3
37	Kir Kasprih	22.3 a-c	48	19.0	141	1	3
38	Viroflex	17.2 a-g	52	12.3	126	2	3
40	Marisca (RS 1224) F_1 RS	17.3 a-g	52	13.0	124	3	3
45	Hybrid Spinach Utopia	17.5 a-g	52	18.0	154	2	3
53	Local	17.3 a-g	49	16.2	94	1	1

[z]Sown on 1 Nov. 1988. Harvested on 15-30 Dec., 1988. Entries: 53. [y]1 = yellow green; 2 = green; 3 = dark green [x]1 = upright; 2 = semi upright; 3 = semi spreading type; 4 = spreading type.

Garden Program

Summary

Since 1987, garden research has been focused on gathering information on individual crops and the possible spatial interactions between crops. The characteristics which might be used in the garden design from 102 varieties of 42 vegetables were recorded from the school and home gardens and placed in the Tropical Vegetable Data File (TVDF) during 1989. Their nutrient contents were analyzed and nutrient production on a garden basis was calculated. Similar data were also collected from 89 varieties of 32 vegetables under the noncirculating hydroponic system to evaluate their adaptability for this urban garden system in 1989. All data were compiled and an expert system for crop selection was developed.

Introduction

The AVRDC garden program aims to improve the nutrition and income of people in the tropics. Research in the first phase of this program demonstrated that a 4 × 4 m garden can supplement a significant percentage of the nutritional needs of a family (with five members) on a year-round basis. Hence, studies in the second phase which started in 1987 were focused on the methodology of garden design and management. Since information on vegetable production in the tropics was hardly accessible, a data base was established using data obtained from garden studies. The key characteristics of vegetables needed for garden planning in the tropics were identified by testing the productivity (weight of edible part, vitamin or mineral) of a garden designed from information from the data base. These data were compiled in an application form when choosing a crop (or variety) for a particular cropping pattern, locality or purpose. An expert system for the crop selection was developed.

Materials and Methods

Home and school gardens. Four home gardens each consisting of 18 1.2 × 0.7 m plots and a school garden consisting of 48 1.2 × 1.5 m plots were planted to different vegetables. These gardens were used for data collection on individual crops and interactions between crops. Each plot was coded. The nutrient contents of 102 varieties of 42 vegetables were analyzed and nutrient production on a garden basis was calculated. These data were analyzed and stored in a database. A retrieval method using readily available computer programs for crop selection was established.

Urban home garden. The noncirculating hydroponic system was adopted for urban home gardens. This system was found economical, clean and easy to manage. Evaluation focused on suitability of different vegetables under this system. The setup of hydroponic systems was shown in the 1987 and 1988 Progress Reports.

Results and Discussion

Home and school gardens. Data on yield, growing and harvesting periods and other characteristics were collected. The coefficient of variation for each character of a crop variety was also calculated to estimate the possible variation within crops. With this information, expected yield can be estimated for a chosen group of vegetables in a certain garden size. These data were utilized to find out the relationship between yields of a particular variety or crop and climatic conditions.

Using a data base program, a preliminary test was carried out to sort and retrieve these data for crop selection. For example, a group of vegetables was identified suitable for growing under mean

air temperature higher than 28°C for less than 45 or 90 days (Table 7). Although data base programs in personal computers for crop selection are convenient and feasible, they need further testing and validation to identify key attributes for vegetable selection in the tropics.

Using data on yield and nutrient content of each vegetable tested, nutrient production on a garden basis and their contribution ratios to recommended daily allowance (RDA) for a family with five members in a 15-day period during the year were calculated. Results indicated that vitamin C from these vegetables was higher than 150% RDA in each period. Other nutrient contributions showed a seasonal variation with lower production in summer than in the other seasons (Fig. 1). Vitamin A was more than 100% RDA in most periods. Iron varied from 30% to 130%, and calcium from 20% to 50%. These results confirmed that a 4 × 4 m garden can produce 80% of vitamins A and C, and 40% of iron and calcium of the RDA for a family of five.

Table 7. Vegetables selected for high temperatures and different growth durations.

Vegetable	Variety	Yield (kg/m^2)	Duration (day)
Mean temperature ≥ 28		Duration ≤ 45	
Amaranth	Softgreen	1.6 ± 1.3	28.3 ± 5.4
Amaranth	Tigerspot	1.2 ± 0.6	27.6 ± 2.5
Amaranth	White KY	2.5 ± 0.5	23.5 ± 1.7
Amaranth	White Lien	2.3 ± 1.7	25.3 ± 4.0
Ching Chiang	Chang Hi	0.6 ± 0.3	34.8 ± 6.2
Ching Chiang	KY	0.1	28.0
Kale	Sie Su	0.6 ± 0.2	42.0 ± 0
Kangkong	Improved	4.2 ± 1.4	27.2 ± 2.9
Kangkong	Large-leaf	4.2 ± 0.2	31.0 ± 0
Kangkong	Ping Tung	2.9 ± 1.2	26.2 ± 2.8
Kangkong	White Cane H.K.	1.4	28.0
Lettuce	Grand Rapid	0.5	39.7 ± 1.2
Lettuce	Kang Tung	0.7 ± 0	36.0 ± 0
Paitsai	Feng Shen	0.8 ± 0.6	31.0 ± 3.2
Paitsai	Golden	0.3	29.0 ± 0
Paitsai	Singapore	1.4	28.0
Paitsai	South Asia	0.8	34.0
Rape Green	40-Day Edible	0.4	35.0
Rape Green	You-tsai-shin	0.2	38.9 ± 3.8
Mean temperature ≥ 28		Duration > 45 ≤ 90	
Amaranth	Softgreen	1.6 ± 1.3	28.3 ± 5.4
Amaranth	Tigerspot	1.2 ± 0.6	27.6 ± 2.5
Amaranth	White KY	2.5 ± 0.5	23.5 ± 1.7
Amaranth	White Lien	2.3 ± 1.7	25.3 ± 4.0
Chinese cabbage	82-156	2 ± 0.4	77.0 ± 3.1
Chinese cabbage	ASVEG 1	11.4 ± 0.8	83.0 ± 2.3
Ching Chiang	Chang Hi	0.6 ± 0.3	34.8 ± 6.2
Ching Chiang	KY	0.1	28.0
Kale	Sie Su	0.2	42.0 ± 0
Kangkong	Improved	4.2 ± 1.4	27.2 ± 2.9
Kangkong	Large-leaf	4.2 ± 0.2	31.0 ± 0
Kangkong	Ping Tung	2.9 ± 1.2	26.2 ± 2.8
Kangkong	White Cane H.K.	1.4	28.0
Lettuce	Celtuce	0.8	47.0
Lettuce	Grand Rapid	0.5	39.7 ± 1.2
Lettuce	Kang Tung	0	36.0 ± 0
Paitsai	Feng Shen	0.8 ± 0.6	31.0 ± 3.2
Paitsai	Golden	0.3	29.0 ± 0
Paitsai	Singapore	1.4	28.0
Paitsai	South Asia	0.8	34.0
Rape Green	40-Day Edible	0.4	35.0
Rape Green	You-tsai-shin	0.5 ± 0.2	28.9 ± 3.8
Vegetable Soybean	AGS 292	0.8 ± 0.3	65.0 ± 4.1

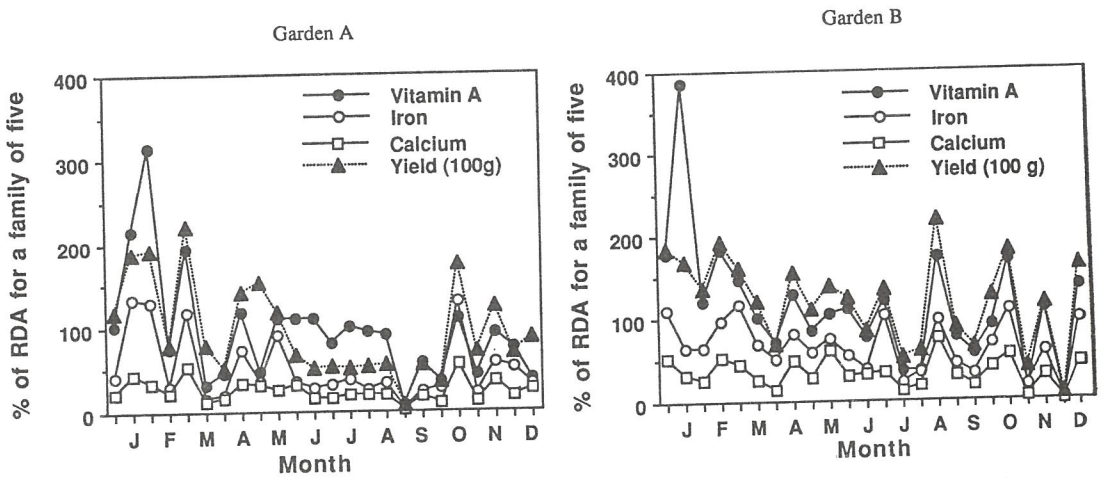

Fig. 1. Yield and contribution ratio of vegetable nutrients obtained in gardens, 1989.

Urban home garden. There were 89 varieties of 32 vegetables tested under this system. Results showed that almost all vegetables are well adapted to this system. However, high temperature constraint for many vegetables during summer could not be overcome by this production system. In these trials poor restricted development was observed during summer (Table 8) perhaps due to low oxygen content in solution. It appears that the technique to enhance root growth under high temperature warrants further study to improve the growth of vegetables not only under this hydroponic systems but also under field conditions.

Table 8. Yield and root weight of some vegetables in an urban garden (hydroponic).

Crop	Variety	Season	Yield (g/box)	Yield CV (%)	Root wt. (g/box)	Root wt. CV (%)	Root/shoot (%)
Ching chiang	Chang-Hi	Summer	583	41.6	77.8	39.9	13.3
Ching chiang	Chang-Hi	Winter	522	100.0	109.2	100.0	20.9
Ching chiang	KY	Summer	632	44.4	98.1	49.7	15.5
Ching chiang	KY	Winter	383	14.2	82.5	5.2	21.5
Chrysanthemum	Tiger Ear	Summer	57	72.5	21.7	66.2	38.1
Chrysanthemum	Tiger Ear	Winter	541	39.8	178.3	40.9	33.0
Kale	Golden Round Leaf	Summer	215	73.9	38.0	73.3	17.7
Kale	Golden Round Leaf	Winter	280	14.3	75.0	6.7	26.8
Kale	Pointed Leaf	Summer	314	55.2	69.4	60.8	22.1
Kale	Pointed Leaf	Winter	345	41.9	111.7	49.4	32.4
Lettuce	Grand Rapid	Summer	728	38.1	128.1	31.2	17.6
Lettuce	Grand Rapid	Winter	782	21.6	141.7	29.9	18.1
Lettuce	USA Red	Summer	285	100.4	47.5	82.0	16.7
Lettuce	USA Red	Winter	855	20.8	143.8	30.3	16.8
Mustard	Shin-Ju Early	Summer	384	63.4	57.2	48.9	14.9
Mustard	Shin-Ju Early	Winter	365	31.5	45.0	33.3	12.3
Paitsai	Ky No. 2	Summer	293	40.7	53.3	48.4	18.2
Paitsai	Ky No. 2	Winter	365	23.3	70.0	14.3	19.2
Paitsai	Nilong	Summer	549	52.4	47.5	53.1	8.7
Paitsai	Nilong	Winter	678	27.1	145.0	43.0	21.4
Paitsai	Singapore	Summer	689	48.2	68.6	54.8	10.0
Paitsai	Singapore	Winter	295	15.3	45.0	11.1	15.3
Paitsai	White Light	Summer	424	36.9	59.0	45.8	13.9
Paitsai	White Light	Winter	310	25.8	60.0	0.0	19.4
Rape Green	Yu-Tsai Sin	Summer	532	39.8	19.0	43.9	22.4
Rape Green	Yu-Tsai Sin	Winter	395	34.7	110.8	44.4	28.1
Spinach	Asron	Summer	30	117.9	10.0	70.7	33.3
Spinach	Asron	Winter	382	21.6	200.0	56.0	52.4

Intercropping of Sweet Potato and Legumes

Summary

This study evaluated different leguminous crops and examined their planting time relative to that of sweet potato to increase the productivity of sweet potato-based intercropping systems. Two soybean varieties (AGS 66 and AGS 129) one vegetable soybean (AGS 292), one mungbean (VC 3890 A) were intercropped with sweet potato (TN 67) on two relative planting dates (the same day or nine days after sweet potato transplanting) in late spring. Results showed that there were significant effects of genotypes, and relative planting dates of legumes on sweet potato yield and the combined yield. Planting of legumes nine days after sweet potato transplanting substantially reduced the competition between legumes and sweet potato. Among legumes, mungbean was dominated by sweet potato because of its slow initial growth. Mungbean was more suited for intercropping with sweet potato than other legumes. However, results of the combined yield indicated that late planting in spring is not suitable for sweet potato-legume intercropping compared to that in other planting seasons in previous trials. It was concluded that suitable genotypes and appropriate relative planting time should be identified to maximize the yield advantage of intercrops.

Introduction

Two component crops when intercropped usually compete with each other for growth resources such as light, nutrients and water. To minimize this competition and increase production, appropriate cultural practices such as choice of genotypes, plant populations and spatial arrangements and relative planting time should be adopted. This study evaluated different leguminous crops and examined their relative planting time to sweet potato in an intercropping system. This trial was carried out in late spring to compare with results from previous trials in different planting seasons and to determine the relationship between environment and agronomic management of these intercrops.

Materials and Methods

Two soybean genotypes (broad leaflet and early-maturing AGS 66 and narrow leaflet and late-maturing AGS 129), one vegetable soybean (AGS 292) and one mungbean (VC 3890 A) were intercropped with sweet potato (TN 67) on two relative planting dates. There were eight intercropping treatments arranged in a randomized complete block design with three replications. There were five sole cropping treatments including each of the above-mentioned crops. The spacing was 50 × 10 cm with two plants/hill (40 plants/m^2) for legumes, and 100 × 25 cm for sweet potato. In intercropped plots two rows of legumes were sown between rows of sweet potato (4 plants/m^2) Sweet potato was transplanted on 12 April and legumes were sown on 12 and 21 April 1989. The plot size was 4 m × 6 m. Mungbean, vegetable soybean, soybean AGS 66 and AGS 129 were harvested on 6 June, 1 July, 31 July and 7 August, respectively. Sweet potato samples were taken on 9 August and 8 September 1989. Yields of mungbean and soybean and yield, fresh and dry weights of component parts of sweet potato were recorded. The light interception of canopies in all treatments was monitored during canopy development and at final harvest of sweet potato.

Results and Discussion

The climatic conditions during this trial was from a dry cool toward a hot-humid season. There was heavy rainfall and high temperatures during the late growth stage of sweet potato this time compared to the previous summer and autumn seasons (Fig. 2).

Results of light interception clearly indicated that the mungbean canopy developed slowly compared to other crops (Fig. 3). Thus, sweet potato growth, in terms of light interception after the legumes' harvest was less affected by mungbean than soybean. Vegetable soybean sown nine days after sweet potato reduced light interception of sweet potato less than that sown on the same day as grain soybean sown at either date.

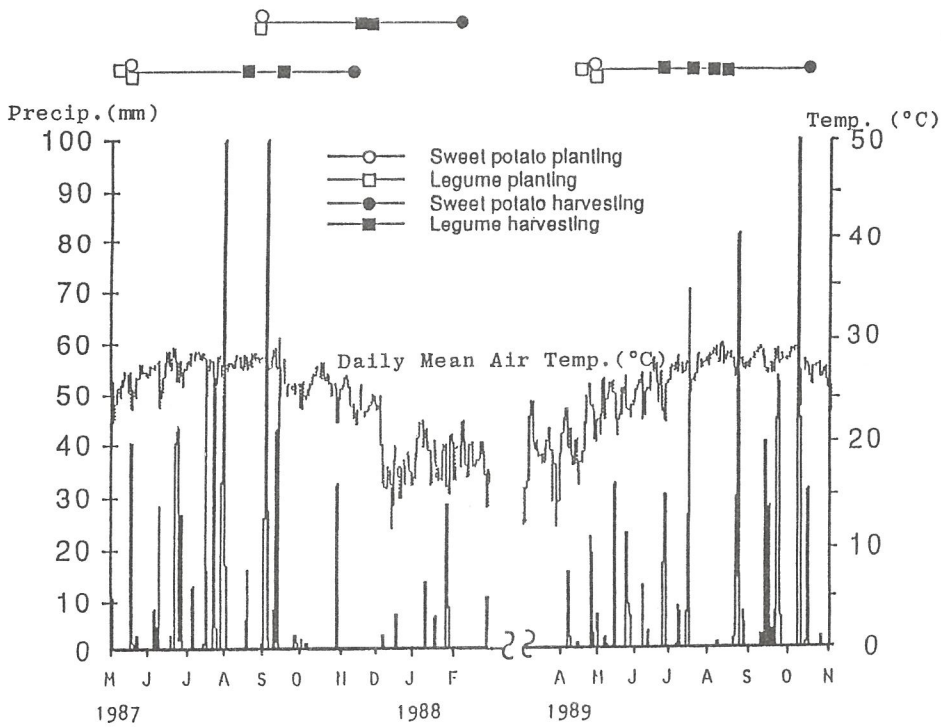

Fig. 2. Changes in mean daily air temperatures (°C) and daily rainfall during sweet potato-legume intercropping experiments.

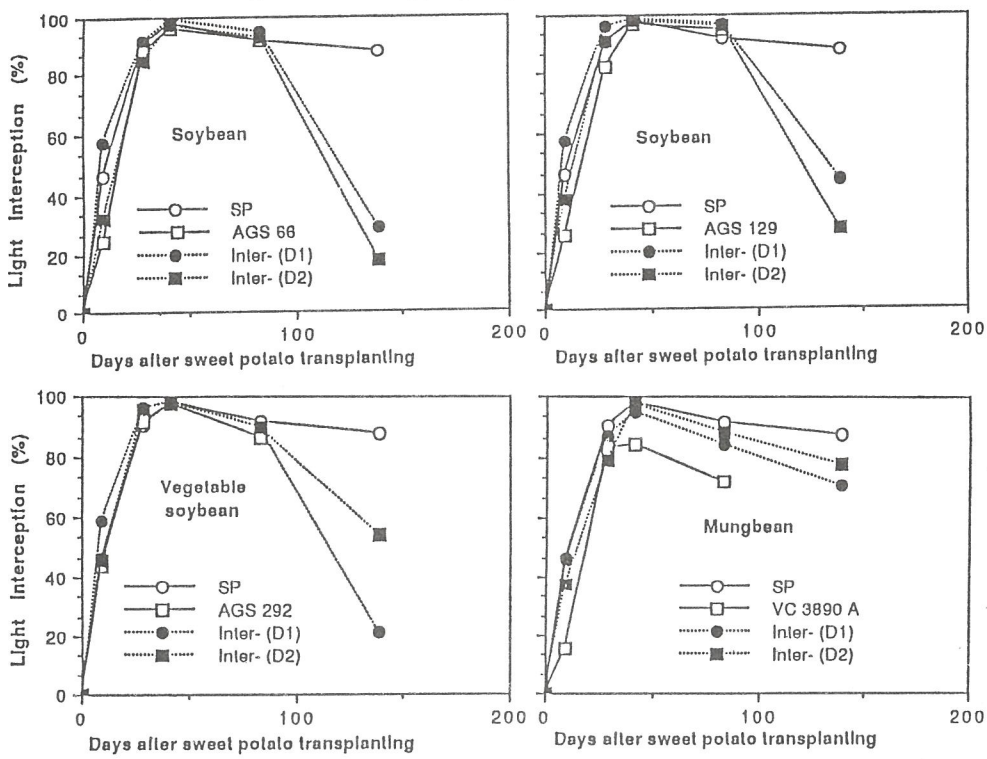

Fig. 3. Light interception of sole legumes, sweet potato and sweet potato-legume intercroppings in late spring.

In general, yields of all entries were relatively low. Only sweet potato-vegetable soybean intercropping had a combined yield advantage (LER >1). The other three intercrops had an LER close to one (Table 9). Among leguminous crops, the three soybean genotypes (including vegetable soybean) were dominant in intercropping. Their yields were not significantly affected when intercropped with sweet potato even though sowing was delayed by nine days after sweet potato transplanting. Mungbean was dominated by sweet potato, especially when it was sown after sweet potato (Table 10). Its yield declined from 0.8 t/ha in sole cropping to 0.4 and 0.2 t/ha in intercropping, when sown on the same day as and nine days after sweet potato transplanting, respectively. It appears that mungbean is sensitive to competition with other crops. Therefore, appropriate planting time should be identified.

Table 9. Yield (t/ha) and LER of sweet potato and legumes under intercropping.

Crop	Cropping	Soybean		Vegetable soybean	Mungbean
		AGS 66	AGS 129	AGS 292	VC 3890 A
Sweet potato	Sole-	13.0	13.0	13.0	13.0
	Inter-	0.3	0.2	2.4	8.5
	I/S	0.0	0.0	0.2	0.7
Legume	Sole-	1.4	1.4	3.5	0.8
	Inter-	1.3	1.1	3.8	0.3
	I/S	0.9	0.8	1.1	0.3
	LER	1.0	0.9	1.3	1.0

Table 10. Yield (t/ha) of legumes under sole cropping and intercropping with different planting times.

Cropping	Planting time[z]	Soybean		Vegetable soybean	Mungbean
		AGS 66	AGS 129	AGS 292	VC 3890 A
Sole-	0	1.4	1.4	3.5	0.8
Inter-	0	1.3	1.2	4.2	0.4
Inter-	9	1.4	1.1	3.5	0.2

[z]Planting time: Days after sweet potato transplanting.

Compared to previous sweet potato-soybean intercropping trials, soybean yielded relatively higher when intercropped. Soybean was less affected by sweet potato in intercropping during this trial than before (Table 11). Sweet potato had a low yield ratio in intercropped compared to sole-cropped plots. In fact, there was almost no marketable root harvested because the environmental conditions after soybean harvest were not favorable to root enlargement of sweet potato. Delay in harvesting from 120 to 150 days after planting did not increase root yield. Root yields in some treatments even declined (Table 12). Root yields of sweet potato were less affected by intercropped mungbean and was not influenced by planting time of mungbean. Mungbean seems suitable to associate with sweet potato. Mungbean yields can be increased without sacrificing sweet potato yields by manipulating the planting time. In sweet potato-vegetable soybean intercropping, the yield of sweet potato was significantly reduced by vegetable soybean. A delay of nine days in sowing provided sweet potato a stronger competitive position than when planted at the same day. Its shorter growth duration than that of grain soybean (30 days less) gave sweet potato more time to recover.

It can be concluded that sweet potato-legume intercrop performed better in cool dry than in hot wet season. If it is adopted across dry and wet seasons, planting should begin in wet season with maturity in the dry season. To maximize the yield advantage of intercrops, suitable genotypes and appropriate relative planting time should be identified.

Table 11. Yield (t/ha) and LER of sweet potato and soybean varieties under intercropping in different seasons.

Season	Cropping	AGS 66		AGS 129	
		Sweet potato	Soybean	Sweet potato	Soybean
Summer	Sole-	16.1	3.2	16.1	1.2
	Inter-	9.3	2.6	6.8	0.7
	I/S	0.6	0.8	0.4	0.6
	LER	1.4		1.2	
Autumn	Sole-	33.3	2.0	33.3	2.3
	Inter-	23.5	0.9	22.7	1.0
	I/S	0.7	0.4	0.7	0.4
	LER	1.1		1.1	
Spring	Sole-	13.0	1.4	13.0	1.4
	Inter-	0.3	1.3	0.2	1.1
	I/S	0.0	0.9	0.0	0.8
	LER	1.06		0.9	

Table 12. Dry weight and yield of sweet potato under intercropping with legumes.

Associated crop (Variety)	Planting time[z]	Tuber no/plant		Yield (t/ha)		Leaf DW (g/m^2)		Stem DW (g/m^2)		Tuber DW (g/m^2)		Total DW (g/m^2)	
		A[y]	B[x]	A	B	A	B	A	B	A	B	A	B
Soybean (AGS 129)	9	2.5	3.0	0.1	0.1	43.2	52.7	66.3	61.6	2.2	0.0	111.7	114.3
Soybean (AGS 129)	0	2.5	0.0	0.3	0.0	49.4	45.5	59.5	39.9	6.0	0.0	114.9	85.4
Soybean (AGS 66)	9	2.5	4.0	0.6	3.0	45.1	54.6	68.8	69.2	14.4	37.7	128.3	161.5
Soybean (AGS 66)	0	0.5	2.0	0.1	0.4	46.4	54.6	34.3	62.3	1.2	8.6	81.9	125.5
V. soybean (AGS 292)	9	9.0	10.5	4.0	5.1	57.9	41.1	78.5	62.4	100.3	149.8	236.7	253.3
V. soybean (AGS 292)	0	0.0	3.0	0.0	1.8	37.4	58.4	34.9	64.3	0.0	51.9	72.3	174.6
Mungbean (VC 3890 A)	9	12.0	12.0	8.0	6.9	47.3	57.9	74.1	70.2	220.5	77.5	341.9	205.6
Mungbean (VC 3890 A)	0	10.0	8.0	9.0	8.3	44.8	47.1	97.6	57.8	272.4	101.2	414.8	206.1
Sole cropping		25.3	19.8	13.0	13.7	51.1	47.1	85.3	80.7	334.7	189.7	471.1	317.4

[z]Planting time: Days after transplanting sweet potato. [y]A-120 days after transplanting of sweet potato. [x]B-150 days after transplanting of sweet potato.

Relationship between Soybean Yield and Environmental Factors

Summary

This project aimed to establish a working model for pooling of information on location-specific problems in an international agricultural research center. A network was set up in cooperation with Hualien (HU), Kaohsiung (KS), Tainan (TN), Taitung (TT), and Taoyuan (TY) District Agricultural Improvement Stations (DAIS), and Taiwan Agricultural Research Institute (TARI) to identify the limiting factors of soybean production in different regions in Taiwan. Results showed that a high plant population density of soybean should be maintained in spring. Increasing the number of seeds per pod is not effective in genetic improvement of soybean. In summer, the vigorously growing soybean produced excessive number of pods and resulted in poor quality seeds; the yield of soybean can be improved by increasing the period from sowing to the setting of first pod. In autumn, low number of pods per plant is a limiting factor in soybean yield. Soybean yield can be improved by planting soybean lines adapted for high population density. The measurement of light interception was found convenient to estimate the LAI and plant growth; it is suitable for this kind of multi-location and multi-season trial. Soybean quality (in terms of protein and oil content) was significantly affected by location and season.

Introduction

It is important to understand crop-environment relationships to identify the suitable production areas and also to fit the suitable crop varieties into the existing cropping systems. Such information can help improve the efficiency of adaptation research of national programs. This project aimed to establish a working model for pooling the information on location-specific problems in an international agricultural research center. A network was set up in cooperation with Hualien, Kaohsiung, Tainan, Taitung, and Taoyuan District Agricultural Improvement Stations, and Taiwan Agricultural Research Institute to identify the main factors limiting soybean production in different regions in Taiwan. In a network, data sheets should be simple and easy to follow. It is important to collect as much information as possible to understand the real situation. Thereafter, identifying the key factors becomes one of the main objectives for these multi-location and multi-season yield trials.

Materials and Methods

In 22 trials conducted for two years with replications over seasons, soybean cultivars, Kaohsiung No. 8 (KS 8), AGS 129 (Kaohsiung NO. 10, KS 10), AGS 66 (Tainan NO. 1, TN 1) and Hualien No. 1 (HU 1) were grown in seven locations across Taiwan. There were two croppings (spring and summer plantings) in a year in each location, except at KS DAIS and AVRDC where there had been three crops a year. A randomized complete block design with four replications was used at each site. Plant spacings were 50 × 10 and 30 × 10 cm for spring and summer, and autumn, respectively. The number of days from sowing to each physiological stage including R_1, R_4, R_7 and R_8 was recorded. Dry weight of plant parts at R_4 was sampled, and leaf area index (LAI) was estimated. Percentage of light intercepted by canopy was measured at R_4, the maximum vegetative growth stage, as an indicator of plant growth. Yield and its components were recorded at harvest. Protein and oil contents of seed samples were analyzed at AVRDC to study the environmental effects on seed quality. Soil samples were collected and analyzed before planting. Weather data were collected from the weather station nearby.

Results and Discussion

Results from trials in the first year were collected and preliminary analysis was made. Planting for soybean in each season in different locations followed the existing cropping patterns. Thus they varied among locations even in the same planting season, especially in summer. There were substantial variations in climatic conditions during the trials in different locations. The growth and yield of soybean were significantly affected by the environmental conditions.

Days to flowering (R_1), pod setting (R_4) and maturity (R_8). Location and season significantly affected days to different physiological stages of soybean (Table 13). All entries had the longest growth duration in spring and the shortest in autumn. The differences were mainly in days to R_1, and attributed to temperatures. There was a significant correlation between days to R_1 and the daily mean air temperatures ($r = -0.731^{**}$). Thus, growth duration of soybean in the northern part of Taiwan was longer than in the other regions. TN 1 attained the earliest maturity among entries, particularly in the southern part of Taiwan during summer. KS 10, KS 8 and HU 1 had similar growth durations.

Yield components. Yield components were significantly affected by location and season (Table 14). KS 8 and HU 1 performed best in spring than in other plantings. KS 10 and TN 1, both AVRDC improved lines, were the best yielders in summer.

Relationships between yield and yield components of the entries were affected by seasons. In spring, yield of KS 8 showed significant relationships with the number of plants per unit area and number of pods per plant. KS 10, TN 1 and HU 1 had a significantly inverse correlation between yield and number of seeds per pod. TN 1 also had a significant correlation between yields and the number of plants. It appears that a high plant population of KS 8 and TN 1 should be maintained in

Table 13. Number of days to soybean growth stages in different seasons and locations in Taiwan.

Location	Variety	R_1			R_4			R_8		
		SP[z]	SU	AU	SP	SU	AU	SP	SU	AU
AVRDC	HU 1	53	43	33	70	62	46	114	107	87
HU DAIS	HU 1	53	41		65	49		116	102	
KS DAIS	HU 1	45	41	29	55	58	37	103	118	90
TARI	HU 1	56			70			125		
TN DAIS	HU 1	47	40		55	46		115	98	
TT DAIS	HU 1	43	40		53	54		103	105	
TY DAIS	HU 1	75	40		88	48		150	117	
AVRDC	KS 10	53	42	31	70	55	46	114	103	88
HU DAIS	KS 10	48	32		56	40		120	105	
KS DAIS	KS 10	43	37	28	52	51	36	102	113	87
TARI	KS 10	46		67				123		
TN DAIS	KS 10	44	39		52	44	102	92		
TT DAIS	KS 10	43	36		54	49		105	105	
TY DAIS	KS 10	57	38		68	47		143	112	
AVRDC	KS 8	50	40	31	70	55	50	113	109	93
HU DAIS	KS 8	48	36		59	44		116	99	
KS DAIS	KS 8	44	40	29	53	54	38	105	117	89
TARI	KS 8	47			68			124		
TN DAIS	KS 8	45	38		52	43		114	98	
TT DAIS	KS 8	43	39		52	52		99	108	
TY DAIS	KS 8	51	38		62	46		130	110	
AVRDC	TN 1	50	39	29	70	55	45	109	109	86
HU DAIS	TN 1	48	31		58	41		114	91	
KS DAIS	TN 1	43	35	27	53	48	36.0	97	106	81
TARI	TN 1	44			68			119		
TN DAIS	TN 1	44	38		51	43		99	86	
TT DAIS	TN 1	43	36		53	46		100	96	
TY DAIS	TN 1	53	40		66	48		143	114	
LSD 0.05			4.8			4.9			7.0	

[z]SP = spring; SU = summer; AU = autumn.

spring. Findings suggested that yield of soybean in spring in Taiwan cannot be improved by an increase in the number of seeds per pod. In summer, yield of KS 8 was negatively correlated with the number of seeds per pod and positively correlated with 100-seed weight. The yield and number of plants per unit area were again highly correlated in TN 1. This showed that the dwarf early-maturing soybean should be planted in a high population even in summer. There was a significantly inverse correlation between yields and the number of pods per plant in KS 8 and KS 10, showing that these vigorous type soybeans produced more pods and resulted in poor quality seeds. In autumn, the number of pods per plant is a yield-limiting factor in all entries except TN 1. KS 8 and HU 1 had a significant correlation between yields and 100-seed weight because these have large seeds and are more sensitive to low temperature during late growing period.

An appropriate ratio of physiological stages of soybean quality development is important to achieve high yield. There was a highly significant correlation between the ratio of days to R_4 to the total growth duration and yield of soybean in summer. It seems that the yields of soybean can be improved by increasing the period from sowing to the first setting of pod.

Other agronomic characteristics related to yield. The plant dry weight per unit area, plant height and leaf area index (LAI), and light interception ratio were measured at R_4 stage. In general, both plant dry weight and LAI at R_4 were significantly correlated with the final yield, particularly in spring (Fig. 4). This indicated that there is room to improve soybean yield by improving its growth. For example, insufficient population density was identified as one limiting factor in the low soybean yield in Taiwan. Furthermore, improvement of soybean lines for high population is required. The measurement of light interception was found convenient in estimating the LAI and plant growth. It is suited for this kind of multi-location and multi-season trial.

Table 14. Soybean yield and its components in different seasons and locations in Taiwan.

Location	Variety	Yield (t/ha)			No. of plants /m^2			No. of pods /plant			No.of seeds /pod			100-seed wt. (g)		
		SP[z]	SU	AU	SP	SU	AU	SP	SU	AU	SP	SU	AU	SP	SU	AU
AVRDC	HU 1	2.8	2.3	1.7	33.9	28.0	38.2	27.6	48.1	14.2	2.0		1.6	21.6	17.8	17.8
HU DAIS	HU 1	1.3	1.8		9.3	14.7		25.8	38.3		2.3	1.5		24.4	18.3	
KS DAIS	HU 1	2.2	1.6	2.0	40.5	12.9	37.2	10.6			1.9	1.6	1.9	24.9	20.1	13.0
TARI	HU 1	2.0			29.7			19.8	6.0		1.6			16.6	17.2	
TN DAIS	HU 1	2.8	1.9		33.4	34.4		41.2			2.0	2.5		18.8	20.1	
TT DAIS	HU 1	2.1		1.0		35.8	24.9		0.2					24.2	21.0	
TY DAIS	HU 1			1.5			35.1		9.4			0.9			12.4	
AVRDC	KS 10	2.5	3.3	1.7	37.5	30.2	35.2	28.8		8.9	1.8		1.7	15.3	16.1	15.3
HU DAIS	KS 10	1.1	1.6		27.9	16.4		73.0	36.4		1.1	1.9		17.6	14.8	
KS DAIS	KS 10	2.3	1.4	2.1	47.6	20.9	47.2	14.6	33.4	13.7	2.0	2.0	2.1	17.1	17.6	8.6
TARI	KS 10	1.8			31.4			26.7			2.0			10.1		
TN DAIS	KS 10	3.1	2.5		36.3	33.9		26.8	6.4		2.3	2.6		15.4	15.4	
TT DAIS	KS 10	1.7	1.5		35.6	41.1								18.8	20.8	
TY DAIS	KS 10		2.1			43.9			0.2			0.7			15.7	
AVRDC	KS 8	3.1	2.6	1.6	36.8	31.7	37.5	20.4		10.1	1.9		1.6	25.5	19.5	20.4
HU DAIS	KS 8	1.8	1.6		28.2	16.9		28.9	38.9		2.4	1.3		29.4	19.0	
KS DAIS	KS 8	2.7	1.5	2.6	34.0	17.3	37.2	11.8	41.4	15.5	1.9	1.4	1.9	29.6	19.5	15.0
TARI	KS 8	2.0			30.6			14.5			1.8			19.2		
TN DAIS	KS 8	2.9	2.4		35.9	32.9	29.8	6.9		1.8	1.9			23.3	25.1	
TT DAIS	KS 8	1.5	1.2		34.7	32.4								17.8	24.5	
TY DAIS	KS 8		2.3			29.5			0.2			0.7			24.7	
AVRDC	TN 1	2.3	2.2	1.4	37.3	32.1	36.8	26.7			12.8	1.9	1.7	13.4	12.4	11.4
HU DAIS	TN 1	1.1	2.4		9.9	15.5		25.6	68.9		2.3	1.8		21.1	12.6	
KS DAIS	TN 1	2.5	2.2	1.7	42.5	24.7	49.1	16.6	38.2	15.5	2.0	2.0	2.0	15.4	14.9	6.8
TARI	TN 1	1.8			31.9			26.8			1.7		9.1			
TN DAIS	TN 1	3.0	2.1		38.9	34.8		26.0	11.4		2.3	2.2		12.4	12.8	
TT DAIS	TN 1	1.6	1.6		34.5	47.4								16.0	14.4	
TY DAIS	TN 1		1.7			41.1			0.3			0.5			11.3	
LSD 0.05			0.7			5.7			11.5			0.4			6.6	

[z]SP = spring; SU = summer; AU = autumn.

Soybean quality. Soybean quality (in terms of protein and oil content) was significantly affected by location and season. Soybean grown in spring had the highest protein and oil content (Table 15). Soybean grown in Taitung had the highest protein and in Tainan, the highest oil content. These results may provide information to quantify environmental effects on soybean quality.

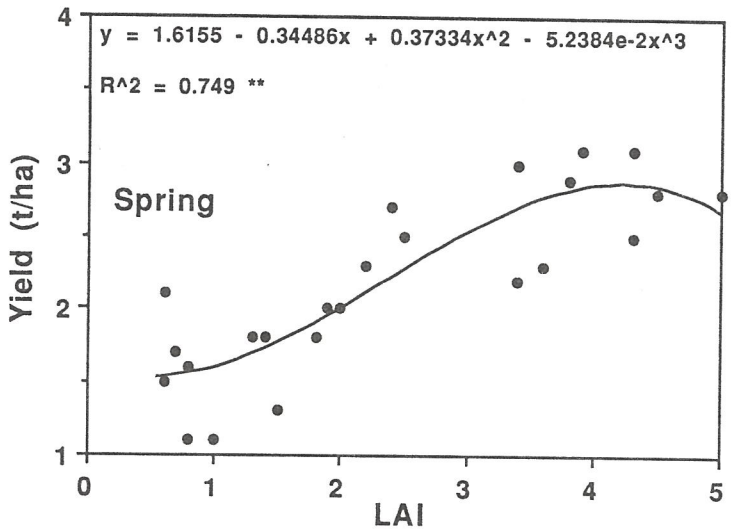

Fig. 4.
Relationship of seed yield and leaf area index (LAI) at R_4 for soybean in spring.

Table 15. Protein and oil content of soybean in different seasons and locations in Taiwan.

Place	Variety	Protein (%)			Oil (%)		
		Sp[z]	Su	Au	Sp	Su	Au
AVRDC	HU 1	41.3	35.1	39.2	21.8	19.5	18.8
HU DAIS	HU 1		40.4			19.1	
KS DAIS	HU 1	43.4	42.4	39.5	22.1	20.3	17.5
TARI	HU 1	43.7	36.9		21.2	20.6	
TN DAIS	HU 1	44.8	36.9		21.3	23.1	
TT DAIS	HU 1	42.6	40.8		20.2	20.9	
TY DAIS	HU 1	44.4	37.8		21.3	18.7	
AVRDC	KS 10	38.8	37.6	38.9	23.6	22.3	19.6
HU DAIS	KS 10	42.4	36.0		22.1	21.9	
KS DAIS	KS 10	41.5	39.8	38.4	22.7	23.0	18.4
TARI	KS 10	40.8	36.3		23.4	20.9	
TN DAIS	KS 10	42.3	36.3		21.4	20.9	
TT DAIS	KS 10	41.3	41.0		23.6	21.0	
TY DAIS	KS 10		37.4			19.8	
AVRDC	KS 8	42.3	41.6	39.8	19.9	18.7	18.8
HU DAIS	KS 8		39.1			19.0	
KS DAIS	KS 8	44.2	41.8	38.5	20.9	18.9	17.1
TARI	KS 8	42.2	36.9		21.6	20.8	
TN DAIS	KS 8	42.8	43.6		20.4	20.8	
TT DAIS	KS 8	43.3	40.9		19.6	21.0	
TY DAIS	KS 8	43.9	38.2		20.5	18.4	
AVRDC	TN 1	40.3	39.7	39.1	21.7	20.7	19.2
HU DAIS	TN 1		38.4			20.0	
KS DAIS	TN 1	45.1	40.9	38.9	20.9	20.5	17.6
TARI	TN 1	42.1	37.2		21.4	20.7	
TN DAIS	TN 1	41.5	37.2		22.0	20.7	
TT DAIS	TN 1	41.5	41.2		21.4	20.9	
TY DAIS	TN 1	41.5	37.5		22.5	19.2	

[z]SP = spring; SU = summer; AU = autumn.

Data Storage, System Analysis and Application

Summary

This project aimed to develop system analysis methods and a data base for the results obtained from cropping systems studies to assist the development of productive and sustainable cropping systems carried out in cooperation with the national programs. Results from field trials from 1986 to 1988 have been keyed into the computer and analyzed. The performance of soybean in different cropping patterns, seasons and locations is discussed in the following pages as an example of incorporating a vegetable component into an existing cropping system.

Introduction

Multiple cropping systems are traditional agricultural production systems in Taiwan. Paddy rice plays an important role in maintaining the land's sustainability in these production systems. However, there is a need to develop new cropping patterns to reduce rice production due to a sharp decline in rice consumption during recent years. Hence a network on cropping systems research has been organized to test new cropping patterns and monitor the changes in physical and biological environments such as soil characteristics, diseases, pests and weeds. These activities provide a chance for developing and validating the methodology in cropping systems research.

Materials and Methods

Field trials were conducted at Hualien (HU), Kaohsiung (KS), Taichung, Tainan (TN), Taitung (TT), and Taoyuan (TY) District Agricultural Improvement Stations (DAIS). Each DAIS office designed three to five new cropping patterns for comparison with the traditional cropping pattern of two rice croppings per year. There were eight cropping patterns with soybean component and one with groundnut among 18 cropping patterns tested. The data of crop yield as well as physical and biological environments such as weather data, soil characteristics, diseases, pests and weeds were collected. All data of field trials from 1986 to 1988 were analyzed at AVRDC to establish the principles of designing improved cropping patterns.

Results and Discussion

Leguminous crops were given priority in rice conversion program to maintain soil productivity. Although groundnut had a higher market value than soybean, it was only tested in the central and northern parts of Taiwan due to lack of mechanical harvesting facilities.

Results of total growth duration of cropping patterns showed that land utilization in the northern and eastern regions of Taiwan is less intensive because of lower temperatures during winter compared with the other regions (Table 16). The cropping pattern of rice-soybean-maize is becoming popular in Chianan areas because farmers accept soybean as green manure if it is damaged by typhoon. However, this cropping pattern had a long total growth duration and might be difficult to complete within one year. Since rice and maize are priority crops, there is a need for early maturing type of soybean for this pattern in Chianan areas.

Return of investment (ROI) of each cropping pattern is shown in Table 17. There was a substantial variation in return; some patterns had a coefficient of variation higher than 50% because of the variation in yield caused mainly by climatic conditions.

To compile these data in an applicable form for designing cropping patterns, the growth duration, yield, production costs and returns of each commodity in different seasons and locations were calculated and their standard deviations were also included for the estimation of probability of success (Tables 18-21). Such information may provide an easy way to compare the advantage of growing different crops, in terms of returns, production costs, and growth duration in a particular season and locality. For example, soybean, maize, and groundnut can be compared with rice in the rice conversion project.

Table 16. Total growth duration (days) of cropping patterns in Taiwan, 1986-1988.

Cropping pattern	Taoyuan	Taichung	Tainan	Kaohsiung	Hualien	Taitung
Rice - Rice	250 ± 8	252 ± 9	262 ± 12		282 ± 11	224 ± 20
Rice - Soybean - Maize			369 ± 11			
Soybean - Rice - Maize			351 ± 8			
Sorghum - Soybean - Maize			344 ± 4			
Rice - Groundnut	249 ± 9	258 ± 4			261 ± 16	
Rice - Soybean					264 ± 2	
Maize - Soybean					232 ± 2	
Rice - Rice - Soybean				303 ± 1		
Maize - Rice - Soybean				313 ± 11		
Soybean - Maize - Maize						353 ± 0

Table 17. Total returns (NT$ 1,000/ha/year) of cropping patterns, 1986-1988.

Cropping pattern	Taoyuan	Taichung	Tainan	Kaohsiung	Hualien	Taitung
Rice-Rice	54.1 ± 4.2	39.5 ± 9.4	37.1 ± 14.6		10.4 ± 3.2	42.6 ± 13.7
Rice-Soybean-Maize			46.8 ± 23.8			
Soybean-Rice-Maize			74.8 ± 15.8			
Sorghum-Soybean-Maize			52.0 ± 25.1			
Rice-Groundnut	58.1 ± 5.3	65.8 ± 17.9			22.0 ± 14.0	
Rice-Soybean					18.7 ± 5.2	
Maize-Soybean					23.5 ± 12.4	
Rice-Rice-Soybean				61.3 ± 18.3		
Maize-Rice-Soybean				70.7 ± 15.0		
Soybean-Maize-Maize						97.2 ± 15.5

Table 18. Growth duration (days) of crops in different locations and seasons, 1986-1988.

Crop	Season	Taoyuan	Taichung	Tainan	Kaohsiung	Hualien	Taitung
Rice	Spring	131.7 ± 5.8	124.7 ± 10.7	146.2 ± 15.9	115.2 ± 1.3	159.0 ± 2.9	124.3 ± 5.4
Rice	Summer	118.0 ± 5.1	127.1 ± 3.8	107.5 ± 3.1	93.8 ± 1.3	123.3 ± 13.3	94.0 ± 11.6
Soybean	Spring			106.2 ± 2.7	100.5 ± 7.1		109.7 ± 11.8
Soybean	Summer			101.6 ± 8.8		101.5 ± 1.2	
Soybean	Autumn				99.8 ± 0.8		
Groundnut	Spring					137.7 ± 6.6	
Groundnut	Summer	117.3 ± 8.0	133.3 ± 14.6				
Maize	Spring	133.7 ± 9.7	109.6 ± 3.2		125.0 ± 2.9	126.0 ± 8.0	108.0 ± 12.8
Maize	Summer						98.5 ± 0.5
Maize	Autumn			133.7 ± 6.0	134.3 ± 1.3		136.8 ± 0.7

Table 19. Crop yields (t/ha) in different locations and seasons, 1986-1988.

Crop	Season	Taoyuan	Taichung	Tainan	Kaohsiung	Hualien	Taitung
Rice	Spring	5.5 ± 0.3	5.8 ± 0.2	6.2 ± 0.3	5.5 ± 0.1	3.7 ± 0.9	5.6 ± 1.0
Rice	Summer	4.5 ± 0.8	4.2 ± 0.7	4.5 ± 1.1	4.3 ± 0.3	3.2 ± 0.6	4.7 ± 0.6
Soybean	Spring			2.9 ± 0.6	2.9 ± 0.2		3.2 ± 0.7
Soybean	Summer			2.3 ± 0.3		2.0 ± 0.4	
Soybean	Autumn				2.6 ± 0.2		
Groundnut	Spring					2.3 ± 0.2	
Groundnut	Summer	2.0 ± 0.3	2.7 ± 0.5				
Maize	Spring	4.7 ± 0.1	2.4 ± 1.2		5.4 ± 0.3	4.3 ± 0.8	3.9 ± 2.3
Maize	Summer						4.6 ± 0.5
Maize	Autumn			6.1 + 2.1	5.6 + 0.3		5.8 + 0.4

Table 20. Production costs (NT$/kg) of crops in different locations and seasons, 1986-1988.

Crop	Season	Taoyuan	Taichung	Tainan	Kaohsiung	Hualien	Taitung
Rice	Spring	8.0±0.5	10.1±0.5	9.0±0.8	10.1±0.2	13.9±2.4	8.9±1.5
Rice	Summer	9.7±1.8	13.6±1.8	12.6±3.6	12.9±0.5	15.1±0.7	10.3±1.5
Soybean	Spring			14.8±2.3	15.1±1.0		14.1±3.2
Soybean	Summer			15.9±2.2		16.3±5.8	
Soybean	Autumn				15.0±0.2		
Groundnut	Spring					30.9±1.8	
Groundnut	Summer	33.2±5.9	22.3±3.4				
Maize	Spring	10.5±0.7	29.8±11.4		8.2±0.3	12.1±2.2	12.7±4.1
Maize	Summer						9.7±0.6
Maize	Autumn			9.7±4.5	6.7±0.2		7.4±0.5

Table 21. Returns of investment (NT$ 1,000/ha) of crops in different locations and seasons, 1986-1988.

Crop	Season	Taoyuan	Taichung	Tainan	Kaohsiung	Hualien	Taitung
Rice	Spring	35.7±7.9	32.0± 2.5	30.9± 4.7	24.6±5.7	5.4± 4.0	22.2± 8.7
Rice	Summer	23.8±6.5	10.2± 7.5	16.2±19.2	9.7±5.5	4.1± 2.0	18.6±10.9
Soybean	Spring			19.3± 1.8	20.5±7.4		22.6±14.9
Soybean	Summer			16.5± 3.9		18.6± 7.8	
Soybean	Autumn				19.3±6.2		
Groundnut	Spring					17.3±16.1	
Groundnut	Summer	20.7±9.2	32.7±20.2				
Maize	Spring	13.8±9.7	-16.6±13.4		36.8±4.1	14.0±10.3	16.2± 0.2
Maize	Summer						24.6± 4.9
Maize	Autumn			34.3±25.5	42.3±6.4		38.8± 6.9

On-Station Testing

Cooperative Projects with Local Institutes

Summary

AVRDC promising materials and selected varieties of snap bean were tested under different environments in Taiwan in cooperation with the ROC national program. Chinese cabbage AVRDC 82-156, mungbean VC 3890 A, and fresh market tomato FMTT 22 were released as Taoyuan ASVEG 2, Tainan Selection No. 5, and Taichung ASVEG 4, respectively, in 1989. Vegetable soybean AGS 292 which was released as Kaohsiung Selection No. 1 in 1987 occupied 71.9% (2,321 ha) and 65.1% (2,620 ha) of total vegetable soybean acreage in spring and autumn 1989, respectively. Entries which outperformed the checks in the regional yield trial (RYT) and observation trials during 1988 and 1989 were: vegetable soybean — GC 83008-16 (yield) and GC 83007-7 (quality); mungbean — VC 3738 A, VC 3751 A, VC 3907 A, VC 3901 A, VC 3888 A and VC 3737A; processing tomato — PT 4121, PT 4225, and PT 4287; fresh market tomato — FMTT 22, FMTT 33, and FMTT 3; cherry tomato — CHT 172, CHT 103 and CHT 105; Chinese cabbage — AVRDC 86-187, 86-181 and 86-182; snap bean — Wisa and Taichung No. 1; snap peas — Snappy and Taichung Sugar 3B; crisp head lettuce — Summer Gold, Mikado Great 3204, Lagomor INTA and Martha; butter head lettuce — Lattuga Toria S.V.; cos lettuce — Corsica, Gallega INTA and Seme Nero; and leaf lettuce — Grand Rapid, FM 1559 and Green Wave.

Introduction

AVRDC promising materials and selected new snap bean varieties were tested in RYT under different environments in Taiwan in cooperation with national programs. Demonstration trials for newly released AVRDC lines, such as fresh market tomato Taichung ASVEG 4 were also carried out in cooperation with the national programs to accelerate technology transfer. These trials were supported and mainly conducted by the national programs in farmers' fields in Taiwan. Carried out in AVRDC, the observation trials of lettuce have been supported by the national program since 1988 with the common objective of evaluating lettuce cultivars under tropical conditions.

Materials and Methods

The RYTs were conducted in randomized complete block designs with four replications. There were 56 regional yield trials and four demonstration trials during 1988-1989.

There were 15 observation trials for five lettuce cultivars in three planting seasons from summer 1988 to spring 1989. These trials were conducted in randomized complete block designs with three replications.

Results and Discussion

Release of AVRDC breeding lines. One AVRDC Chinese cabbage, mungbean and fresh market tomato breeding line was released by District Agricultural Improvement Stations (DAIS) in Taiwan during 1989.

Chinese cabbage F_1 hybrid 82-156 was released as Taoyuan ASVEG 2 by Taoyuan DAIS. It is heat-tolerant and high yielding. Although it may have the problem of tip burn in summer, it is considered the most suitable cultivar in autumn and spring because it is tolerant to downy mildew (*Peronospora brassicae*), a serious disease during these seasons. Its leaf-weight type is preferred by consumers in Taiwan. Many leaf-weight types such as the Chang Puh group of cultivars may bolt before forming heads during autumn and spring. Results from trials (Taoyuan DAIS) showed that this variety can produce firm heads when transplanted as late as early November in northern Taiwan.

Fresh market tomato F_1 hybrid FMTT 22 was released as Taichung ASVEG 4 by Taichung DAIS. This is a heat-tolerant variety with resistance to bacterial wilt (*Pseudomonas solanacearum*) and tobacco mosaic virus (TMV). It outperformed the local cultivars in both highlands and lowlands. Although it has light green shoulders, it commands higher price than the most popular cultivar Known You 301, in the market because of its firm fruits.

An improved mungbean line VC 3890 A was released as Tainan Selection No. 5 by Tainan DAIS. It is resistant to powdery mildew (*Erysiphe polygoni*). Pods uniformly mature with a seed yield potential of more than 2 t/ha per harvest.

Performance of AVRDC releases. An AVRDC introduced vegetable soybean line AGS 292 (Taishoshiroge) was released in Taiwan as Kaohsiung Selection 1 (KS 1) after its outstanding performance in RYT. The crop covered 1815 ha in spring 1988 and 2014 ha in autumn, occupying 45.5% and 56.0% of the total acreage for vegetable soybean during these seasons, respectively. These figures increased to 2,321 (71.9%) and 2,620 (65.1%) hectares in spring and autumn 1989, respectively.

Seed production and distribution of AVRDC promising lines for testing. A large amount of propagating materials was distributed and multiplied during 1989 to demonstrate the yield potential of promising AVRDC releases. Among these were seeds of Chinese cabbage, fresh market tomato, and processing tomato PT 4225.

Regional yield, demonstration and observation trials

Soybean. There is a need for an early maturing soybean variety (about 90 to 95 days), with reasonably high yield (2.5 t/ha) and large seeds (the hundred-seed weight is more than 14 g) for the rice-soybean-maize cropping pattern in summer in Chianan areas.

AVRDC lines AGS 253 and AGS 301, with another nine entries were evaluated in RYTs in spring, summer and autumn 1988. Kaohsiung No. 8 (KS 8) had the best yield performance among entries across all trials in three seasons. Both had similar yields to check cultivar KS 10 but lower than KS 8 in spring. They matured earlier than check cultivars; however, they had significantly lower yields than the latter in summer. This was mainly attributed to lodging under hot humid conditions. They tended to have similar yield and days to maturity as the check cultivars in autumn. KS 10 had a significantly higher oil content in spring and summer (Table 1).

Vegetable soybean. AVRDC vegetable soybean line AGS 292 (KS 1) has been recognized to have maintained a competitive status in the Taiwan vegetable soybean industry. Further improvement of vegetable soybean variety in Taiwan should be on quality and characteristics for mechanical harvest in addition to yield potential. Two AVRDC promising lines, GC 83006-7 and GC 83008-16, and four from Kaohsiung DAIS, with three check cultivars were evaluated in vegetable soybean RYT in autumn 1988.

Low yields at AVRDC were due to late sowing and the unfavorable low temperatures at pod filling stage. The yield of GC 83008-16 was similar to that of the high yielding check KS 1 in autumn in all locations (Table 2). It performed better than KS 1 in spring in all trials, except at Lunyang where KS 1 was the best yielder among entries (Table 3). KSV 124 outyielded other entries in both autumn and spring trials. Its sensitivity to the environment was close to the mean response of all entries. However, its pod was smaller than that of KS 1.

Although GC 83006-7 did not yield as much as KS 1, it had good seed quality in terms of hardness, color, and protein content similar to the high quality check cultivar 305. Its yield was higher than that of the latter.

Table 1. Yield and agronomic characters of soybean entries during regional yield trials in Taiwan, 1988.

Entry	Yield (t/ha)			Days to maturity			Protein	Oil
	Spring	Summer	Autumn	Spring	Summer	Autumn	(%)	(%)
TARI 8	2.0	2.1	1.6	103	100	88	40.9	21.0
TARI 9	2.1	2.2	1.9	105	98	89	40.2	21.3
AGS 253	2.0	1.6	2.1	105	101	91	40.7	20.8
AGS 301	1.9	1.7	1.8	105	98	88	40.1	19.0
B 3	1.9	2.1	1.4	103	98	90	41.1	19.7
G 4	2.0	2.3	2.1	112	109	92	39.9	21.7
HL 74-48	2.2	2.5	2.1	105	102	89	40.2	21.3
SRE-D-14B	1.6	1.9	2.0	105	104	91	40.8	21.7
KS 1625	2.1	2.1	2.4	107	106	91	40.4	20.2
KS 1745	2.2	2.5	2.3	106	100	89	40.3	21.3
KS 8	2.3	2.3	2.5	108	105	91	40.8	20.1
KSS 10	1.9	2.4	2.0	106	104	90	39.1	22.2

Table 2. Marketable yield of vegetable soybean entries during regional yield trials in Taiwan, autumn 1988.

Entry	Kaohsiung DAIS		AVRDC Shanhua	Mean	Index
	Kantien	Chouju			
KVS 2	10.4 b	8.1 ab	2.6 ab	7.0 a	102
KVS 39	10.3 b	7.9 b	2.7 ab	7.0 ab	101
KVS 124	12.5 a	7.8 b	2.3 bc	7.5 a	109
KVS 169	9.4 b	6.1 cd	2.9 a	6.2 ab	89
GC 83006-7	5.8 d	7.8 b	1.8 cd	5.1 ab	74
GC 83008-16	8.0 c	8.8 ab	2.0 cd	6.3 ab	91
KS 1	8.9 bc	9.7 a	2.2 bc	6.9 ab	100
205	8.3 c	7.3 bc	1.5 d	5.7 ab	82
305	5.9 d	6.0 d	1.6 d	4.5 b	65

Table 3. Marketable yield of vegetable soybean entries during regional yield trials in Taiwan, spring 1989.

Entry	Kaohsiung DAIS		Tainan DAIS	Taichung DAIS	Lunyang BS	AVRDC	Mean	Index
	Kantien	Yenpu						
KVS 2	9.6 a	7.1 a	7.5 abc	16.9	4.8 e	3.3	8.2	113
KVS 39	9.0 a	7.9 a	7.8 ab	17.7	4.2 f	4.0	8.5	116
KVS 124	9.9 a	8.3 a	7.1 abc	18.0	3.7 g	3.8	8.5	116
KVS 169	9.2 a	7.7 a	6.6 bcd	13.7	2.1 i	3.2	7.1	97
GC 83006-7	5.4 c	4.4 b	6.0 cd	16.4	6.9 d	4.6	7.3	100
GC 83008-16	7.6 b	7.1 a	8.4 a	14.1	3.0 h	3.2	7.2	99
KS 1	5.3 c	4.7 b	6.6 bcd	13.8	9.1 a	4.2	7.3	100
205	5.2 c	4.4 b	6.1 cd	14.5	7.7 c	3.6	6.9	95
305	5.2 c	2.7 c	5.3 d	13.1	8.2 b	3.6	6.4	87

Mungbean. The mungbean breeding programs in Taiwan aimed to develop high and stable yielding genotypes with dull seeds weighing more than 6 g per 100 seeds; early and uniform maturity for mechanical harvesting; and resistance to pests. Mungbean has to be mechanically harvested, because of shortage and high cost of labor. Therefore, uniformly maturing lines developed by AVRDC are particularly suitable in Taiwan.

Results in the 1989 spring trial showed that all AVRDC lines performed better or as well as check varieties Tainan Selection No. 3 (TN 3) and Tainan Selection No. 5 (TN 5) at five locations except

VC 3853 A at Putzu and VC 3751 at Chianan. All entries had similiar seed size, with the exception of VC 3751 A, VC 3773 A, VC 3853 A and VC 3928 A.

VC 3737 A had a relatively high yield and its performance was closer to the mean response of all entries in all locations in summer 1988 and spring 1989.

Processing tomato. Three RYTs were conducted in late summer, autumn and winter during 1988 to 1989. These trials including four AVRDC F_1 hybrid processing tomato cultivars, were evaluated mainly for Chianan areas.

In the late summer, all entries yielded as high as the heat-tolerant check F_1 hybrid, TN 3 (PT 3037), except PT 4172, CXD 104 and UC 204 A. In autumn, all AVRDC F_1 hybrids yielded significantly higher than or similarly to check varieties TN 2 and P 933. There were no significant differences among entries in the winter trial.

PT 4287, PT 4121 and CXD 104 had significantly bigger fruits than the check varieties TN 3 and P 933 in all trials. Their fruit color and soluble solids were similar to that of the checks TN 3 and P 933.

All AVRDC F_1 hybrids performed well in RYTs in 1989. PT 4287 and PT 4225 had the highest yields among entries, but all were sensitive to environments. PT 4121 and PT 4172 performed similarly to the heat-tolerant check cultivar TN 3, in terms of yield and sensitivity to environment.

Fresh market tomato. The newly released fresh market tomato F_1 hybrid FMTT 22 (Taichung ASVEG 4) was evaluated in a demonstration planting with two other potential F_1 hybrids FMTT 3 and FMTT 33, and the most popular cultivar Known You 301 (KY 301). The main purpose of the demonstration was to showcase the yield potential and management techniques of FMTT 22 to farmers in different locations. There were four plantings in summer 1989; two in the lowlands, Shanhua and Penghu, and two in the highlands, Yuchi and Hsinyi.

Results revealed that all AVRDC F_1 hybrids had significantly higher yields than the check cultivar KY 301 in all locations (Table 4). It is interesting to note the differences in performance between the check and other entries at Penghu (lowlands).

The fruit size, pH value, soluble solids and titratable acidity of AVRDC F_1 hybrids were similar to that of KY 301. However, the latter had a higher rate of fruit cracking under highland conditions.

Table 4. Yield of fresh market tomato in demonstration plantings, summer 1989.

Entry	AVRDC Shanhua	Puli B.S.		Penghu B.S. Penghu	Mean	Index
		Yuchi	Hsinyi			
FMTT 3	64.0 a	54.1 b	66.6 b	101.4 a	71.5	238
FMTT 22	64.3 a	63.9 a	85.1 a	105.4 a	79.7	265
FMTT 33	67.8 a	51.8 b	75.3 b	98.8 a	73.4	244
Known You 301	40.5 b	32.7 c	38.4 c	8.5 b	30.1	100

BS is branch station.

Cherry tomato. Cherry tomato is one of the popular tomato types in Taiwan. Seven AVRDC promising lines were evaluated in cooperation with Tainan DAIS. All entries yielded equally better than two check cultivars, Girl's Sweet and Sugar Pearl at AVRDC and Tainan DAIS. CHT 172 was the best yielder among entries, but its fruits were larger than those of the checks.

Chinese cabbage. A new set of Chinese cabbage entries including four AVRDC F_1 hybrids was evaluated in RYTs in summer 1989. There were substantial variations in yields among locations with the average yields across entries of 12.9 t/ha in Tainan DAIS and Lungyang, and 24.6 t/ha at AVRDC. These differences were attributed to the effects of direct seeding and transplanting. It appears that the national program considers labor-saving techniques as important as yield potential in Chinese cabbage production. There were no significant differences in yields among entries, except in AVRDC 86-162 which was lower than the others.

Sweet potato. The sweet potato RYT had a new set of entries including two from AVRDC. C 74-357 and check cultivar Tainan 18 were the two best yielders among entries. AVRDC lines did

not have high yields in these trials compared to other entries, because two entries were selected mainly for summer planting. CN 1489-89 had the highest dry matter content among entries.

Snap bean and snap pea. Two snap bean RYT trials were conducted (in autumn 1988 and spring 1989) at AVRDC. Results showed that all entries outyielded the check cultivar, Thailand. Wisa and Taichung No. 1 were the best yielders among entries in summer 1988 and spring 1989, respectively. Kentucky Wonder had larger pods, and mean pod weight than other entries. Consistently seasonal effects were noticed on snap bean yields which were higher in spring than in autumn in both trials.

An observation trial of snap pea was conducted in cooperation with Taichung DAIS. Four entries were tested. Among them, Snappy and Taichung Sugar 3B performed better than Wase Amai and Sugar snap. Snappy had the biggest pods among entries. This new vegetable seems adapted to the cool-dry winter in southern Taiwan.

Lettuce. There were 107 entries (including 10 flat-leaf, 39 curled-leaf, 8 deeply-notched leaf, 29 crisp head, 11 cos, and 10 butter-head type), evaluated in three planting seasons (summer and autumn 1988, and spring 1989). Yields in summer which varied from 1.0 to 14.2 t/ha were low compared to that of 14.5 to 52.7 and 7.8 to 35.2 t/ha in autumn and spring, respectively. Yields in summer 1989 were lower than that in summer 1987. It appears that the growth of lettuce under summer conditions in Taiwan is not stable, indicative of the need to develop improved and heat-tolerant varieties.

The heading and cos-type lettuce tended to have higher yields than other varieties tested in summer and autumn. The heading type attained maturity later than other types in autumn. Maturity of all types was not significantly different from each other in summer.

The crisp head lettuce had the highest yield in autumn among trials. Only 22, 15 and 15 among 29 entries were harvested in autumn, spring and summer, respectively. Summer Gold, Mikado Great 3204, Lagomor INTA and Martha which outyielded other entries in summer also performed well in other two seasons.

The butter-head lettuce also performed better in autumn than in other seasons. Among 10 entries in summer, there were only four which produced marketable heads. Lattuga Toria S.V. was the best yielder among entries. It also performed well in autumn. Malagarita, Dolly, Lattuga Toria S.V., and Tagus F.2 outyielded other entries in autumn. Butter Crunch, Okayama Salad and Tagus F.2 were the best performers in spring.

The cos lettuce had the highest yield per day per unit land among different lettuce types in autumn. Corsica, Gallega INTA and Seme Nero had higher yields than other entries in summer. They also performed well with PSX 50182 in autumn.

The growth of leaf lettuce was poor in summer. Of the 57 entries, 22 were harvested. Grand Rapid, FM 1559 and Green Wave were the best yielders among entries in summer. During autumn, Loosehead, Catologna, Salad Bowl and Black Seeded Simpson yielded better than other entries. Black Seeded Simpson performed well in two seasons. These results indicated that there were strong interactions between lettuce and the environment.

There were no significant differences among four asparagus lettuce entries. Their yields were low and growth duration was long compared to leafy-type lettuce.

Soil Science

Effects of Different Nitrogen Concentrations on Growth of Tomato Using Kyowa Hydroponic System

Summary

The Kyowa nutrient circulation hydroponic system was utilized to examine the effects of continuous nitrogen application on the growth and fruit production of tomato.

Plants of a Japanese tomato cultivar, Bestom were grown with nutrient solutions containing nitrate-nitrogen at 60, 90 and 120 ppm in the winter of 1988 to 1989 and were measured for their growth, fruit yields and nutrient contents.

The total fruit yield per plant was 5.6 kg, 6.2 kg and 6.4 kg for N-60, N-90 and N-120, respectively. Among treatments, N-60 did not show nitrogen-deficiency symptoms even in the leaf. N-90 was found suitable for tomato cultivation by statistical analysis of its growth performance and yield production and from the standpoint of resource utilization.

Introduction

This experiment is a part of the hydroponic research to improve nutrient noncirculating and capillary techniques for vegetable production. It was designed to increase fruit production by applying nitrate-nitrogen at different concentration levels to culture solutions using the Kyowa circulation hydroponic system.

Materials and Methods

Seeds of a Japanese tomato cultivar, Bestom were sown directly in substrates of vermiculite mixed with smoked rice hulls in plastic baskets.

Two seedlings were allowed to grow in each basket (volume = 42 liters) with culture solution, but only one stem was maintained in every plant over the growing period. A randomized complete block design with two replications was used in this experiment.

Tap water was added to each container three times a week to maintain the culture solution and compensate for the water loss due to evapotranspiration. To enhance root length, the solution in each container was maintained 3.0 cm above the basket at early stage.

Flower initiation was on 10 November 1988 and terminal leaf cutting was done on 2 January 1989.

The culture solutions together with the microelements used during the vegetative and reproductive stages were renewed twice a week throughout the experimental period.

Fruits were harvested at weekly intervals from 9 January to 31 March. The whole plants were harvested on 31 March and separated into old and young parts. All samples were subjected to chemical analysis and their fresh and dry weights were taken.

Results and Discussion

Change in pH of the culture solution. The pH value of the culture solution was maintained at N-120 = N-90 > N-60 ppm treatments throughout the experimental period.

Change in electrical conductivity. The EC value of the culture solution increased with an increase in nitrogen and rose gradually toward the end of the experiment irrespective of the nitrogen treatment.

Cumulative amounts of water uptake. There were no distinct differences in weekly cumulative water uptake between nitrogen treatments up to the final harvesting time.

Fruit yield. Tomato yield in terms of fresh weight seemed to increase in this order of nitrogen treatment: N-120 = N-90 > N-60 ppm. However, no distinct differences in fresh weight of fruits on each cluster were observed among nitrogen treatments, except in the first and fourth clusters (Table 1).

The weekly cumulative yield (dry weight basis) of tomato per plant up to final harvesting was quite similar to that of the fresh weight.

Fruits of plants treated at N-120 and N-60 ppm had higher water content than those at N-90 ppm.

Table 1. Fruit weight (kg) distribution of different clusters at harvest.

Treatment N level (ppm)	1st	2nd	3rd	4th	Cluster 5th	6th	7th	8th	9th	Total wt. per plant
60	0.6 b[z]	0.9 a	0.9 a	0.6 b	0.6 a	0.5 a	0.5 a	0.4 a	0.5 a	5.6 a
90	0.6 b	1.1 a	0.9 a	0.8 a	0.6 a	0.6 a	0.6 a	0.6 a	0.5 a	6.2 a
120	0.8 a	0.8 a	0.9 a	0.7 a	0.6 a	0.7 a	0.6 a	0.7 a	0.5 a	6.4 a

[z]Means with the same letter are not significantly different at 5% probability level by DMRT.

Overall growth status and fresh and dry matter production. Treatments N-60, N-90 and N-120 ppm had the total weight of fresh and dry matter of 8.8 and 0.8 kg/plant, 9.5 and 0.9 kg, and 10.1 and 0.8 kg, respectively.

Nutrient content. The young parts of the roots had higher nitrogen content than the old ones with a tendency to increase as nitrogen concentration increases. A reverse trend was observed for phosphorus content in roots. Roots showed a similar trend for potassium content as for nitrogen but the old leaves and fruits grown at the early stage had higher potassium content than those at the later stage although at the same nitrogen levels of the solution. No remarkable differences in potassium content were observed between the old and young plant parts. The Ca content of roots and leaves showed similar tendencies as the potassium in leaves and fruits.

Total nitrogen content of plant parts. The total nitrogen content of old (grown at the early stage) and young (grown at the later stage) plant parts is shown in Table 2.

Table 2. Total nitrogen content of plant parts (in g/plant, dry weight basis).

N level	Growth stage	Root	Stem	Leaf	Fruit	Total
60 ppm	Early	0.5	1.5	1.9	4.0	8.0
	Later	1.2	0.8	4.6	4.6	11.2
	Total	1.6	2.3	6.6	8.7	19.2
90 ppm	Early	0.7	1.6	2.4	5.2	9.9
	Later	1.0	1.1	4.5	5.4	12.0
	Total	1.7	2.7	6.9	10.6	21.8
120 ppm	Early	0.3	1.5	2.2	4.8	8.8
	Later	1.4	0.7	4.8	5.1	12.0
	Total	1.8	2.2	7.0	9.9	20.9

The root, leaf and fruit grown from the later stage had higher nitrogen content than those grown at the early stage; however, the stem showed a reverse tendency.

No remarkable differences were observed in nitrogen content in plant parts among treatments except in the root with N-60 ppm and the stem with N-60 and N-120 ppm.

Nitrogen concentration level. Results suggested that nitrate-nitrogen at 90 ppm concentration level of culture solution is acceptable for tomato production under the Kyowa nutrient circulation hydroponic system.

Continuous Soybean Cropping

Summary

Soybean has been cultivated twice or three times a year in the spring, summer and autumn on the same land since 1983. In 1987, total yield of AGS 129 and KS 8 reached 10.6 and 9.0 t/ha, respectively. In the spring of 1988, charcoal rot severely infected the crop, considerably reducing the yields of AGS 129 and KS 8 from 4.7 to 4.3 and 4.6 to 3.3 t/ha, respectively. Yield in 1989 was almost the same as 1988 for AGS 129 but slightly increased (3.7 t/ha) in KS 8.

Introduction

This study attempted to establish an effective fertilizer application technique and soil management for soybean in continuous cropping. It likewise determined how long soybean can be continuously cultivated on the same piece of land without reduction in yield.

Materials and Methods

Seeds of two soybean cultivars, KS 8 (a dominant broad-leaf cultivar in Taiwan, used as reference) and AGS 129 (a narrow-leaf AVRDC advanced line) were sown on 26 January. Figure 1 shows the cropping sequence used.

The experiment was carried out using a split-plot design with two replications. The main plot consisted of AGS 129 and KS 8, whereas the subplot, the fertilizer treatment (with or without compost application).

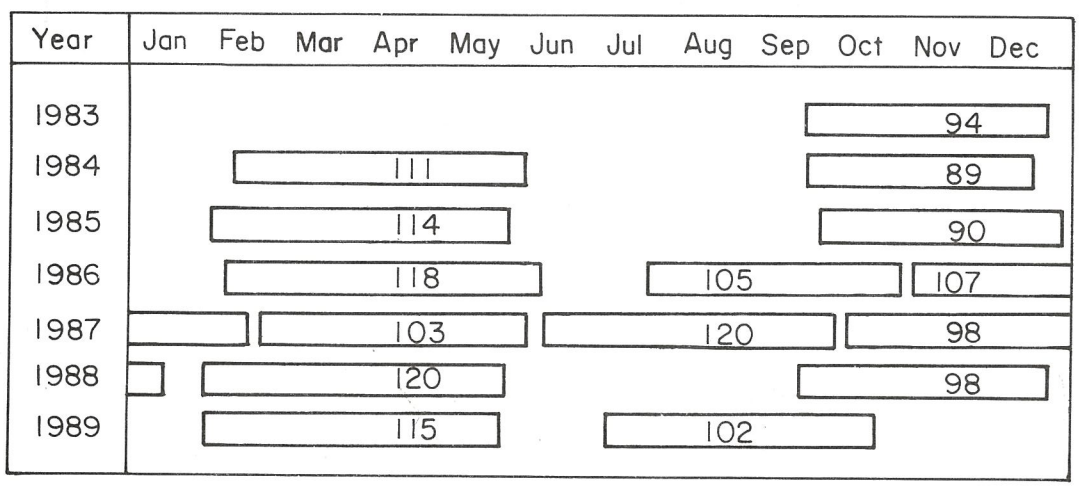

Fig. 1. Cropping sequence of soybean. Numbers in the figure indicate days of growth duration.

Results and Discussion

The yields of cultivars with and without compost from spring 1987 to spring 1989 are shown in Table 3. Soybean planted with compost in the spring of 1989 suffered from charcoal rot disease (*Macrophomia phaseolina*), but was slightly less affected than in spring 1988.

The yield of AGS 129 was 4 t/ha, approximately the same as that of spring 1988, but that of KS 8 increased about 10% over that of 1988 under the same field conditions.

Table 3. Yields (t/ha) of soybean under continuous cropping from spring 1987 to spring 1989.

Variety	Treatment	1987 Spring	1987 Summer	1987 Autumn	1988 Spring	1988 Autumn	1989 Spring
AGS 129	w/ 50 t/ha compost	4.7	3.4	2.7	4.3	3.4	4.2
	Control	4.6	3.8	2.2	3.7	2.8	3.7
KS 8	w/ 50 t/ha compost	4.6	2.6	2.5	3.3	3.9	3.7
	Control	4.7	2.8	2.3	3.0	3.2	3.2

Promoting Vegetable Soybean Yield and Quality through Organic Fertilizers

Summary

The effects of fertilizers on soil fertility were not clear considering the variations in different cropping seasons. One or two fertilizers among those examined seemed to be useful in seed production. However, their effects on seed quality need to be studied further.

Introduction

This study was conducted to improve the yield and the eating quality of vegetable soybean by applying organic fertilizers or compost. It is a part of the research project aimed to improve the quality of frozen vegetable soybean.

Materials and Methods

The experiment was continuously cropped in the autumn of 1988 and spring and summer of 1989, and laid out in a randomized complete block design with four replications.

AGS 129, an advanced AVRDC line with narrow leaf was used in all cropping experiments. Two plants were allowed to grow per hill with spacings of 10 cm between hills and 50 cm between rows in each 25 m^2 plot at a population density of 400,000 plants/ha.

Sowing and harvesting were done on 15 September and 23 November for the 1988 autumn cropping, 22 February and 8 May for spring 1989 and 27 June and 8 September for summer 1989.

Organic materials such as sugarcane compost, cattle dropping compost, castor-oil granule, organic fertilizer #1 produced by Taiwan Fertilizer Company (F#1) and organic fertilizer #3 produced by Taiwan Sugar Company (S#3) were applied as a basal dressing in combination with basal application and/or top dressing of chemical fertilizers in all experiments. Among them, F#1 had the highest P, K, Ca and Mg contents and castor-oil granule, N.

Results and Discussion

Autumn 1988. Soil samples taken from the same plot before sowing and after harvesting were analyzed for major chemical components. After harvest, the soils seemed to have higher contents of all the components, except for T-N. Significant differences were observed in the number of leaves, total number of pods and dry weights of leaf, petiole, hull and graded seed in some of the plots. Data on yield are shown in Table 4. No distinct differences were found among the plots. Results indicate

that application of organic material was not effective in increasing seed production under such conditions. Significant differences in fiber content and fiber/total carbohydrate ratio were observed in some plots under given conditions.

Spring 1989. Major soil components in soil samples taken from the same plots before sowing and after harvesting were compared. Soil after harvest seemed to have lower K_2O, Ca and T-C contents, C/N ratio and EC value, but the pH increased within the same plots. T-N, P and Mg contents did not change as much in the same plots irrespective of sampling time.

The effects of organic materials on related growth parameters and the dry weights of plant parts were evaluated at flowering and harvesting stages, respectively. No significant differences were found between plots except in plant height at flowering stage and dry weight of root at harvesting time. Soybean yields are given in Table 5. Organic materials did not increase yield. Significant differences in sugar and fiber contents were observed.

Summer 1989. Statistical analysis indicated that there were significant differences in soil components in some plots, both within the same sampling time except for pH taken before sowing. Furthermore, the soil obtained after harvesting showed higher contents of T-N and available potassium, pH value and EC value within the same plots.

Significant differences in plant height, number of leaves, flowers and branches, dry weights of root and petiole at flowering stage, and number of leaves, nodes, branches, pods (3 seeds) and total pods at harvesting time were observed in some plots. Yields are presented in Table 6. Statistical analysis suggested that among organic fertilizers used, only F#1 seemed effective in enhancing soil fertility.

Statistical analysis indicated that there were significant differences in protein and sugar contents, sugar/starch ratio and fat/available carbohydrate ratio in some plots. The influence of organic fertilizer application was not clear and varied with different cropping seasons. The problem of improving the taste of vegetable soybean through organic fertilizer application remains unsolved.

Table 4. Yields (t/ha) of vegetable soybean trial, autumn 1988.

Treatment	Graded yield	Ungraded yield	Total yield	Grade ratio (%)
Sugarcane compost	9.8 a[z]	2.1 a	11.9 a	82.7 a
Cattle dropping compost	9.2 a	2.0 a	11.2 a	81.9 a
Castor-oil granule	9.1 a	2.3 a	11.3 a	80.1 a
F#1 organic fertilizer	9.5 a	2.3 a	11.8 a	80.6 a
S#3 organic fertilizer	10.0 a	2.0 a	12.0 a	82.9 a
Control	9.5 a	1.8 a	11.3 a	84.0 a

[z]Data are means of four replicates; means in each vertical column followed by the same letter are not significantly different at 5% level according to DMRT.

Table 5. Yields (t/ha) of vegetable soybean trial, spring 1989.

Treatment	Graded yield	Ungraded yield	Total yield	Grade ratio (%)
Sugarcane compost	9.0 a[z]	4.7 a	13.7 a	65.5 a
Cattle dropping compost	9.3 a	4.6 a	13.9 a	67.0 a
Castor-oil granule	9.2 a	4.6 a	13.9 a	66.5 a
F#1 organic fertilizer	9.3 a	4.5 a	13.8 a	67.3 a
S#3 organic fertilizer	9.4 a	4.5 a	13.9 a	67.6 a
Control	9.2 a	4.3 a	13.5 a	68.1 a

[z]Data are means of four replicates; means in each vertical column followed by the same letter are not significantly different at 5% level according to DMRT.

Table 6. Yields (t/ha) of vegetable soybean trial, summer 1989.

Treatment	Graded yield	Ungraded yield	Total yield	Grade ratio (%)
Sugarcane compost	8.3 a[z]	6.6 a	14.9 bc	55.6 ab
Cattle dropping compost	7.6 a	6.6 a	14.2 c	53.4 b
Castor-oil granule	8.3 a	6.9 a	15.1 b	54.8 ab
F#1 organic fertilizer	9.5 a	6.6 a	16.1 a	59.1 a
S#3 organic fertilizer	8.3 a	7.2 a	15.5 ab	53.5 b
Control	8.3 a	7.3 a	15.6 ab	53.5 b

[z]Data are means of four replicates; means in each vertical column followed by the same letter are not significantly different at 5% level according to DMRT.

Decomposition of Organic Fertilizers in Summer

Summary

These experiments were aimed at obtaining information on the decomposition of organic matter in upland soils during summer.

Organic materials such as sugarcane compost, cattle dropping compost, castor-oil granule, organic fertilizer #1 and organic fertilizer #3 were individually placed in net bags at conventional rates together with top soil taken from AVRDC upland fields. These organic materials were buried (5-20 cm in depth) in the same field. Samples were taken at intervals up to 90 days after application.

Among materials tested, organic fertilizer F#1 differed significantly from others in terms of total carbon, total and available nitrogen, available phosphorus, potassium, calcium and magnesium contents, value of electric conductivity in the soil after application; and time trends throughout the experimental period. This fertilizer seemed effective under given experimental conditions in providing essential plant nutrients.

However, further studies on the behavior of both total and available nitrogen including nitrate nitrogen are needed to analyze their decomposition or rates of release in soils with and without irrigation in summer and winter.

Introduction

Organic matter, an important soil amendment to improve the soil's physical and chemical properties, is also an essential source of plant nutrients which are slowly released through microbial decomposition in the soil.

These experiments were initiated to obtain insight into the decomposition of organic materials in the soil under upland field conditions during summer.

Materials and Methods

Top soil was taken from AVRDC upland fields, air-dried, passed through a 2-mm sieve, and then mixed with sugarcane compost (SCC), cattle dropping compost (CDC), castor-oil granule (COG), organic fertilizer #1 (F#1), or organic fertilizer #3 (S#3). The mixing ratios used (Table 7) were the same as those used in the organic fertilizer application trials on vegetable soybean.

The mixtures were then placed in net bags (8 × 16 cm, 80 mesh) made of synthetic fiber and buried in the same soybean cropping field where top soil at a depth of 5-20 cm was collected. The experiment was carried out in a randomized complete block design with two replications. Irrigation was introduced twice in the field.

From soil samples obtained from the bags at 0, 3, 6, 17, 30 and 60 up to 90 days after application, the following were determined: soil moisture content and available nitrogen (1 N.KCl, 20:100) under wet conditions, and organic matter content, total nitrogen (Kjeldahl method), available phosphorus (Olsen method, 2.5:5), potassium, calcium, and magnesium (Morgan method, 10:50), pH (2:5) and electrical conductivity (1:5) under dry conditions.

Table 7. Application rates of organic fertilizers.

Compost	Rate (t/ha)	Rate (g/1 L soil)
Sugarcane (SCC)	40.0	27.0
Cattle dropping compost (CDC)	20.0	13.0
Castor-oil granule (COG)	0.5	0.3
T.F. organic fertilizer #1 (F#1)[z]	20.0	13.0
T.S. organic fertilizer #3 (S#3)[y]	20.0	13.0
Control	0.0	0.0

[z]Produced by Taiwan Fertilizer Company. [y]Produced by Taiwan Sugar Company.

Results and Discussion

Moisture content. Moisture content of the soil rose very rapidly during the first week, reaching the maximum on the sixth day, then subsequently declined gradually up to the 17th day. Moisture content stabilized from 24% to 21% towards the end of the experimental period.

The highest soil moisture content observed on the sixth day was due to irrigation on the fifth day after fertilizer application.

pH values of water extract (2:5). The pH values of all extracts increased rapidly one week after application and reached the peak during the third to fourth week. However, pH values stabilized for the rest of the experimental period.

Electrical of conductivities of water extract (1:5). EC values of all samples increased during the first week with a few exceptions on the sixth day and subsequently decreased slowly until the 60th day after application. EC values slightly increased until the end of the experiment.

Total carbon content. Soils showed rapid increase in the total carbon content on the first three days, reaching a maximum on the sixth day after application and then slowly decreased until the end of the experiment.

Total nitrogen content. Considerable fluctuations in total nitrogen content were observed during the first week irrespective of the treatment because of the effect of irrigation water introduced. Total nitrogen content decreased slowly in the soils up to the 60th day but slightly increased toward the end of the experiment. This slight increase could be attributed to the presence of soybean plant roots in the same field. However, a quantitative evaluation of nitrate nitrogen is needed to fully understand the behavior of total nitrogen.

Available nitrogen content. Available nitrogen in the soils except those with S#3 and SCC were similar on the sixth day after the application. The rapid decrease observed on the sixth day after the application of F#1, CDC, COG and control could be attributed to leaching as a result of irrigation.

The carbon to nitrogen (C/N) ratios of the soils immediately increased after application, reaching the peak on the third or sixth day but decreased after on the sixth to 17th day, then gradually increased again up to the 60th day and beyond.

SCC, S#3, CDC and control soils had almost the same phosphorus content, maintaining relatively constant levels throughout the experimental period. However, both F#1 (with the highest value during the initial period up to the sixth day after application) and COG soils (with the lowest value during the same period) were considerably different from the other soils in this respect. F#1 decreased very rapidly within one week after application but COG increased in between the second and the fourth week after application and then started to decrease toward the end of the experiment.

All soils except F#1 had nearly constant levels of potassium during the first month but decreased very slowly toward the end of the experiment. Potassium content of F#1 soil decreased very rapidly within three to six days after application and then gradually up to the end of the experiment.

All soils had similar calcium content throughout the experimental period which increased gradually in two to three weeks after application and then stabilized for the rest of the experimental period.

Magnesium in the soil decreased gradually throughout the experimental period with a few exceptions.

Based on the results obtained the organic fertilizer F#1 seemed more effective in providing available plant nutrients under the given experimental conditions.

However, further evaluation on the behavior of total nitrogen and available nitrogen including nitrate-nitrogen constituent are needed to obtain their decomposition or rates of release in upland soils under irrigated and nonirrigated conditions in summer and winter.

Effects of Nutrient Composition on Mineral Distribution in Chinese Cabbage

Summary

The study examined the effects of different nutrient composition ratios on their distribution and relationships with tipburn or internal rot in Chinese cabbage.

Chinese cabbage transplants (Hybrids 85-216 and 82-46) were cultivated for 35 days using solution culture techniques with potassium, calcium and magnesium at different concentrations, and nitrogen and phosphorus at conventional rates.

Growth and yield of both hybrids were affected by the nutrient concentration ratios. Ca distribution even in the innermost leaves was affected greatly by an adequate supply of nutrients while its concentration in the outer blade of inner leaves appeared regulated by the application of nutrients with suitable composition ratios. However, Hybrid 85-216 was more resistant to tipburn or internal rot than Hybrid 82-46. Thus, the nutrient supply and variety of Chinese cabbage greatly influenced tipburn incidence.

Introduction

Tipburn, characterized by necrotic lesions on the outer blade of fast growing young leaves, is associated with a low concentration of calcium in affected tissues (Thibodeau and Minotti 1969[1]; Kuo et al. 1981[2]). Many studies on how to prevent or minimize its occurrence have been carried out (Palzkill et al. 1976[3]; Cox and Dearman 1981[4]). Despite these studies, leaf tipburn becomes widespread and severely reduces the market value of cole crops. However, studies on changes in calcium concentration in apple fruits during development (Magness et al. 1936[5]; Oberly and Kenworthy 1961[6]; Simons 1962[7]) which eventually led to practical remedies for bitter pit (Van der Boon 1974[8]), a calcium-related disorder, revealed the possibility that similar studies can also be undertaken to find a control strategy for tipburn in Chinese cabbage.

This work was therefore carried out as a preliminary trial to study the effects of distribution of different nutrient compositions in Chinese cabbage and the relationship of nutrients with the occurrence of tipburn or internal rot.

Materials and Methods

Equipment and cultural conditions. The experiment was carried out in a net house at AVRDC from 10 April to 29 May 1989. Air temperature, and maximum and minimum humidity ranged from 27 to 37°C, 55-64% and 86-94%, respectively. Solution temperatures were 27-32°C.

Chinese cabbage seeds (Hybrids 85-216 and 82-46) were first sown in plastic pots (ϕ = 6 cm, height = 8 cm) containing smoked rice hulls and placed in containers with half-strength nutrient solution. Seedlings were transplanted two weeks later to 45-l containers, each with two plants and an initial solution of 44 l. Three plants were maintained in each treatment arranged in a randomized complete block design.

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[1]Thibodeau, P. O. and P.L. Minotti 1969. The influence of calcium on the development of lettuce tipburn. J. Am. Soc. Horti. Sci., 94: 372-376.

[2]Kuo, C. G. et al. 1981. Tipburn of Chinese cabbage in relation to calcium nutrition and distribution. Hort. Sci. 14: 131-138.

[3]Palzkill, D. A., T. W. Tibbits and P. H. Williams. 1976. Enhancement of calcium transport to inner leaves of cabbage for prevention of tipburn. J. Am. Soc. Hort. Sci., 101: 645-648.

[4]Cox, E. F. and A. S. Dearman 1981. The effects of trickle irrigation, misting and row position on the incidence of tipburn of field lettuce. Hort. Sci. 15: 101-106.

[5]Magness, E. S. et al. 1936. Effect of nutritional treatments on internal cork of apples. Proc. Amer. Soc. Hort. Sci. 34: 206-209.

[6]Oberly, G. H. and A. L. Kenworthy 1961. Effect of mineral nutrition on the occurrence of bitter pit in Northern Spy apples. Proc. Amer. Soc. Hort. Sci. 77: 29-34.

[7]Simons, R. Y. 1962. Anatomical studies of the bitter pit area of apples. Proc. Amer. Soc. Hort. Sci. 81: 41-50.

[8]Van der Boon, J. 1974. Influence of nutrition on bitter pit in apples. In: G. Naumann (Editor), Second Discussion Meeting on Bitter Pit in Apples. Act. Hort., 45: 9-16.

Nutrient treatment. There were six treatments with different concentration ratios of potassium, calcium and magnesium (Table 8). Nutrient solutions were checked weekly as necessary. All treatments were aerated round-the-clock for 15 min per hour and maintained at pH 6.5 ± 0.3 by 5 N H_2SO_4 while water level was allowed to decrease gradually up to 5 cm below the initial level. Water consumption was recorded thrice weekly. The status of plant growth and vigor was checked twice a week.

Table 8. Nutrient formula used in the experiment.

Treatment (cation ratio)	Macro-element N	P	K	Ca	Mg
			mg/l		
A 2:1:1	100	40	100	50	50
B 6:1:1	100	40	300	50	50
C 6:3:1	100	40	300	150	50
D 6:6:1	100	40	300	300	50
E 2:1:1	100	40	100	50	100
F 6:6:2	100	40	300	300	100

Analytical procedure. Plants at harvest were dissected into three parts (the outer blade, inner blade and petiole) to determine the distribution pattern of elements in the leaves. Fresh and dry weights of plants were recorded.

Nitrate in the nutrient solution was determined colorimetrically by UV method (220 nm) (Franson 1985[9]), phosphate by ascorbic acid method and potassium, calcium and magnesium by atomic absorption spectrophotometer.

Total nitrogen, phosphorus, potassium, calcium and magnesium in the leaf were analyzed after digestion. Total nitrogen was determined by Kjeldahl distillation method. Phosphate, potassium, calcium and magnesium were analyzed by the same methods previously described.

Results and Discussion

Effect of cation ratio on growth. Results showed that there were significant differences ($P < 0.05$) between yields, head and root weight in both varieties. Hybrid 85-216 produced higher yields and head weight (Table 9); however, Hybrid 82-46 formed bigger roots. Although this is an exceptional case of the root-shoot relationship, it indicated that larger root mass does not always lead to higher yield and that some other factors such as translocation of nutrients after absorption should also be considered.

Table 9. Effects of different nutrient compositions on the fresh weight per plant of Chinese cabbage.

Treatment	Total fresh weight (g)		Head (g)		Root (g)	
(cation ratio)	85-216	82-46	85-216	82-46	85-216	82-46[z]
A 2:1:1	1678 a[z]	1503 ab[z]	778 a[y]	521 a[z]	131[x]	139 ab[z]
B 6:1:1	1518 ab	1074 c	744 a	373 b	122	124 b
C 6:3:1	1511 ab	1427 ab	629 ab	422 ab	137	148 ab
D 6:6:1	1588 ab	1468 ab	711 ab	411 ab	118	135 ab
E 2:1:2	1321 b	1159 bc	503 b	369 b	139	127 b
F 6:6:2	1537 ab	1733 a	660 ab	660 a	126	187 a

[z]$P < 0.05$. [y]$P < 0.01$. [x]Not significant.

[9]Franson, F. A. H. 1985. Standard methods for the examination of water and waste water. American Public Health Association. Washington, DC 20005.

Effects of cation ratio on tipburn occurrence. The symptoms of marginal necrosis appeared after head formation. These were the abnormal signs observed during the entire growing period. Tipburn or internal rot in Chinese cabbage is highly related to variety and nutrient composition of the growing solution. Although calcium concentration was higher in Hybrid 82-46 than in Hybrid 85-216 in the outer blade of inner leaves, Hybrid 85-216 showed more resistance to tipburn or internal rot than Hybrid 82-46. However, this difference could be related to the cation exchange capacity (Armstrong and Kirkby 1979[10]) or the calcium requirement of the plant rather than growth, head and root mass of the variety.

An increase in potassium, calcium and magnesium concentration of the nutrient solutions can reduce the incidence of tipburn or internal rot. Treatment A showed better growth and resistance to tipburn or internal rot although the nutrient concentration was rather low compared to other treatments. This indicated that suitable nutrient balance could lower the plants' abnormal response.

A significant ($P > 0.05$) difference was observed in terms of water consumption. Treatments with less tipburn or internal rot showed more water uptake indicating that transpiration in the leaf favored the translocation of elements, hence ensuring a better balance for the plant's requirements in building up new tissue.

Effects of cation ratio on nutrient distribution. Nitrogen was higher in the plant's outer blade than in the inner blade and petiole. Phosphorus was higher in the petiole. The distribution patterns of both varieties were the same; both showed decreases in nitrogen and phosphorus concentration in the outer leaves of the wrapper head, i.e. 17-24th leaves of Hybrid 85-216 and 25-32nd leaves of Hybrid 82-46.

Potassium concentration in the petiole was always higher than in inner and outer blade. In the petiole and inner blade, potassium concentration decreased from the outer leaves to the inner leaves. However, a steady increase in potassium concentration was found in the outer blade from the outer leaves (non-wrapper leaves) to the inner leaves (head). This could be explained by higher transpiration rate in the outer leaves which eventually led the potassium to accumulate in the petioles of outer than inner leaves. In the head, transpiration of leaf was greatly reduced, thus less potassium was found in the petiole. Because of high potassium mobility, a high concentration of potassium was observed in the inner and outer blades of inner leaves.

Outer leaves accumulated more calcium than the inner leaves because of less transpiration in the inner leaves. Transpiration is important for calcium translocation after root absorption. Also calcium could be regulated more by adsorption than by mass flow (Ferguson and Bollard 1976[11]) which makes it a highly immobile element in the plant, resulting in less accumulation in the inner leaves. A close examination of the nutrient distribution pattern revealed that decrease in calcium concentration was faster in the outer blade than in the inner blade and petiole. Older leaves accumulated more calcium than young ones in the nonwrapper leaves of Chinese cabbage, implying the difficulty in calcium translocation and redistribution.

The distribution pattern of magnesium also indicated difficulty in translocation wherein outer leaves accumulated more magnesium than the inner leaves. However, magnesium concentration was higher than calcium in the outer blade.

Results suggest that nutrient supply had great influence on the distribution of elements even in the innermost leaves of the plant. Calcium concentration in the outer blade of inner leaves could be increased by applying suitable nutrient compositions.

Although root activity tended to decrease as electrical conductivity increased, regression analysis showed that there was no significant difference in the root activity; analysis of variance also revealed no significant differences in root activity. These indicated that incidence of tipburn or internal rot and the difference in absorption of nutrients were not related to the ability of the root to absorb elements. It was the supply of nutrients and the manner of translocation of elements within the plant that caused the difference.

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[10]Armstrong, M. J. and E. A. Kirkby 1979. The influence of humidity on the mineral composition of tomato plants with special reference to calcium distribution. Plant Soil 52:427-435.

[11]Ferguson, I. B. and E. G. Bollard 1976. The movement of calcium in woody stems. Ann. Bot. (London) 40: 1057-1065.

Pepper Tolerance to Varying Soil Moisture Levels in Sloping Bed Fields

Summary

Two large-scale sloping bed fields were constructed in 1988 to determine the yield potential and tolerance of crops to varying soil moisture levels.

In the first trial, the yield and tolerance of 112 pepper accessions were examined from August 1988 to January 1989 using these fields. Nine accessions without yield reduction and seven with 10% yield reduction were found tolerant to higher soil moisture conditions. Among these 16 accessions, 10 had acceptable yields.

Further experiments are needed to understand crop tolerance to varying soil moisture levels in sloping beds.

Introduction

The evaluation of crop tolerance to both flooding and drought is important in both production and breeding work. In this trial, 112 pepper accessions including *Capsicum annuum*, *C. frutescens*, *C. chinense*, *C. baccatum*, *C. pubescens* and *C. chacoense* were grown at the same time on sloping bed fields with a gradient soil moisture content. The experiment aimed to develop a quick and simple screening method applicable to a large number of germplasm and breeding lines to identify high yield potential and greater tolerance to soil flooding and drought under tropical conditions.

Materials and Methods

Two sloping bed fields (20 × 50 m) were constructed in 1988 using upland surface soil (alluvial) (Fig. 2a and 2b). Water was supplied in the field through piping systems set from the surrounding ditch of each field. Water supply was automatically kept at a constant level throughout the growing period so that a gradient soil moisture condition was established by capillary action. Seedlings of 112 pepper accessions including Blue Star, Szechuan and Passion which are widely cultivated in Taiwan were transplanted in the fields on 29 August and 1 September 1988 at a distance of 75 cm x 50 cm with one accession per row. Harvesting was done from 12 October 1988 to 17 January 1989 according to fruit maturity.

The rates and frequency of chemical fertilizer application are given in Table 10. The fields were mulched with silvery- black vinyl sheets to prevent erosion of surface soil and fertilizer runoff due to rain.

Results

Moisture content. Some geometric differences in soil moisture content were observed (Fig. 3) at different distances from the water pipe under the existing conditions. Each gradient of the soil moisture content was well established in both soil surface and subsoil layers.

Table 10. Rates and frequency of fertilizer application (kg/ha).

	N	P_2O_5	K_2O	Time applied
Basal application	60	150	50	
Top dressing 1	30		–	2 weeks
Top dressing 2	40		30	6 weeks
Top dressing 3	40		30	10 weeks
Top dressing 4	30		40	14 weeks
Total	200	150	150	

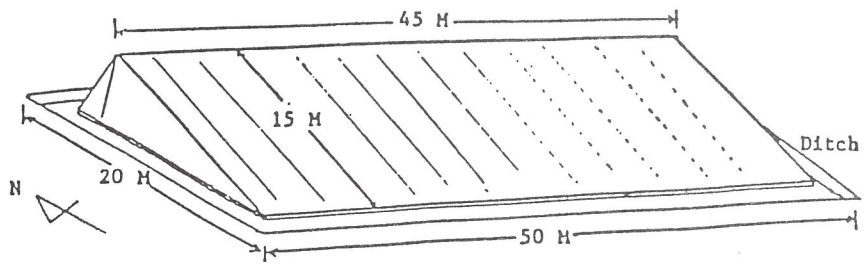


Fig. 2a. Top view of a sloping-bed field.

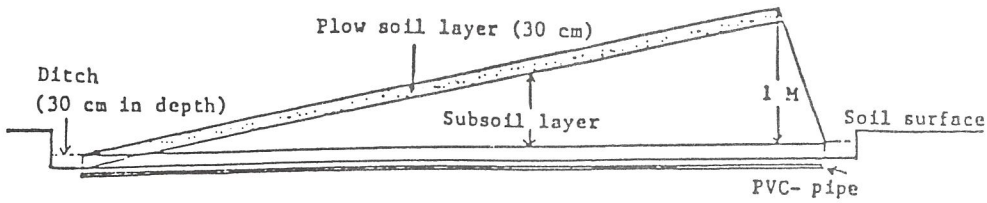


Fig. 2b. Profile of a sloping-bed field.

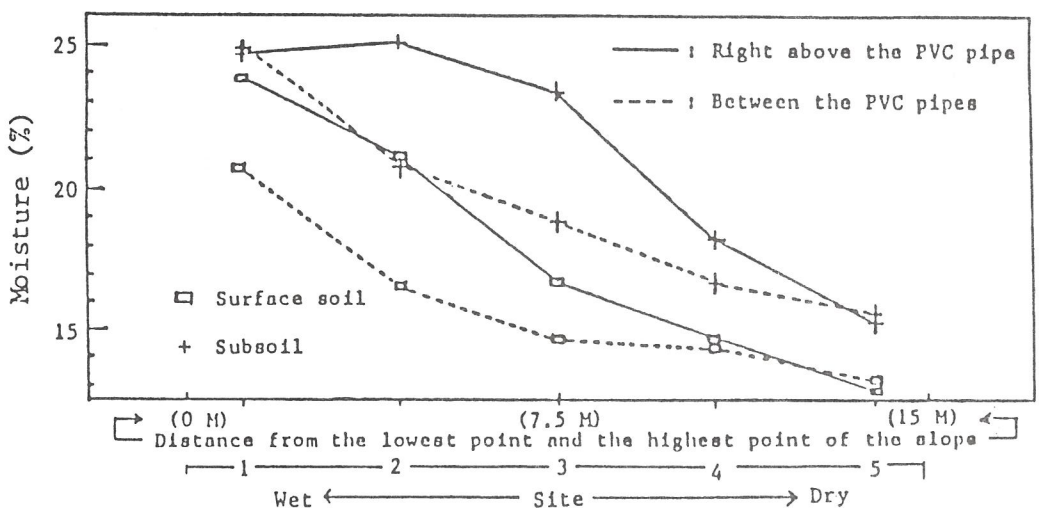


Fig. 3. Soil moisture content of the sloping-bed field.

Pepper tolerance to varying soil moisture levels. Mature fruits of five or six pepper plants taken from three sites in the same rows were used as composite samples and their yields were evaluated to determine the plants' tolerance to varying soil moisture levels within the same accessions but not among accessions.

Nine accessions with no yield reduction in Site No. 1 were found tolerant to higher soil moisture condition (Table 11).

Of the 112 accessions tested, seven and 58 attained high and medium yield levels, respectively. The rest has low yields.

Based on yield level and 10% yield reduction level, 10 of the 15 accessions listed in Table 11 were considered acceptable.

Given the same accessions or breeding lines, further experiments that deal with drought conditions and irrigation water movement in the fields are needed.

Table 11. Accessions tolerant to high soil moisture conditions.

Yield level	Varieties		
	No yield reduction (9 accessions)		10% yield reduction (6 accessions)
High			C00105
Medium	C00689	C00704	C00693
	C00299	C01377	C00707
	C00753	C00773	C00948
Low	C00737	C00303	C00708
	C00629		C00187

Soybean Tolerance to Varying Soil Moisture Levels in Sloping Bed Fields

Summary

This second trial in sloping bed fields examined the yield production and tolerance to varying soil moisture levels of 111 soybean varieties.

Among these varieties, 10 without yield reduction and 22 with 10% yield reduction under high soil moisture condition were tentatively selected as tolerant and potential materials. Of these 32 varieties, 21 had acceptable yields.

In addition to seed weight, the number of pods and seeds and total dry matter were considered very useful in evaluating tolerance to high soil moisture levels.

Further experiments particularly on water and fertilizer management and screening for crops are needed to determine the vegetables' tolerance to flooding and drought stress.

Introduction

Crop tolerance to flooding and drought and greater tolerance to soil stress under tropical conditions are important considerations if high yield is desired.

This study is the second in a series of trials on crop tolerance to varying soil moisture levels. One hundred and eleven soybean varieties were grown in sloping bed fields in spring to early summer 1989 to make a preliminary survey of their yield and tolerance to varying soil moisture levels.

Materials and Methods

Seeds of 111 soybean varieties including KS 8, AGS 129 and AGS 66 which are widely cultivated in Taiwan were directly sown at the rate of three to four grains per hole on their respective rows (one variety per row) within a row distance of 10 cm and between row spacing of 75 cm in the fields. After germination, seedlings were thinned to two plants per hole.

Chemical fertilizers were applied only as basal dressing at the rates (kg/ha) of 60, 90 and 60 for N, P_2O_5 and K_2O, respectively, before sowing the seeds. Pods were harvested as plants attained maturity. The fields were mulched with silvery-black vinyl sheets throughout the experimental period to prevent soil and fertilizer run-off due to rains.

Results and Discussion

Soil moisture in the topsoil layer. After harvesting, irregular distribution of soil moisture was observed along the contour lines of the fields and was related to the distribution of irrigation pipes installed underneath the field base. More in-depth investigation is needed on this aspect.

Soybean yield. Forty to 60 mature plants were sampled and their yields and 100-seed weight were measured.

Of the 111 soybean varieties evaluated, 17 and 78 had high and medium yields; the remaining 16 had low yields.

Soybean tolerance to varying soil moisture levels. The yield and tolerance of plants to varying soil moisture levels were evaluated within the same varieties but not among varieties.

Ten varieties with no yield reduction when water-logged seemed tolerant to high soil moisture conditions (Table 12).

Twenty-one of the 32 varieties listed in Table 12 were slightly less tolerant to high soil moisture levels.

Table 12. Varieties tolerant to high soil moisture conditions.

Yield level	Varietal number[z]	
	No yield reduction	10% yield reduction
High	–	29
Medium	9, 50, 104, 112, 211, 256, G 38	19, 85, 95, 100, 102, 110, 114, 115, 188, 226, 286, 298, 324
Low	205, 266, G 9053	113, 118, 124, 178, 185, 292, 295, G215

[z]Varietal number without prefix belongs to AGS Series.

Soybean tolerance to high soil moisture levels. Thirty-nine soybean varieties were examined to establish a fast and simple screening method applicable to a large number of vegetable varieties for higher yield and greater tolerance to soil moisture stress.

Ten plants of each variety were taken from three sites within the same row and their soil moisture tolerance was evaluated on the basis of growth parameters and dry weights.

Based on seed yield among the 39 varieties examined, only AGS 58, 128, 160 and G38 were considered tolerant to high soil moisture conditions.

Among four varieties the growth parameters and plant parts (no. of pods and seeds), seed yield and total dry matter were examined. These were considered very important in evaluating tolerance to high soil moisture conditions and dry matter production potential under the existing experimental conditions.

Sloping Field Cultivation as a Screening Method for Flood and Drought Tolerance

Summary

This project was designed to determine the uniformity of moisture and nutrient distribution in a sloping bed field and to evaluate the applicability of sloping field cultivation as a screening method for flood and drought tolerance. The response of three Chinese cabbage cultivars under various soil moisture conditions was examined.

Soil moisture distribution was governed by irrigation piping system and bed height. Moisture fluctuation between two pipes was greater than above the pipe. Water could hardly reach the position between two pipes at bed height above 75 cm. It is suggested that water be supplied directly from the base of the bed rather than through a piping system to obtain equal moisture distribution.

Soil nutrient movement followed water movement in the soil. High in the bed, nutrients accumulated on top soil due to plant uptake and evapotranspiration. Low in bed, nutrients were carried down by water and accumulated in subsoils.

Based on yield, Chinese cabbage response to moisture gradient in sloping bed was within the first meter from lower end and 3 m above the upper end. A terraced bed is recommended for screening crops under soil moisture stress.

Introduction

Flooding and drought are major constraints in crop production in the tropics. Screening cultivars tolerant to both stresses is important. To create a moisture gradient environment on a field scale for a screening trial, a sloping field cultivation method was proposed in 1988. Two sloping (45 x 15 m) beds were constructed in the field at AVRDC. Bed was increased from 10 cm up to 115 cm. Bed height varied to develop a gradually changing soil moisture condition. Since water was continuously supplied into the bed through pipes underneath the bed, water moved upward by surface evaporation and capillary force. Moisture content was controlled by the length of the capillary path in the soil, thus reflected by the bed height. Although soil moisture content changed with bed height, due to the slope, nutrient movement and accumulation made the sloping bed a complex environment, especially after successive cultivation of pepper and soybean.

This project was designed to survey the uniformity of distribution of moisture and nutrients in a sloping bed field and evaluate the applicability and acceptability of sloping field cultivation as a screening method for flood and drought tolerance.

Materials and Methods

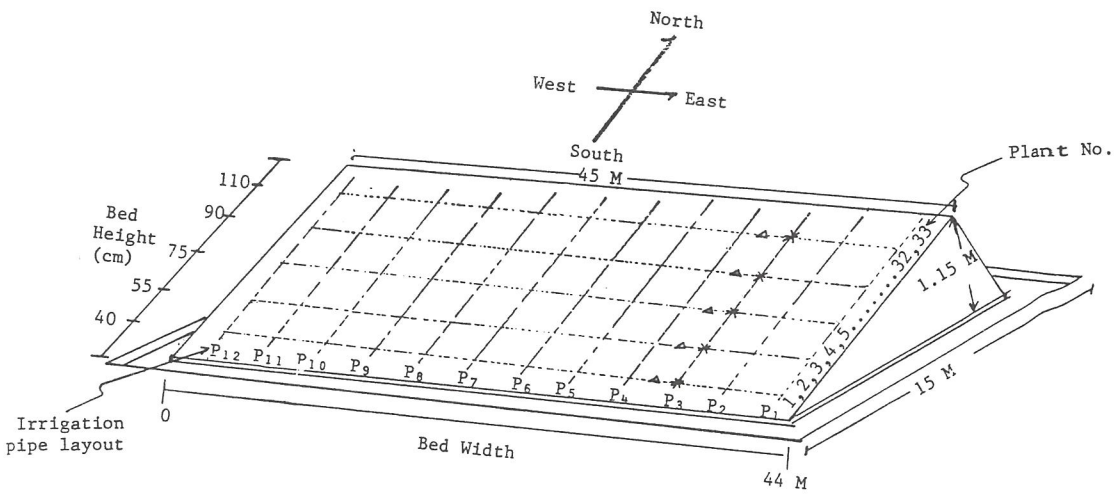
After soybean cultivation in spring, the sloping field lay fallow in summer. The vinyl covering was removed from the surface of the bed before autumn. Forty-four beds were prepared up the slope in south-north direction spaced at 1 m. Three Chinese cabbage cultivars, namely, Hybrid 62, 82-156 and Shih-Gha 8 (local variety) which were sensitive, mildly sensitive and less sensitive to internal rot, respectively were transplanted on 29 September 1989.

The actual sloping bed layout in the field is presented in Figure 4. There were 12 irrigation pipes installed underneath the sloping bed, each at 4 m apart. Pipes were numbered 1 to 12 from the east to west. The base of the bed was surrounded by a 30-cm deep irrigation ditch where the pipes continuously supplied irrigation water to the sloping bed. Surface and subsoil samples in five bed heights (40, 55, 75, 90 and 110 cm), right above the pipes and between the pipes were collected before planting and at harvest. Relevant soil properties and soil moisture were measured. In addition, 35 tensiometers were set above the fourth and the ninth pipes, between the fourth and fifth pipes; and between the ninth and 10th pipes to monitor soil moisture fluctuations after head initiation. Tensiometer readings were taken twice daily. Water supply from the eighth to 12th pipes was cut off after head initiation to determine the Chinese cabbage response to drought.

For each 1-m bed, 33 Chinese cabbage plants were transplanted and numbered from the base to the top of the sloping bed. Total weight and head weight of individual plants were determined at harvest and plotted against bed height. Root systems of seven different bed heights were also surveyed.

Results and Discussion

Soil nutrient variations before planting. Soil pH, EC and MgO at 40-cm bed height were higher than those of 100 cm, but this trend was the reverse in other nutrients. Variations of soil



* Sampling location at 5 bed heights above pipes

Δ Sampling location at 5 bed heights between pipes

Fig. 4. The sloping bed layout in the field and sampling location.

nutrients with different bed widths and heights showed that a considerable amount of nutrient supplied by fertilizer moved upward through plant uptake and evapotranspiration. MgO supplied by irrigation water accumulated downward due to water movement. Soil EC and total nitrogen fluctuations seemed greater than for other nutrients. However, the difference was small compared with P_2O_5, K_2O, MgO and CaO.

Soil pH decreased toward the east side of the sloping bed; the reverse was true for P_2O_5 and K_2O indicating that slope of bed also declined toward the west. Nonuniformity of nutrient distribution in the sloping bed within a short period indicated that this method was not applicable for screening crops sensitive to soil nutrient variation.

The topsoil contained more nutrients than the subsoil except at 40-cm bed height or below, where subsoils accumulated more nutrients than topsoils. Since low bed height was close to the irrigation ditch, these parts were saturated with water. Therefore, instead of moving upward, nutrients moved downward to the subsoils.

In topsoils, soil nutrients were higher between two pipes than above the pipes; these were lower in subsoils. It took water much longer to move laterally than vertically because the distance between two pipes was 2 m. Hence, nutrients accumulated between two pipes. On the other hand, subsoil was saturated with moisture especially at low bed heights, right above the pipe with nutrients accumulating more than between two pipes.

Soil moisture distribution and EC fluctuation at head initiation. Moisture in both top and subsoils fluctuated greatly along the pipes in all five bed heights. Such differences were more pronounced at lower bed heights. Since water was supplied from the bottom of the bed, moisture was higher in subsoil than topsoil. The east side of the sloping bed was higher than the west side. Fluctuations in moisture variation between the third and the fourth pipes were significantly greater than in soils above the pipes. Moisture content varied in soils above different pipes and in those between pipes, which resulted in complex and irregular moisture distribution in the sloping bed field. To get equal moisture distribution, water should be supplied directly from the base of the bed rather than through pipes.

Soil EC during the experiment showed higher fluctuation compared with that in soils before planting. This indicated fast nutrient movement even after 20 days of cultivation.

Soil moisture changes after head initiation. Soil moisture (or suction), a useful index for characterizing the energy status of soil water with respect to plant's water uptake, can be measured directly *in situ* by a tensiometer. Readings obtained can be converted to soil moisture content with a soil water curve. At saturation level, no suction exists; as moisture decreases, reading in the tensiometer increases.

At low bed height, water replenishment from irrigation was fast enough to meet the uptake by plant, thus moisture levels remained relatively constant. When bed height increased, the replenishment of water took more time to reach the topsoil. Thus, water depletion by plants was much faster than replenishment; the readings increased drastically at later stages. Diurnal variations in water depletion were notable.

Moisture data from topsoils above the ninth pipe and between the ninth and the 10th pipes clearly indicated the considerable amount of water was taken by plants and evaporated from soil surface. The gap between morning and afternoon (time when data were taken) was greater at 10-cm bed height than at 40 cm. Since tensiometer readings represented soil water potential, moisture at high bed position was low and water suction was great. Even if the plants absorbed the same amount of soil water, the potential would increase more at high bed than at low bed position. Because irrigation water from the ninth pipe was cut off 25 DAT, moisture level decreased and finally, readings at 40-cm bed height reached the same level as that at 90 cm.

Due to continuous water supply, soil moisture levels remained constant at the lower part of the bed above the fourth pipe, but slightly increased at the higher part of the bed. Water could hardly reach a bed height above 75 cm. Thus readings were almost the same for high bed positions.

Yield of Chinese cabbage and root development. Soil moisture levels varied with bed height, but most of them were within the desired ranges for crop growth. Hence, yield of all three cultivars (Hybrid 62, 82-156 and Shih-Gha 8) were almost the same within most bed regions. All cultivars were not tolerant to flooding. Shih-Gha 8 was easily infected by soft rot. Yield losses due to drought were slightly higher in Shih Gha 8 than in the other two.

Cutting water supply off after head initiation reduced yield slightly because sufficient water remained in soils to sustain plant growth. In addition, water could move laterally from one side of the bed where water was supplied continuously to the other. From these results, the sloping field is not advisable for screening crops under extremely flooded and drought conditions.

Soil nutrient fluctuation at harvest. After 40 days of cultivation, soil nutrient fluctuations became greater than before planting of Chinese cabbage. However, variations with bed widths and heights were almost the same compared with soils before planting.

To improve sloping bed cultivation, the following are recommended:

1. Decrease the size of sloping bed and supply irrigation water directly from the base of bed without piping system,
2. Supply water intermittently rather than continuously,
3. Construct a terraced bed field with different bed heights instead of a sloping bed, and
4. Beds of different heights should be separated to prevent nutrients from flowing out of the beds.

International Cooperation

Training

Enrollment

During the year under review, 113 training participants from 13 countries were enrolled as research fellows, research scholars, research interns, production trainees, special purpose trainees, and undergraduate student trainees.

The 113 participants contributed an aggregate training time of 418.75 man months or 35 man years (Table 1). The participants were distributed into the three major programs of the Center: Crop Improvement, Production Systems and Development (Table 2). Thirty-nine scholars (34.5%) were enrolled in four disciplines under the Crop Improvement Program. Twenty-three (20.4%) were enrolled in four disciplines under the Production Systems Program. There were 43 participants (38.1%) registered in the Vegetable Production Training Course and Training Management under the Development Program.

Training Sponsors

There were nine other training sponsors in addition to AVRDC (Table 3) which provided financial support to 113 participants. The Japan Shipbuilding Industry Foundation provided scholarships to 58 participants from six countries equivalent to 308 man months of training.

The Asian Development Bank through the Collaborative Vegetable Research Program in Southeast Asia (AVNET) provided financial support to 27 technical personnel from the network to participate in short courses on Integrated Pest Management of Diamondback Moth, Viruses of Pepper, Anthracnose of Pepper, Bacterial Wilt and Germplasm Evaluation. The first three courses were held at AVRDC headquarters and the last two were conducted in Thailand and Indonesia, respectively.

Development of Training Materials

From the Japan Shipbuilding Industry Foundation grant, AVRDC was able to procure a video unit. During 1989 a video technician was hired and video production began. Two instructional videos on:

Table 1. Distribution of trainees by country and period of scholarship.

Countries	RF	RS	RI	PT	SPT	UST	Total	MM
Bangladesh				1			1	5
Canada		1					1	12
Denmark					1		1	0.75
Guadeloupe					1		1	1.5
Indonesia			2	10	4		16	67.25
Iran				1			1	5
Japan				1		1	2	7
Korea			1				1	5
Lesotho			2				2	10
Malaysia			5	6	6		17	66.25
Philippines	1		3	8	6		18	76.75
Taiwan			2		4	18	24	48.25
Thailand			5	16	7		28	114
Total	1	1	20	43	29	19	113	418.75

RF = Research Fellow RS = Research Scholar RI = Research Intern PT = Production Trainee SPT = Special Purpose Trainee UST = Undergraduate Student Trainee MM = Man months.

Table 2. Distribution of trainees by program/discipline and training period.

Program/Discipline	RF	RS	RI	PT	SPT	UST	Total	MM
Crop Improvement Program								
Plant Breeding		1	5		1	1	8	44.5
Plant Pathology			2		13	2	17	21.3
Plant Physiology			1		1	1	3	8.75
Entomology					8	3	11	22.0
Subtotal		1	8		23	7	39	96.5
Production Systems Program								
Ag. Chemistry					3	8	11	19.0
Soil Science			1	1		3	5	16.0
Cropping Systems			3		3		6	20.25
Crop Management			1				1	5.0
Subtotal			5	1	6	11	23	60.25
Development Program								
Production Technology				42			42	206.0
Training Management	1						1	12.0
Subtotal	1			42			43	218.0
Support Units								
Seed Technology (GRSU)			7			1	8	44
Subtotal			7			1	8	44
Grand Total	1	1	20	43	29	19	113.0	418.75

Table 3. Distribution of scholars by sponsors.

Sponsor	RF	RS	RI	PT	SPT	UST	Total	% MM
JSIF	1		17	40			58	308
AVRDC			1	1		17	19	42
AVRDC/TOP					2		2	2
ADB					20		20	23.5
COA			2		4		6	13.25
CIDA		1					1	12
CRG					1		1	1.5
IFS					1		1	0.75
PPIC						2	2	4
MCC				1			1	5
WTO				1			1	6
Self-sponsored					1		1	0.75
Total	**1**	**1**	**20**	**43**	**29**	**19**	**113**	**418.75**

JSIF – Japan Shipbuilding Industry Foundation AVRDC – Asian Vegetable Research and Development Center TOP – Thailand Outreach Program ADB – Asian Development Bank COA – Council of Agriculture, Republic of China CIDA – Canadian International Development Agency CRG – Counseil Regionale Guadeloupe IFS – International Foundation for Science, Sweden PPIC – Potash and Phosphate Institute of Canada MCC – Mennonite Central Committee, Bangladesh WTO – Wadomari Town Office, Japan

(1) integrated pest management of the sweetpotato weevil, and (2) growing vegetables using the AVRDC hydroponic method were produced. A major effort was made by the staff to draft the manuscript of the vegetable training manual.

To complement the other instructional media, AVRDC produced slide sets. Some were developed primarily for use in the production training course. Others were developed as self-contained instructional packages. AVRDC intends to make these slides available to its national partners.

Plans were made to produce small, low-cost, simply worded, generously illustrated booklets dealing with basic concepts in vegetable production. Ten topics were developed and are presently undergoing technical editing and art work.

IMPACT Newsletter. Designed to keep the former trainees of AVRDC in close contact with the Center, the IMPACT newsletter was published twice. It contains updates for the alumni particularly on vegetable production. An attempt was made in each issue to motivate trainees to respond to the newsletter, thereby reestablishing a linkage with the AVRDC training program. Approximately 50 former trainees (about 20% of AVRDC former scholars) responded to each of the first two issues.

AVNET Project

Summary

A technical assistance agreement to establish a Collaborative Vegetable Research Program for Southeast Asia (AVNET) was signed in May between the Asian Development Bank (ADB) and AVRDC. AVRDC appointed an AVNET coordinator. Each of the four participating countries, Indonesia, Malaysia, the Philippines and Thailand, designated a policy and technical coordinator. The AVNET coordinator and the technical coordinators formed the Program Coordinating Committee. A memorandum of understanding between AVRDC and each of the four participating countries was prepared to implement AVNET.

During 1989 a planning meeting was held for Subnetwork 1, Germplasm Improvement of Selected Vegetables. The participants discussed in detail the action work plans, respective responsibilities, training needs and all other relevant aspects required to successfully implement AVNET. Specific training was organized for network participants on pepper viruses and the anthracnose disease of pepper at AVRDC and on bacterial wilt of tomato and pepper at Kasetsart University, Bangkok, Thailand.

A planning meeting was also held for Subnetwork 2, Integrated Pest Management. The participants discussed the work plans, facilities needed, responsibilities of the collaborating network partners, the establishment of benchmark information at the commencement of the project, training and all other matters of common interest to the success of the project. A training program was organized at AVRDC for network participants. Construction of parasite-rearing facilities began in each of the countries.

Introduction

The Technical Assistance Agreement (TA) for the establishment of a Collaborative Vegetable Research Program in Southeast Asia between the Asian Development Bank (ADB) and AVRDC was formally signed on 26 May 1989. The Bank as stated in the TA section 1.02 authorized the commencement date of the project on 1 May 1989. Activities of one subnetwork commenced in anticipation of the approval of the TA. This report outlines the project management, germplasm subnetwork, and diamondback moth integrated pest management subnetwork (IPM-DBM) activities during the year under review.

Project Management

As stipulated in the agreement, AVRDC provided a Program Coordinator in the person of Dr. S. Shanmugasundaram. In addition, four senior Center staff, namely Drs. S.K. Green, G.L. Hartman, R.T. Opeña and J. Poulos participated actively in the germplasm subnetwork. A fifth scientist, Dr. N.S. Talekar served as lead person for the IPM-DBM subnetwork.

The collaborating countries on their part have designated the following as policy and technical coordinators:

Country	Policy Coordinator	Technical Coordinator
Indonesia	Dr. Paransih Isbagio	Dr. Subijanto
Malaysia	Dr. Mohd Yusof Hashim	Dr. Saharan Haji Anang
Philippines	Dr. Ramon Valmayor	Ms. Flordeliz D. Tiamzon
Thailand	Dr. Sujin Jinahyon	Dr. Sutevee Suprakarn

The technical coordinators and the AVNET coordinator constituted the AVNET's Program Coordinating Committee (PCC).

A detailed memorandum of understanding (MOU) was prepared by AVRDC in consultation with each of the collaborating countries. Malaysia, the Philippines and Thailand signed the MOU. The Indonesian MOU is in process as of this reporting.

An estimated program expenditure for the first year was submitted on 18 May 1989 to the Bank to obtain funds as an advance. The Bank approved the first release of US$300,000.

Germplasm Subnetwork

Planning Meeting. The germplasm subnetwork meeting which aimed to organize a formal collaborative vegetable research network (AVNET) with the NARS of Indonesia, Malaysia, the Philippines and Thailand was held in June.

Twenty-four NARS representatives including the technical coordinators, and 16 AVRDC staff members attended the meeting. Among them were nine trainees on virology who after the planning meeting continued their three-week virology training at AVRDC. The participants came up with resolutions for the establishment of germplasm enhancement, evaluation and international vegetable disease screening nurseries.

A two-week training of two technical staff (also called crop coordinators) from the network was proposed.

On information exchange, the germplasm group proposed the publication of **AVNET NEWS** twice a year.

Bacterial Wilt of Pepper and Tomato

Bacterial wilt is the most damaging soil-borne disease of tomato in the lowland tropics and subtropics. Resistance to the disease has been bred into AVRDC varieties. However, varieties found resistant in one location were later noted to be susceptible in others. Apparently, the variety's reaction to the pathogen is influenced by presence of different pathogen races as well as local environmental conditions. It is important that screening procedures be standardized so that results obtained in each country could be useful in the others. The workshop on bacterial wilt of tomato held in Thailand was attended by two representatives from Thailand and one each from Indonesia, Malaysia and the Philippines. The workshop organizers were Dr. Niphone Thaveechai and Dr. Wichai Kusitratna. Dr. Glen L. Hartman was invited as resource person.

The workshop aimed to come up with standardized and improved techniques on bacteriology for collaborative research work on bacterial wilt of tomato among the four Southeast Asian network partners and AVRDC.

Anthracnose of Pepper

The two-week training on anthracnose was held in September at AVRDC with one representative from each of the four participating countries.

Dr. Hartman's group evaluated the three currently used techniques to screen for resistance and to select one of the procedures for the trainees. Along with standardizing the inoculation techniques, the group established a collection of isolates and the basis for identification of *Colletotrichum* species.

The training course was attended by eight researchers from the cooperating countries. The main topics covered were pepper virus identification, virus strain determination, serological methods for the detection of viruses in infected tissues including ELISA, agar gel immunodiffusion, virus purification and antiserum production. Various methods for the control of pepper viruses, such as seed treatments and the use of reflective mulches to ward off insect vectors were discussed and demonstrated.

The trainees were provided with PVY antiserum and a leaf extraction device to assist in the survey in their own countries. A plan of an insect proof screenhouse such as those used at AVRDC was also supplied as a guide for setting up a similar screenhouse in their respective countries.

The training on germplasm evaluation hosted by Indonesia was held in December.

Progress of In-country Activities

Thailand had collected the following germplasm: tomato — Seeda, Seedathip 1, Seedathip 2, P 502, VF 134-1-2; pepper — Huey Siton, Mun, Luang, Yuak; yardlong bean — Rajburi, KU 7, KU 8, RW [illegible], cucumber — Taeng Ton, Pol-Lek, Jed Bai. The seeds were distributed to other AVNET partners for evaluation.

Malaysia had collected the following germplasm: tomato — MT 1, MT 11, Local White; cucumber — Tangkak, Bukit Mertajam, MT1 1, MT1 2; chilies — MC 4, MC 5, Kulai; long bean — MKP 5, MKP 4. The seeds were given to the AVNET coordinator who distributed the seeds to each of the countries in the network for evaluation.

AVRDC agreed to produce antisera for the four participating countries so that virus surveys could be conducted by the NARS. The following antisera were supplied to the virology cooperators in October 1989: CMV, TEV, TMV, PeMV, CVMV. They were also provided with DAEA cellulose upon request since this chemical is difficult to obtain in their home countries.

A pepper virus abstract data base covering 1983 to 1988 was sent to the participants in August.

Three countries reported their activities on pepper virus work. Preliminary virus surveys were initiated in Indonesia and Malaysia. In the Philippines, a survey of the pepper-growing areas of Regions III and IV in Luzon island was conducted. The samples were tested for PVY by DAS ELISA, using the antiserum obtained from AVRDC. All 10 samples from the University of the Philippines at Los Baños (UPLB) and two out of 30 samples from the province of Pampanga reacted positively to PVY. Inoculations have been made on virus indicator plants maintained in the greenhouse. The desiccated samples will be tested for other viruses with antisera from AVRDC.

Screening for resistance to TMV in pepper breeding lines is ongoing at the Institute of Plant Breeding (IPB), UPLB. Isolates of TMV are maintained in *Nicotiana tabacum* cv. Samsun grown in insect-proof cages.

A survey of pepper anthracnose was made in some areas of Regions III and IV in Luzon island. Pathogenicity and identification of the fungal isolate or strain is ongoing at IPB.

Integrated Pest Management of Diamondback Moth

Planning Meeting. AVRDC organized a two-day planning meeting for IPM-DBM at AVRDC to discuss the status of the diamondback moth (*Plutella xylostella* L.) problem in Thailand, Malaysia, Indonesia, and the Philippines and the ongoing DBM research activities in these countries.

The participants presented detailed reports of DBM situation in their countries. The AVRDC entomologist discussed the DBM problem in the region and AVRDC's research and development activities on this pest.

The IPM-DBM training was held in March. Trainees were given practical assignments and experiences in mass rearing of three parasites.

In the Philippines, UPLB and the Benguet State University (BSU) collaborate in the network. DBM parasitoids provided by AVRDC on 6 July and 7 August 1989 were mass reared in the laboratory and in the field. The parasitoids reared were *Diadegma eucerophaga* at UPLB and BSU; *Apanteles plutellae* at UPLB; and *Trichogrammatoidea bactrae* at UPLB.

DBM and *Corcyra cephalonica* were mass reared in cabbage-petchay and rice bran-binlid media, respectively. The second instar DBM larvae were used in rearing *A. plutellae* and *D. eucerophaga* while *Corcyra* eggs were used for *T. bactrae*.

Petchay and cabbage plants were raised and used in mass rearing of DBM. The combination of rice bran and binlid at 1:1 ratio proved to be good in mass rearing *Corcyra*.

Diadegma eucerophaga. The parasitoid was initially reared at the Department of Entomology, UPLB Laboratory at an average temperature of 27°C. Initial results showed a very low parasitism rate on DBM second instar larvae, with only 2-5% parasitism. The parasitoids developed into *D. eucerophaga* cocoons. The development of the cocoons and the emergence rate were poor and all those that emerged were males. Due to these problems, rearing of these parasitoids was transferred to BSU.

Apanteles plutellae. The parasitoid was reared in the laboratory and in a field cage. Initial results showed that the parasitoid was more effective and suited to UPLB conditions. About 40-50% parasitism on the second instar DBM larvae was noted. At present about 1,000 cocoons have been collected from the laboratory rearing. In the UPLB field rearing, no cocoons were recovered due to frequent rains which destroyed the host plant.

Trichogrammatoidea bactrae. The parasitoid was reared in *Corcyra* eggs at room temperatures. Among all parasitoids, this parasite was the easiest to mass produce. In UPLB at present there are about 50,000 parasitoids preserved for future field release.

Other parasites. In the Philippines, 100 cocoons each of *D. eucerophaga* and *A. plutellae* were given to Mr. Poelking of BSU. Twenty insect cages have been repaired at UPLB for mass rearing of DBM and the parasitoids.

Construction of parasite rearing facilities commenced in the Philippines, Thailand and Malaysia. For Indonesia, funds were sent to begin the construction.

The AVNET coordinator travelled to the Philippines and Thailand, met with the technical coordinators in each country and observed the ongoing activities of the Germplasm and IPM-DBM subnetworks.

AVRDC-Indonesia Vegetable Research Program

Summary

From November 1988 to October 1989 research activities were carried out on variety trial, integrated pest management (IPM) of diamondback moth (DBM) and screening of hot pepper accessions resistant to virus diseases. Some hot pepper accessions showed tolerance to anthracnose and cucumber mosaic virus (CMV) and tobacco etch virus (TEV). Germplasm training course was held in Lembang. The renovation/improvement of old greenhouses to support pest and disease control studies started.

Germplasm Improvement of Selected Vegetables

Seed multiplication of four cultivars each of yardlong bean, cucumber, and tomato was carried out. Yardlong bean and cucumber seeds are now ready for distribution in Malaysia and Thailand, respectively. Tomato seeds were sent to AVRDC for further multiplication. Two cultivars of shallot and three of garlic were sent to Philippines for tissue culture.

Training on germplasm collection, evaluation and maintenance was conducted in December. The training aimed to gather common opinion among participating countries about the conduct of variety trials.

Pest and Disease Control

IPM of Diamondback Moth

A larval parasitoid of DBM, *Apanteles plutellae*, and an egg parasitoid from Kurdj were introduced in Indonesia in April and May 1989. *A. plutellae* was successfully mass produced in the screenhouse and will be used for biological control program of DBM in the lowland. Rearing of *T. bactrae* on DBM eggs in the laboratory failed. In early November 1989, *T. bactrae* from Thailand was again introduced and mass reared on *Corcyra cephalonica* eggs. This effort was successful. At present, biological studies of *A. plutellae* and *T. bactrae* are now conducted in the screenhouse and laboratory of LEHRI.

A. plutellae is more tolerant and active at high temperature than *D. eucerophaga*. Therefore, a preliminary study was carried out at Subang Experimental Station (temperature 25° to 35°C; altitude ± 200 m a.s.l.) from September to December 1989. Results of this study were deemed useful in setting up a DBM biological control program in the lowlands.

An Indonesian entomologist served as a resource person at the IPM-DBM training course at AVRDC and two staff members from LEHRI attended the same course.

In April-May, LEHRI introduced a larval parasitoid (*A. plutellae*) and egg parasitoid (*T. bactrae*), which is endemic to Thailand. In early November, *T. bactrae* was also imported from Thailand. About 350 cocoons of *D. eucerophaga* and *A. plutellae* from LEHRI were introduced to the Philippines (by Prof. Belen Morallo-Rejesus) in November.

The most important fungal disease on hot pepper is anthracnose. The two agents of anthracnose on pepper are *Colletotrichum capsici* and *Colletotrichum gloeosporioides* ssp. *capsici*. Anthracnose

occurs both in the low and highland. The second important fungal disease is leaf spot caused by *Cercospora capsici*, but it is distributed mostly in highlands. Screening for resistance was done in the lowland (Subang) and highland (Segunung). Some accessions showed certain degree of resistance. LV 755, LV 173, LV 735, LC 413, LC 414, LV 629, LC 118 were resistant to *C. capsici* in seedbed. LV 206 and LV 729 were moderately resistant to *C. gloeosporioides*. There were no accessions of pepper found resistant against *C. capsici*.

On viruses, 47 samples of healthy looking plants were taken from the germplasm collection in Subang. They were tested with antisera of CMV, PVY, TEV and TMV using indirect method of ELISA. Results indicated that not all healthy looking plants are virus-free. Detection of virus on sample-II (155) collected from Subang indicated that: 103, 58, 44 and 5 samples contain AMV, TEV, PVY and TMV, respectively. The other 94 samples from Brebes showed that 65, 35, and 8 samples contain CMV, PVY and TMV, respectively. Antiserum of TEV was not used on the samples from Brebes.

Sixteen pepper accessions were screened against CMV, TEV and CMV+TEV. Infection was done by means of sap inoculation (1:5 weight of inoculum/volume of phosphate buffer pH 7.0). Regarding visual symptoms, results indicated that none of the accessions was resistant to CMV or CMV+TEV, and inoculation of TEV alone rendered that three accessions (LV 752, LV 120 and LV 173) immune, five accessions (AT 39, LV 471, LV 118, LV 125 and LV 280) resistant, and three accessions (LV 108, LV 206 and LV 359) moderately resistant.

AVRDC-Korea Bilateral Program

Chinese Cabbage

To investigate the distribution of turnip mosaic virus (TuMV) strains in Korea, 270 samples from 130 locations were collected and sent to AVRDC for assistance in identifying the virus strain(s). As the first step in the breeding program for TuMV resistance, 11 crosses were made between Korean inbreds and the O-2 cultivar which had been found resistant to five known strains of the virus. The backcross method will be employed for further manipulation of the materials.

Mungbean

In 1989 the Crop Experiment Station introduced 50 breeding lines from AVRDC for a preliminary yield trial (PYT) and 20 lines from the IMN. In the PYT, all lines tested showed low yield, compared to the check variety, Seonhwanogdu. Six breeding lines yielded more than 80% over Seonhwanogdu and had comparatively good seed coat quality. Considering several important characteristics, VC 4530-C and VC 4169 were the best entries. In the IMN, 7 breeding lines yielded 15% more than Seonhwanogdu. In this trial the yield of the check was unusually low because of excessive soil moisture. Considering several characteristics, VC 2768-A, VC 2991-A and VC 3902-A were comparatively desirable. However, almost all AVRDC breeding lines were late maturing, sensitive to lodging and large seeded, whereas, Korea needs mungbean lines which attain an early maturity, have short flowering period, disease and lodging resistance, and small seeds.

Pepper

A total of 489 anthracnose isolates were collected from 213 areas throughout the country for identification of the pathogen species. Results showed that 485 isolates were *Colletotrichum gloeosporioides* and the remaining four isolates were *C. dematium*. This confirmed that anthracnose of pepper in Korea is caused mainly by *C. gloeosporioides*.

Some 500 accessions of pepper were introduced from AVRDC. About 200 of the accessions were multiplied in 1989 and a part of the multiplied seed will be sent back to AVRDC when processing is finished. Most of the accessions multiplied were screened for resistance to two isolates of *Phytophthora capsici*, two races of bacterial leaf spot caused by *Xanthomonas campestris* pv. *vesicatoria* (Races 1 and 3), *C. gloeosporioides* and TMV-T. Three accessions were found resistant to both isolates of *Phytophthora capsici* and one accession was resistant to both races of bacterial leaf spot, while 10 and 3 accessions were resistant to TMV-T and anthracnose, respectively.

Tomato

Two processing tomato cultivars, TN 3 and TM 103, were evaluated in three different locations: Suwon, Taegu and Chunchon. TN 3 performed very well in 1988, but the yield level of both entries was disappointingly low in 1989 compared to the check variety, Jinhong.

A total of 50 cherry tomato lines were grown for preliminary evaluation. Some promising lines showed yield potential of 60-80 t/ha and fruiting ability of 250 or more fruits per plant. They showed a wide range of variations in fruit size, sweetness and acidity. Some lines selected will be further evaluated in replicated trials in 1990.

AVRDC-MARDI Vegetable Research Program

Tomato

Two evaluation trials were conducted to test the performance of exotic varieties under epiphytotic conditions of *Pseudomonas solanacearum* on peat soil in Jalan Kebun. The experimental plots were laid out in a randomized complete block design with three replications. Fourteen plants per variety were planted in two rows spaced at 60 × 60 cm plot.

In the first trial, 15 processing tomato varieties including nine AVRDC lines were tested against the local check, MT 1. AVRDC lines, PT 4098 and PT 4026 were the highest yielders although their yields were not significantly different from that of MT 1. These two lines showed favorable agronomic characters including ideal fruit size (Table 1). MT 1 was the most tolerant to bacterial wilt.

In another trial, 18 fresh market tomato varieties were tested against the local check, MT 11. Eleven of these were from AVRDC. Four AVRDC lines, namely, FMTT 94, FMTT 104, CLN 5915-206D4-2-1 and CL 5915-2065D4-2-2 showed potential yields higher than MT 11 and comparable firmness and color of fruits. However, only line FMTT 104 had significantly bigger fruits than the check variety, MT 11 (Table 2).

Hot Pepper

Varietal Evaluation. Twenty-five hot pepper accessions from AVRDC were evaluated at the Gajah Mati Station. Experimental plots were laid out in a randomized complete block design with two replications. Varieties MC 4 and MC 5 were used as checks. Due to differences in agronomic

Table 1. Performance of 16 processing tomato varieties at the Jalan Kebun Peat Station.

Varieties	Source	Fruits/plot[z]		Disease rating		Survival rate (%)
		No.	Wt. (kg)	Bacterial wilt	Virus	
PT 4098	AVRDC	107 c[y]	4.5 a	2.3 a	0.0 a	83
PT 4026	AVRDC	102 c	3.6 ab	2.7 a	0.3 a	79
MT 1 (check)	MARDI	115 c	2.7 abc	1.0 a	0.0 a	82
Puti tomato	Japan	704 a	2.5 abc	2.3 a	0.0 a	79
PT 4172	AVRDC	66 c	2.2 abc	3.3 a	0.0 a	76
PT 4165	AVRDC	51 c	2.0 abc	3.7 a	0.0 a	71
Cherry tomato	Local	382 b	1.4 bc	1.7 a	0.0 a	87
PT 4121	AVRDC	20 c	1.3 bc	4.7 a	0.0 a	61
PT 4110	AVRDC	22 c	1.1 bc	3.3 a	0.3 a	69
Ogatafukuju	Japan	12 c	0.8 c	4.0 a	1.0 a	56
K 258	AVRDC	14 c	0.7 c	4.7 a	0.0 a	46
K 262	AVRDC	19 c	0.7 c	2.0 a	1.0 a	76
TM 103	AVRDC	19 c	0.7 c	2.7 a	1.0 a	69
Seifuku	Japan	14 c	0.7 c	3.0 a	0.0 a	71
Eve	Taiwan	38 c	0.1 c	3.7 a	0.0 a	70
Mini Bell	Taiwan	2 c	0.1 c	3.0 a	0.0 a	63

[z]Plot size = 1.5 × 4.2 m^2. [y]Means within columns are not significantly different by DMRT at 5% probability level.

Table 2. Performance of 19 fresh tomato varieties at the Jalan Kebun Peat Station.

Varieties	Source	Fruits/plot[z]		Average fruit wt. (kg)	Disease rating		Survival rate (%)
		No.	Wt. (kg)		Bacterial wilt	Virus	
FMTT 94	AVRDC	56 a[y]	2.0 a	34.9	2.0 ab	0.0 a	79
FMTT 104	AVRDC	24 bc	1.7 ab	68.8	1.3 b	0.6 a	77
PT 5	LS[x]	46 ab	1.4 abc	29.8	1.7 b	1.3 a	78
CLN 5915-206D4-2-1	AVRDC	30 abc	1.1 abcd	35.0	2.7 ab	0.7 a	71
CLN 5915-206D4-2-2	AVRDC	22 bc	1.0 abcd	45.1	2.7 ab	0.0 a	61
MT 11 (Check)	MARDI	21 bc	0.8 bcd	36.0	1.3 b	0.6 a	77
FMTT 114	AVRDC	20 bc	0.7 bcd	36.8	2.7 ab	0.3 a	63
CLS 5915-223D4-2-1	AVRDC	25 bc	0.7 bcd	28.8	1.3 b	1.0 a	76
FMTT 3	AVRDC	16 bc	0.6 bcd	39.4	1.7 b	0.0 a	74
CLN 95-280D5-1-0	AVRDC	18 bc	0.6 bcd	33.5	1.0 b	0.3 a	85
Scorpio	USA	6 c	0.4 cd	67.8	2.0 ab	0.3 a	76
Sidayak	Thailand	15 c	0.3 cd	21.5	4.7 a	0.0 a	43
FMTT 22	AVRDC	8 c	0.2 cd	35.6	3.3 ab	0.3 a	54
FMTT 33	AVRDC	10 c	0.3 d	26.0	2.3 ab	0.3 a	75
CLN 913992D5-3-0	AVRDC	7 c	0.2 d	25.7	3.0 ab	0.0 a	71
H. Contessa 301	USA	4 c	0.2 d	43.8	2.7 ab	0.3 a	71
Pink King	Taiwan	4 c	0.2 d	42.0	3.0 ab	0.0 a	87
Redland S Taste	Yates	2 c	0.1 d	59.0	1.7 b	0.7 a	69
Tropical Cropper	Taiwan	2 c	0.1 d	45.0	1.7 b	0.0 a	60

[z]Plot size = 1.5 × 4.2 m^2. [y]Means within columns are not significantly different by DMRT at 5% probability level. [x]Local Seed Company.

characters as a result of different species tested simultaneously, no statistical analysis was done on the data. Line C 00551 produced good yield with favorable agronomic characters including acceptable fruit size of over 7 cm. Other lines bore either bell-shaped or small, *frutescens* type of fruits.

Diseases of Pepper

Anthracnose (*Colletotrichum capsici*). Earlier studies indicated that all 'cili padi' varieties (not necessarily *C. frutescens*) were resistant to anthracnose and that smaller and more pungent fruits were highly tolerant to the disease.

The resistant factors from 'cili padi' 6 and Serrano Huasteco (a Mexican genotype) had been successfully incorporated into susceptible cultivars. To date, 68 resistant breeding lines have been screened at Jalan Kebun Peat Station to identify lines that are acceptable to commercial growers.

Chili Veinal Mottle Virus (CVMV). A total of 30 genotypes have been identified highly resistant to CVMV. Most of these are exotic in origin. Nine genotypes which were obtained from AVRDC but originated from France, namely, Cq7a, C33a-C37a, C40a-C41a and C58a were found resistant to CVMV. All local collections tested were found highly susceptible. The local 'cili padi' 6 was resistant.

Cucumber mosaic virus (CMV). CMV has become more prevalent lately. It normally occurs in mixed infection with CVMV or other viruses. It also shares common aphid vectors with CVMV. The 12 resistant genotypes identified to date are all exotic materials. The three French genotypes obtained from AVRDC, namely, C17a, C40a and C41a were resistant to CVMV. Some genotypes resistant to CVMV were also found resistant to CVM.

Genetics of CVMV Resistance. Genetic study was carried out on three CVMV resistant segregating populations which derived their resistance from 'cili padi' 6 (combination no. 83017) and Serrano Huasteco (combination no. 83013). The resistant genes were incorporated into MC 5, a susceptible variety. Genetic analysis indicated the presence of a pair of recessive genes conferring

the resistance to CVMV in 'cili padi' 6 and Serrano Huasteco. Preliminary findings also indicated that these two pairs of recessive genes are located in different gene loci.

Diallel crosses are presently carried out to evaluate the identity of the other CVMV resistant genes.

Breeding for resistance to CVMV. Two different CVMV resistant genes, one from 'cili padi' 6 and the other from Serrano Huasteco had been successfully incorporated into the local susceptible cultivars. The resistant breeding lines are presently tested at F_8 generation to identify superior lines for further crossing to incorporate CMV resistant gene.

Effects of CVMV and CMV on MC4 and MC5

To evaluate the relative tolerance of hot pepper MC4 and MC5 to CVMV and CMV infections, plants of these two varieties were sap inoculated with the viruses either singly or mixed. In mixed infection, the two viruses were simultaneously inoculated.

Preliminary results showed that when MC4 and MC5 plants were infected with CMV a month after sowing, the yield was reduced by 11.2 and 40.2 %, respectively. However, in CVMV infection the yield of MC4 was reduced to 28.6% and that of MC5 to 31.1%. Results indicated that MC4 was more tolerant to CMV than MC5 and that CVMV tolerance of the two cultivars did not differ significantly. CVMV also greatly reduced the yield of MC4 although CMV was more severe than CVMV in MC5.

Results showed that infection of the two viruses caused greater yield losses than that caused by either one of the viruses. When sap was simultaneously inoculated, the yield reduced to 38.4 and 44.0% in MC4 and MC5, respectively. This represented an increase in yield losses of 27.2% and 3.8% when compared to infection by CMV alone and 9.8% and 12.9% by CVMV.

When infected with CVMV first and then CMV a week later, the yield reduced to 22.0% and 34.8% in MC4 and MC5, respectively. However, when infected with CMV first and then followed by CVMV, the yield of MC4 was reduced by 29.9%, whereas that of MC5, 48.2%.

Chinese Cabbage Yield Trial

Six varieties, namely, Green Sun, Autumn Queen, Autumn Pride, Saladeer (check) and two high yielding AVRDC varieties, No. 82-156 and 77m (3)-40 were evaluated. The trial was conducted in a randomized complete block design with four replications. The trial was conducted in four locations: Jalan Kebun (peat soil), Bertam (mineral soil), Sungai Baging (coastal sand) and Terengganu (alluvial soil). The plot sizes were 1.5 × 3 m with two rows at a distance of 50 × 40 cm.

Trials in all locations were completed except in Bertam. Variety No. 82-156 outyielded the check on both coastal sand peat soils while variety 77m(3)-40 performed better than the check only on peat soil. However, all varieties evaluated on alluvial soil did not show any significant yield difference compared to the check variety. Green Sun had the highest yield in all soil types (19.9 t/ha on coastal sand, 17.8 t/ha on peat soil, and 16.2 t/ha on alluvial soil). AVRDC variety No. 82-156 performed better on peat soil (17.3 t/ha) than on alluvial soil (15.6 t/ha) and on coastal sand (12.5 t/ha).

Control of diamondback moth on cabbage. Studies on population dynamics of diamondback moth (DBM) in Cameron Highlands and in Jalan Kebun Station indicated that the DBM population is high in dry months (January and February) and low during wet months (April, May and June). DBM mortality in wet season is mainly due to diseases of the larvae caused by fungi, bacteria and viruses. Larval parasites, *Apanteles plutellae* and *Diadegma eucerophaga* are mainly responsible for the high mortality of DBM during the wet season.

Other studies showed that DBM already acquired resistance to insect growth regulators (teflubenzuron, chlorfluazuron and diflubenzuron), synthetic pyrethroid (cypermethrin) and an organophosphorus compound.

An IPM trial showed that insecticide application on a prophylactic basis is not necessary when DBM population is low. However, an IPM approach is required when the DBM population is high.

Soybean Varietal Evaluation

An advanced yield trial was conducted at Serdang to evaluate the performance of nine promising soybean varieties against the local check variety, Palmetto.

Results from the first season trial showed that two varieties had significantly higher yields than Palmetto (Table 3). The two varieties, Duocrop and 7507-38-4 produced yields of 3.2 t/ha and 3.1 t/ha, respectively compared to 2.1 t/ha of Palmetto.

Varietal evaluations under saturated soil conditions were conducted in two seasons. Results indicated that four varieties, namely, 7521-26-1, Guntur, Duocrop and Palmetto have potential high yields (3.8 5.9 t/ha). Of these, 7521-26-1 was the most stable in yield performance and had better seed quality. A mechanized trial was conducted as a follow-up and variety 7521-26-1 produced an estimated yield of 2.0 t/ha.

Table 3. Soybean yields in AYT 1 at Serdang, 1989.

Treatment	Days to flowering (DAP)	Days to maturity (DAP)	Lodging index	Plant height at maturity (cm)	Seed size (g/100 seed)	Total plot yield (kg)	Yield (t/ha)
GK 171/19	33 c	93 b	3.3 a	82.6 a	16.3 cd	1.3 abc	2.7 abd
G 2261	33 c	86 c	1.2 c	67.8 ab	13.5 g	1.2 abc	2.5 abc
BP 130/2	37 b	92 b	2.2 ab	56.8 bc	15.3 de	1.1 bc	2.2 bc
IAC-6	44 a	101 a	2.7 a	70.7 ab	17.7 b	1.5 abc	3.1 abc
Guntur	47 b	92 b	2.5 ab	65.0 bc	14.8 ef	1.2 abc	2.4 abc
7207-1	33 c	92 b	2.5 ab	59.1 bc	17.0 bc	1.3 abc	2.6 abc
Duocrop	33 c	101 a	1.5 bc	50.4 c	19.5 a	1.6 a	3.2 a
7521-26-2	33 c	92 b	2.3 ab	60.5 bc	16.4 cd	1.4 abc	2.9 abc
7507-38-4	44 a	101 b	3.3 a	72.0 ab	16.7 bc	1.5 ab	3.1 ab
Palmetto	33 c	88 c	1.5 bc	58.4 bc	13.9 fg	1.1 c	2.1 c
x	36.0	93.9	2.3	64.3	16.1	1.3	2.7
CV (%)	0.0	1.8	27.0	14.7	4.8	21.0	20.9

Vegetable Soybean. The performance of two vegetable soybean lines was evaluated for another season at Jalan Kebun Peat Station. Findings showed that seeds of GC 81083-63 are smaller than those of AGS 190. Both varieties were found palatable.

Mungbean in Rotation with Corn

Data from four seasons indicated that mungbean is suitable for rotation with grain corn. Mungbean yields of 2-3 t/ha were obtained without adversely affecting the yields of grain corn.

Sweet Potato Germplasm Collection

In 1989, sweet potato research was limited mainly to the maintenance of the existing sweet potato germplasm collection of more than 500 entries. Some elite accessions of sweet potato were also introduced from North Carolina State University, USA through collaboration with CIP.

Towards the end of the year sweet potato accessions were collected from Sabah, East Malaysia. A trip was organized in collaboration with the Department of Agriculture, Sabah, the Tropical Agriculture Research Center (TARC) and National Agricultural Research Centre (NARC) of Japan.

AVRDC-Philippine Outreach Program

Preliminary Yield Trial on Chinese Cabbage

Summary

A yield trial was conducted on seven test entries including two checks, heat tolerant Reyna Elena (ASVEG 1) and heat susceptible B-40 in the dry season. Five entries had comparable yields (19.2-24.7 t/ha) as the highest yielding check Reyna Elena (25.0 t/ha). However, during the wet season there were no significant differences in marketable yields among entries. The check Reyna Elena obtained the highest yields (17.4 t/ha).

Introduction

Five hybrids and two open-pollinated (OP) lines and only five hybrids were evaluated during the dry and wet season, respectively, to determine their marketable head yields and reactions to soft rot.

Materials and Methods

Each entry was planted in 1 × 4.8 m raised subplots distributed in a randomized complete block design replicated three times. Two furrows 50 cm apart, were set in each subplot. One seedling was planted per hill with 40 cm between hills within the furrows. N, P_2O_5 and K_2O were basally applied at 60-35-33 kg/ha, respectively, at planting. Side dressing with 20 kg/ha N one week after transplanting and two subsequent applications of 20-0-25 kg/ha N and K_2O were done two weeks after transplanting and at head initiation, respectively.

Results and Discussion

Dry Season (1988-1989). Of the entries evaluated, the check Reyna Elena produced the highest marketable head yields of 25 t/ha (Table 1). Line B-20 produced significantly low mean head

Table 1. Yield performance of AVRDC Chinese cabbage lines in a preliminary yield trial, 1988-89.[z]

Entry	Yield (t/ha)		Mean head wt. (g)		Harvest rate(%)[w]		Solidity (g/cc)[v]		Soft Rot (%)	
	DS[y]	WS[x]	DS	WS	DS	WS	DS	WS	DS	WS
77M (3)-40	18.9 bf		658.2 a-g		86.3		0.7 a		6.7	3.3
77M (2/3)-46	23.0 abc		753.1 ab		91.7		0.7 a		12.2	–
82-156	18.4 c-g	15.1	682.4 a-e	517.7	80.0	87.0	0.6 a-d	0.5	–	3.3
82-157	19.2 a-e	15.3	649.1 a-h	520.4	88.3	88.0	0.7 a-c	0.5	–	–
83-20	24.7 ab	17.3	704.7 a-d	564.0	96.7	92.0	0.6 a-d	0.6	–	2.8
85-202	23.1 abc	14.9	743.0 abc	542.8	93.3	82.0	0.7 ab	0.6	–	–
85-216	20.1 a-d	16.9	670.9 a-f	565.0	88.3	90.3	0.7	0.6	–	2.2
Reyna Elena	25.0 a	17.4	764.1 a	567.2	98.3	92.7	0.6 a-d	0.5	–	2.2
B-40	7.0 h		565.8 d-h		36.7		0.4		–	–
Grand Mean	19.9	16.2	687.9	546.4	84.4	88.7	0.6	0.5		
CV (%)	15.2	15.6	11.5	7.2	11.8	11.3	10.6	11.6		

[z]Means in each vertical column followed by the same letter are not significantly different at 5% level according to DMRT. [y]Dry season transplanted 2 January 1989; harvested 14 February 1989. [x]Wet season transplanted 28 June 1989; harvested 10 August 1989. [w]Percentage of harvestable stand. [v]An approximate measurement of head firmness expressed in g/cc.

weight (565.8 g) and solid content (0.3 g/cc) compared to the rest of the entries. Two OP lines, 77M (3)-40 and 77M (2/3)-46 and Hybrid 85-216 produced the most solid heads of 0.7 g/cc.

Wet Season (1989). There were no significant differences in yield, mean head weight and harvest rate between test entries and the check Reyna Elena. The marketable yield ranged from 14.9 t/ha for hybrid 85-202 to 17.4 t/ha for Reyna Elena. The most compact head of 0.6 g/cc was from hybrid 85-202 which was significantly different from the check (0.5 g/cc). The percent of soft rot infection was low in all entries.

General Yield Trial on Chinese Cabbage

Summary

Further evaluation trials were conducted on three promising selections during the dry and wet seasons to reconfirm their yield potentials over the check. Hybrid 85-216 produced the highest yields of 23.9 t/ha and 16.1 t/ha during the dry and wet seasons, respectively. No significant differences were observed during the dry season. However, during the wet season, all entries significantly outyielded the check Reyna Elena (10.9 t/ha).

Introduction

Lines which consistently gave high yields in the preliminary yield trial were further evaluated in the general yield trial. Three promising lines were compared to the Philippine Seedboard variety Reyna Elena during the 1988-89 wet and dry seasons.

Materials and Methods

The entries were transplanted in double-row 1 × 4.8 m^2 raised beds distributed in a randomized complete block design replicated four times. The rows were set 50 cm apart and the hills 40 cm within rows. The plants were fertilized with 60-35-33 kg/ha N, P_2O_5 and K_2O, respectively at planting; sidedressed with 20 kg/ha N one week after transplanting; and subsequently applied with 20-0-25 kg/ha N and K_2O at two weeks after planting and at head initiation, respectively.

Results and Discussion

Dry Season. No significant differences in marketable head yield were observed among entries (Table 2). The grand mean yield was 23 t/ha. Hybrid 85-216 attained the highest yield (23.9 t/ha), mean head weight (805.9 g) and solid content (0.8 g/cc) but also had the lowest harvest rate (88.3%) among entries.

Table 2. Yield performance of promising Chinese cabbage lines in a general yield trial, 1988-89.[z]

Entry	Yield (t/ha)		Mean Head Wt. (g)		Harvest Rate (%)[w]		Solidity (g/cc)[v]		Soft Rot (%)	
	DS[y]	WS[x]	DS	WS	DS	WS	DS	WS	DS	WS
85-202	22.7	13.5 bc	747.7	525.9	90.8	77.3 abc	0.7 ab	0.4	2.2	12.8
85-216	23.9	16.1 a	805.9	547.3	88.3	88.3 a	0.8 a	0.5	7.5	4.3
82-157	21.9	12.5 abc	684.6	456.8	96.3	82.3 ab	0.6 b	0.4	–	29.0
Reyna Elena	23.6	10.9 bc	746.6	554.1	94.5	60.3 bc	0.7 ab	0.6	–	35.3
Grand Mean	23.0	13.3	746.2	521.0	92.4	77.0	0.7	0.5		
CV (%)	16.7	19.1	6.6	16.5	11.0	19.2	10.2			

[z]Means in columns are not significantly different at 5% level according to DMRT. [y]Dry season transplanted 2 January 1989; harvested 13 February 1989. [x]Wet season transplanted 30 August 1989; harvested 13 October 1989. [w]Percentage of harvestable stand. [v]An approximate measurement of head firmness expressed in g/cc.

Wet Season. There were significant differences in marketable head yields among entries. The yields ranged from 10.9 t/ha for the check Reyna Elena to 16.0 t/ha for Hybrid 85-216. Hybrid 85-216 had the highest harvest rate of 88.3% and was the least affected by soft rot. The check Reyna Elena had the most compact head of 0.6 g/cc although there were no significant differences among entries.

Single-seed-descent Trial on Tomato

Summary

Seventy determinate and indeterminate fresh market tomato lines were tested during the 1988-89 dry and 1989 wet seasons. The CLN and CHT series produced high grand mean yields of 45 t/ha during the dry season. The unfavorable conditions of the wet season resulted in very low yields of the FMTT tomato. High incidence of bacterial wilt totally destroyed the set of CHT indeterminates planted on 14 August 1989.

Introduction

CLN F_2 and F_1 fresh market tomato lines were tested under the single-seed-descent (SSD) trial to evaluate their performance under local conditions. Screening of the entries was based on yield potential and resistance or tolerance to diseases, pests and physiological disorders.

Materials and Methods

In 1988-89 dry season, 26 CLN F_2, eight CHT F_1, and two CL 5915 OP lines were planted on 9 February 1989. In wet season, 14 FMTT F_1 and 17 CHT F_1 were planted on 14 August 1989. All entries were planted in 5-m long one-row plots, with 1 m between rows and 12 plants per row. The entries were distributed in a randomized complete block design with two replications.

The indeterminates were provided with bamboo pole trellis, suspended with plastic twine. In both seasons, all entries were mulched with rice straw. The crop was raised following the AVRDC recommended cultural management practices for tomato.

Yield and horticultural characters and observations on pests, diseases and physiological disorders were recorded.

Results and Discussion

In 1988-89 dry season, the determinate tomato produced high yields and showed low incidence of TMV, fusarium wilt, fruit crack and blossom end rot (BER). However, the entries were susceptible to sunscalding (ratings of 1.5 to 4.5).

Among test lines, CLN 698 BC_1F_2-512-0-12-6 (57 t/ha), CLN 684 BC_1F_2-58-5-4 (53.3 t/ha) and CLN 466 BC_1F_2-217-6-6-4 (52.3 t/ha) gave the highest yields. However, differences were not significant over the checks, Pope (51.4 t/ha) and Marikit (47.4 t/ha).

For the CHT indeterminate series, CHT-102 (57 t/ha), CHT-103 (52.4 t/ha), CHT-101 (52.2 t/ha) gave yields comparable to Pope (49.9 t/ha) and Marikit (41.9 t/ha). Low incidence of fruitworm, tobacco mosaic virus (TMV), southern blight, and BER was observed. However, fruit cracking and sunscalding were moderately high due to the thin skin of CHT lines.

Between two sets of entries evaluated during the wet season, FMTT-108 produced the highest yields of 5.9 t/ha. Poor performance of entries was due to their susceptibility to both bacterial and fusarium wilt. With the CHT F_1 entries, 80-100% of the plants per row succumbed to bacterial wilt infection. The trial was discarded because of low plant population.

Preliminary Yield Trial on Tomato

Summary

Among 66 lines evaluated during 1988-89 dry season, the CLN series gave the best yield (grand mean of 35.7 t/ha). All 58 lines evaluated gave very low yields due to severe tobacco mosaic virus (TMV) and bacterial wilt (BW) infections.

Introduction

Selections from SSD were evaluated under the PYT in both dry (1988-89) and wet (1989) seasons. In the dry season, fresh market tomato lines were evaluated to determine the entries' tolerance to heat and moisture and to identify high yielding lines resistant to tropical pests and diseases. The evaluation of fresh market tomato during the wet season focused on the same objectives.

Materials and Methods

A total of 66 lines were transplanted from 1 December to 17 January (dry season) in staggered plantings in five sets of trials. During the 1989 wet season, 58 lines were evaluated in four sets of trials transplanted from 26 June to 13 July.

The experiments were laid out in a randomized complete block design in three replicates. Twelve seedlings were transplanted per row of 5-m^2 subplots during the wet season. The dry season planting was made on 5-m long and 1-m apart furrows; during the wet season, 1-m wide and 5-m long raised beds with 0.3 m sidewalk were used. The indeterminate lines were provided with bamboo pole trellis. All trials were subjected to timely pest and disease control measures, fertilizer application, mulching, weeding and cultivation.

Yield, horticultural characters and ratings on pests, diseases and physiological disorders were recorded.

Results and Discussion

The test lines transplanted in January gave better yields than those in December. This may be attributed to lower fruit-setting in December, particularly on processing tomato (2.8 grand mean score) and high incidence of TMV, fusarium wilt and fruitworm.

The 1989 wet season which was characterized by high precipitation (254 mm average during the growing period, June to December) and high temperature (31.2°C average maximum, 24.2°C average minimum), resulted in poor performance of the entries. However, the lines that had high yield potential under severe TMV and BW infection were: (a) CLN 698 BC; F_4-291-0-6; (b) CLN 229 BC, F_4-12-5-3-12-10; (c) CLN 36 BC, F_4-42-2-2-12-0; and (d) CLN 466 BC, F_4-44-20-0.

General Yield Trial on Tomato

Summary

Fourteen AVRDC fresh market tomato lines and six processing lines were evaluated during the 1988-89 dry season. Eight fresh market tomato lines were evaluated in the 1989 wet season. Lines CL 5915-197 (G) D4-1 and CL 5915-455 (G) D4-2 significantly outyielded the check Marikit. Five out of six F_1 processing tomato lines gave yields comparable to the check Mapula. During the wet season, five out of eight fresh market tomato lines significantly outyielded the two checks.

Due to high yield potential and desirable agronomic characters, lines CL 5915-206 (G) D4-2 and CL 5915-222 (G) D4-0 were included in the 1989-90 RYT for fresh market tomato.

Introduction

Lines found promising in four seasons in the PYT were evaluated in the GYT for further screening in terms of high yield, desirable fruit characters and resistance to tropical diseases. Seeds of outstanding entries from the GYT were increased for regional evaluation under the national cooperative testing programs.

Materials and Methods

Six processing tomato F_1 hybrids (transplanted on 27 December 1988) and 14 fresh market OP (transplanted on 28 November 1988) were evaluated during the 1988-89 dry season and eight fresh market OP lines (transplanted on 26 June 1989) during the wet season. In the dry season, 12 seedlings were transplanted in 5-m long and 1 m apart furrows, with subplot areas of 5 m^2. In the wet season, 5-m long and 1-m wide raised beds with 0.3 m pathways were used. Twelve seedlings were transplanted per bed. The subplot in the wet season was 6.5 m^2.

Proper cultural management practices were adopted. Rice straw mulch was provided in both seasons.

Yield data, horticultural characters and ratings on pests, diseases and physiological disorders were recorded.

Results and Discussion

The F_1 processing tomato hybrids with better yield performance than the check Mapula were PT-1599, PT-1600, PT-778 and TM 103. Poor yield of PT 3027 was due to low fruit-set, high fruitworm damage and high TMV incidence.

The yield performance of 14 fresh market OP lines are presented in Table 3. Highest yield average of 19.5 t/ha was produced by CL 5915-206 (G) D4-2.

In four seasons, two lines were selected for inclusion in the 1989-90 regional trial. These were: CL 5915-206 (G) D4-2 and CL 5915-222 (G) D4-0. Both lines showed heat tolerance, resistance to TMV and BW and early maturity.

A new set of GYT entries was evaluated during the 1989 wet season. Five out of eight entries significantly outyielded the checks, Pope and Marikit. Low yield performance (grand mean of 10.0 t/ha) during the wet season was due to incidence of TMV, BW and BER brought about by the unfavorable environmental weather conditions.

Table 3. Yield performance of tomato entries in general yield trials in four seasons.

Entry	WS 1987	DS 1987-88	WS 1988	DS 1988-89	Average of four seasons
			(t/ha)		
CL 1131-0-0-7-2-0	9.3	7.6	16.1	22.9	14.0
CL 1131-0-0-43-4-12	10.9	14.6	15.1	25.8	16.6
CL 1131-0-0-43-8-1	16.9	15.5	13.0	19.5	16.2
CL 5915-197 (G) D4-1	9.9	17.1	13.6	30.7	17.8
CL 5915-223 (G) D4-2	10.5	12.7	15.8	25.1	16.0
CL 5915-153 (G) D4-2	10.6	10.0	10.4	11.1	10.5
CL 5915-217 (G) D4-1	10.2	8.0	11.1	21.5	12.7
CL 5915-362 (G) D4-1	8.1	6.9	13.0	24.1	13.0
CL 5915-222 (G) D4-0	11.8	15.7	14.6	25.7	17.0
CL 5915-369 (G) D4-1	12.5	12.6	15.0	22.5	15.6
CL 5915-455 (G) D4-2	10.5	10.2	13.4	30.3	16.1
CL 5915-206 (G) D4-2	15.3	15.4	18.8	28.7	19.5
CL 5915-229 D6-1-4	4.1	13.3	11.7	24.1	13.3
CL 5915-222 D6-0-5	3.6	12.9	17.9	27.0	15.3
Marikit (ck)	10.2	7.1	15.6	22.6	13.9
Grand Mean	10.3	12.0	14.3	24.1	

Evaluation and Selection of AVRDC Mungbean Breeding Lines

Summary

Promising selections identified in previous years were planted for further evaluation and selection under local agroclimatic conditions.

Of the 33 selections, only VC 4140-B-5, VC 4140-B-4 and VC 4140-B-1 with yields of 1.2 t/ha, slightly outyielded the check BPI-Mg7.

Twenty-two lines were selected for inclusion in the PYT next season.

Introduction

AVRDC mungbean breeding lines previously selected both in Taiwan and the Philippine Outreach Program (POP) were evaluated to develop varieties adapted to local agroclimatic conditions, with high bean yield potential, early and uniform maturity, resistance to common pests and diseases, tolerance to lodging, and acceptable eating and processing qualities.

Materials and Methods

Thirty-three promising lines selected from AVRDC early breeding lines and one check cultivar were planted on 29 May 1989. Each entry was planted in two nonreplicated 5-m long rows with 0.5 m between furrows. Appropriate cultural management practices for mungbean were observed.

Results and Discussion

Of the 33 selected early breeding lines, VC 4140-B-5, VC 4140-B-4 and VC 4140-B-1 (1.2 t/ha) slightly outyielded the check BPI-Mg7 (1.2 t/ha). VC 4140-B-4 was rated highly resistant while VC 4140-B-1 was moderately resistant and BPI-Mg7 susceptible to CLS.

Twenty-two lines out of 33 were selected for further evaluation in the PYT. Selection was based on yield performance, disease resistance and other desirable characteristics.

Preliminary Yield Trial on Mungbean

Summary

The study was conducted to identify mungbean lines with high bean yield potential, desirable agronomic characters and disease resistance, particularly to the Cercospora leaf spot (CLS) and powdery mildew (PM).

In Set I with 20 entries, V 3530-B-1-1 with 1.3 t/ha and VC 3560-B-4-4 with 1.2 t/ha surpassed the yield of the check Pag-asa 5 (1.2 t/ha). However, the difference was not significant. The grand mean in all entries was 1.0 t/ha.

In Set II with 18 entries, the grand mean yield was only 0.7 t/ha. However, 10 entries outyielded the check Pag-asa 5 although the mean differences were not statistically significant. Slight CLS infection was observed late in season.

Introduction

Selections from the observation trial nurseries were evaluated in the PYT for one to two years to identify those with high bean yield potentials, desirable agronomic characteristics and resistance/tolerance to diseases, particularly CLS and PM. Selections from the PYT were elevated to the general yield trial (GYT).

Materials and Methods

For crop year 1988-89, two sets of trials were conducted. Set I (with 20 entries) and Set II (with 18 entries) were planted on 29 May and 30 June 1989, respectively. In both sets, entries were sown in four-row, 5-m long plots distributed in a randomized complete block design and replicated three times. The rows were spaced 0.5 m apart.

Cultural management and data collection were based on AVRDC recommended standard practices for mungbean.

Results and Discussion

In Set I, entries VC 3530-B-1-1 and VC 3560-B-4-4 both with 1.2 t/ha, slightly surpassed the yield of the check cultivar Pag-asa 5 (1.2 t/ha) but there were no significant differences in their yields. The grand mean was 1.0 t/ha. However, the highest yielding entry was rated susceptible to CLS.

In Set II, with lower mean bean yield of 0.7 t/ha, 10 entries outyielded the check Pag-asa 5, although differences were not statistically significant. The highest yielder was VC 3995-B-6 (1.0 t/ha), closely followed by VC 3108-1-2B (Y). Slight infection of CLS was observed late in season.

General Yield Trial on Mungbean

Summary

Forty entries were evaluated in two sets of trials. In Set I (with 24 entries), six promising lines produced higher yields than Pag-asa 5 (check). The highest yielder was line VC 3982-2B-2-1-1-B. In Set II (with 16 entries) eight lines gave higher mean yields than the check, BPI-Mg7. However, only the yield of (1.3 t/ha) VC 3901-B-4-1-1-1-B was significantly different from BPI-Mg7 (1.1 t/ha). VC 3751-1-B-2-2-B was least infected by CLS.

Introduction

Selected materials from the PYT were elevated to the GYT to obtain more precise information on their adaptability to local agroclimatic conditions and reactions to common pests and diseases. Results obtained from this two-year trial will serve as the basis for selecting entries for inclusion in the regional yield trial (RYT).

Materials and Methods

Two sets of promising lines were evaluated during the 1989 wet season. Set I (with 24 entries) and Set II (with 16 entries) were planted on 30 June 1989. A randomized complete block design (4-row and 5 m long plots) with four replications was used.

Cultural management and data collection were based on AVRDC recommended standard procedures for mungbean evaluation trials.

Results and Discussion

In Set I, the mean yield of six lines ranged from 0.9 to 1.1 t/ha, which was not significantly different from the check, Pag-asa 5 with 0.9 t/ha (Table 4). The highest yielder was line VC 3982-2B-2-1-1-B. In Set II, only the highest yield of VC 3901-B-4-1-1-1-B (1.3 t/ha) was significantly different from the check's (BPI-Mg7) 1.1 t/ha (Table 5). Line VC 3751-1-B-2-2-B was least infected with CLS.

Table 4. Performance of six highest yielders from 24 entries evaluated in the GYT during the 1989 wet season.[z]

Entry	Yield t/ha	100-seed wt. (g)	Days to maturity	Disease rating	
				CLS[y]	Virus[x]
VC 3982-2b-2-1-1-B	1.1 a	5.0 j	56.0	2.0 e-g	1.2
VC 4091-2B-5-B-3-B	1.0 ab	4.6 k	58.8	2.0 e-g	2.5
VC 4083-2B-2-B-1-B	1.0 ab	5.7 fg	56.8	1.8 a-h	2.5
VC 3890-B-2-1-1-B	1.0 a-c	6.3 bc	57.8	1.3 gh	1.5
VC 3902-B-4-1-1-B	0.9 a-c	7.2 a	58.8	1.3 gh	2.0
VC 3116-B-5-B	0.9 a-c	5.6 fg	55.8	4.3 ab	2.5
Pag-asa 5 (ck)	0.9 a-c	5.6 gh	59.3	2.3 ef	1.8
Grand mean	0.8	5.5	59.5	2.4	2.3
CV (%)	25.5	1.5	1.7	23.6	23.4

[z]Means in each vertical column followed by the same letter are not statistically different at 5% level probability according to DMRT. [y]Rated on a scale of 1-5, where 1 = highly resistant and 5 = highly susceptible. [x]Rated on a scale of 1-3, where 1 = resistant and 3 = susceptible.

Table 5. Yield and other characters of eight best entries in the GYT compared to BPI-Mg7 during the 1989 wet season.[z]

Entry	Yield (t/ha)	100-seed wt. (g)	Days to maturity	CLS rating[y]
VC 3901-B-4-1-1-1-B	1.3 a	5.6 de	53.3	2.0 c-e
VC 3944-2B-2-2-1-B	1.3 ab	6.0 a	53.5	2.5 c-e
VC 3890-2B-2-1-B	1.3 a-c	5.6 de	53.8	1.5 e
VC 3821-B-1-1-1-B	1.2 a-c	5.7 cd	53.5	3.0 b-d
VC 3758-2B-2-1-B	1.2 a-d	5.2 g	53.3	3.3 a-c
VC 3822-2B-3-1-B	1.2 b-e	5.5 ef	53.8	2.3 a-c
VC 3751-1-B-2-2-B	1.1 b-e	5.5 ef	54.8	1.3 e
VC 3902-2B-4-2-1-B	1.1 b-e	5.9 ab	53.5	2.5 c-e
BPI-Mg7 (ck)	1.1 b-f	5.9 a	53.0	4.0 ab
Grand mean	1.1	5.6	63.9	2.4
CV (%)	8.7	1.4	1.2	30.6

[z]Means in each vertical column followed by the same letter are not statistically different at 5% probability level according to DMRT. [y]Rated on a scale of 1-5, where 1 = highly resistant and 5 = highly susceptible.

Regional Yield Trial on Mungbean

Summary

Four AVRDC lines were included in the 1988-89 crop season regional yield trial (RYT). EGM 2768 and EGM 2307 performed better than the check BPI-Mg5 in the wet season while EGM 2762 was better during the dry season.

After six cropping seasons of RYT evaluation (1986-1989), AVRDC line VC 2768 B, also known as POP line EGM 2768, was officially released by the Philippine Seedboard in May 1989 as BPI-Mg9 commonly known as Taiwan Green. BPI-Mg9 produced grand mean yields of 1.4 t/ha and 1.1 t/ha during the wet and dry seasons, respectively, across locations.

Introduction

The RYT for mungbean under upland monoculture conditions was conducted in cooperation with the Institute of Plant Breeding (IPB) and other institutions involved in varietal improvement of field legumes. The test was conducted in eight to nine locations to evaluate the performance of promising varieties in different regions of the country. Results from the RYT were used as a basis for recommendation of new varietal releases for regional or national production by the Philippine Seedboard.

Materials and Methods

The promising varieties selected in the PYT or GYT were submitted to the National Legume Technical Committee of the Philippine Seedboard for inclusion in the RYT. Acceptable entries were evaluated in four to six seasons in different cooperating stations. Performance of entries was yearly reviewed by the Technical Committee. Entries that consistently surpassed the yield or other characteristics of the standard checks were submitted to the Philippine Seedboard for approval while those inferior to the checks were dropped from the trial after four seasons.

For 1988-89, five entries together with one regional and one national check were evaluated during the wet and dry seasons in five locations. Each entry was planted in 10 m^2, four-row subplots, distributed in a randomized complete block design and replicated four times. The cultural management and data collection were based on the guidelines of upland crop national cooperative trial (UCNCT) of the Philippine Seedboard.

Results and Discussion

During the wet season, EGM 2768 (with 1.7 t/ha) ranked first and EGM 2307 (with 1.6 t/ha), second among seven entries tested. The highest yielding check, BPI-Mg5, produced 1.6 t/ha. However, during the dry season, only line EGM 2762 with 0.9 t/ha had similar yield as the check, BPI-Mg5 (Table 6).

After the six cropping seasons of RYT (1986-1989), EGM 2768 was approved by the Philippine Seedboard in May 1989 as BPI-Mg9, commonly called Taiwan Green for commercial production.

In a series of 25 trials conducted in nine locations for six cropping seasons, BPI-Mg9 produced average bean yields of 1.3 t/ha and 1.1 t/ha during the wet and dry seasons, respectively. The highest average yield during the wet season was produced in La Granja (2.0 t/ha) and during dry season in Bicol (2.1 t/ha). BPI-Mg9 showed moderate resistance to both CLS and PM. It had upright growth habit and matured uniformly 60 days after planting. It had large and glossy green seeds. Crude protein content was 23.8 and carbohydrate at 62.6%. Its eating quality was widely accepted by consumers.

BPI-Mg9 has been popular among farmers especially in northern Philippines. In 1987-88, a total of 140 ha were planted to BPI-Mg9 in Regions 1 to 4.

Table 6. Performance of AVRDC mungbean lines in the RYT across locations, 1988-89.

Entry	Yield (t/ha)[z]		100-seed wt. (g)		Disease rating[x] CLS		PM	
	WS	DS	WS	DS	WS	DS	WS	DS
EGM 2307	1.6 (2)[y]	0.8 (5)	5.0	4.8	3	2	1	2
EGM 2768	1.7 (1)	0.7 (7)	5.8	4.9	3	3	1	2
EGM 2762	1.4 (7)	0.9 (2)	5.3	4.9	3	2	1	2
EGM 2778	1.6 (4)	0.8 (6)	5.8	5.5	3	2	1	2
BPI-Mg5	1.6 (3)	0.9 (4)	5.4	5.1	2	2	1	3

[z]Mean of five locations. [y]Number in parentheses represents the rank among seven entries. [x]Rated on a scale of 1-5, where 1 = highly resistant and 5 = highly susceptible.

International Mungbean Nursery

Summary

Twenty selected elite lines from AVRDC were field-tested. Results showed that only two lines produced an average yield of more than 1 t/ha. VC 3890 A yielded 1.1 t/ha and VC 3737 A, 1.0 t/ha. Several lines showed high resistance to CLS.

Introduction

The IMN is an international cooperative trial coordinated by AVRDC. The entries are elite mungbean cultivars/accessions from different countries assembled by AVRDC and sent to cooperating

stations for evaluation. The study aimed to provide information on the range of adaptation of the crop; specific adaptation of individual cultivars; and characteristics of the mungbean plant that influence adaptation. The test also serves as a means of disseminating superior cultivars to mungbean researchers.

Materials and Methods

Twenty elite accessions selected and developed at AVRDC were planted on 30 June 1989 in a randomized complete block design with three replications. Each entry was planted in 5-m long, four-row subplots set 0.5 m apart.

Cultural management and data collection were based on the standard procedures suggested in the AVRDC International Cooperator's Guide for mungbean evaluation trials.

Results and Discussion

The average yield of 20 IMN entries was 0.8 t/ha during the wet season. Only two accessions produced an average yield of more than 1 t/ha. These were VC 3890 A and VC 3737 A with 1.1 and 1.0 t/ha, respectively. All entries matured between 56 to 59 days after planting. Among high yielding lines, VC 3737 A, VC 4059 A and VC 3902 A exhibited moderate levels of CLS resistance.

Preliminary Yield Trial on Soybean

Summary

The study aimed to evaluate and identify soybean lines with high bean yield potential, resistance to common pests and diseases and other desirable attributes.

Nineteen promising accessions/lines from AVRDC and other sources were evaluated during the dry and wet seasons of 1988-1989. Line GC 90086 with 1.7 t/ha outyielded the check UPL-Sy4 (1.5 t/ha) during the dry season, although the difference was not significant.

During the wet season, four lines outyielded the highest yielding check, but only G 7395 with 3.2 t/ha significantly outyielded the check UPL-Sy4 with 2.5 t/ha.

Introduction

Promising selections from the early breeding lines were evaluated in the PYT to identify lines/accessions with high bean yield potential, resistance to common pests and diseases and other desirable agronomic characteristics.

Materials and Methods

Nineteen and 20 entries were evaluated against the standard check, BPI-Sy4, during the dry and wet seasons respectively. The dry season trial was planted on 12 December 1988 and wet season trial on 19 June 1989. In each trial, the entries were sown in four-row subplots distributed in a randomized complete block design and replicated three times. N, P_2O_5 and K_2O at 30-30-30 kg/ha, respectively were applied at planting. Cultural management and data collection were based on the standard cultural practices suggested in the AVRDC International Cooperator's Guide for soybean evaluation trials.

Results and Discussion

Out of 19 entries evaluated during the dry season, only GC 90086 with 1.7 t/ha outyielded the highest yielding check UPL-Sy4 (1.5 t/ha). However, the yield difference was not statistically significant. All entries showed tolerance to soybean rust.

During the wet season trial, four test entries outyielded the highest yielding check, UPL-Sy2. However, only G 7395 with 3.9 t/ha significantly outperformed the check, UPL-Sy4 with 2.5 t/ha. So far, only line G 73955 showed resistance to bacterial pustule. All entries were rated resistant to moderately resistant to soybean rust and soybean mosaic.

General Yield Trial on Soybean

Summary

The selected lines from the PYT were elevated to the general yield trial to further verify their yield potential, resistance to common pests and diseases and desirable agronomic characters.

Out of 18 entries evaluated during the dry season, only POP-10 (AGS 225) with 1.6 t/ha slightly outyielded the highest yielding check, UPL-Sy4 although the difference was not statistically significant.

During the wet season trial, only the bean yields of AGS 147 (3.4 t/ha) had significant differences from the check UPL-Sy4 (2.4 t/ha).

Introduction

Promising lines selected from the PYT were elevated to the GYT to further test their yield potential, reactions to major pests and diseases and to identify other desirable agronomic characters. The selections from the GYT were finally evaluated in the RYT for regional evaluation and possible regional and/or national recommendation.

Materials and Methods

Seventeen and 18 entries were planted during the dry and wet season, respectively. All entries in both seasons were planted in 10 m^2 subplots, distributed in a randomized complete block design with four replications. The plants were fertilized at 30 kg/ha each of N, P_2O_5 and K_2O at planting.

Cultural management and data collection were based on the standard cultural practices suggested in the AVRDC International Cooperator's Guide on soybean evaluation trials.

Results and Discussion

During the dry season trial, the 18 entries produced a grand mean yield of 1.3 t/ha. Only POP 10 (AGS 225) outyielded the highest yielding check UPL-Sy4 with 1.6 t/ha. POP 10 was rated moderately resistant to soybean rust.

Of the 17 entries evaluated during the wet season, only AGS 147 with 3.5 t/ha gave a significant difference over the check UPL-Sy4 (2.4 t/ha). Further, only AGS 147 showed comparable resistance to bacterial pustule as UPL-Sy4. All entries were rated resistant to moderately resistant to soybean rust and soybean mosaic virus.

Regional Yield Trial on Soybean

Summary

Thirteen promising lines were evaluated in the regional yield trial (RYT) against two standard checks during the dry and wet seasons. The study was designed to verify the performance of the promising varieties under the different regions of the Philippines in terms of bean yield potential and reactions to major pests and diseases.

Results of evaluation from the Economic Garden showed that during the wet season, only AGS-129 (EGSy 129) with 3.2 t/ha and LGSy 1-13 with 2.8 t/ha significantly outyielded the highest yielding check UPL-Sy4 (2.3 t/ha). However, during the dry season trial, none of the entries outyielded the check variety.

Introduction

The regional yield trial for soybean under upland monoculture conditions was conducted in cooperation with IPB and other institutions involved in soybean varietal improvement. Coordinated by the Field Legumes Technical Group of the Philippine Seedboard, promising entries from various national breeding programs were assembled and evaluated in four seasons in 8-12 cooperating stations using a common standard procedure. The study was designed to identify high yielding varieties with agronomic attributes adapted to the different regions of the country. Recently, promising entries in the RYT in a given region were further evaluated in two seasons for technology adaptation (TA) before these were released or recommended for regional/national level.

Materials and Methods

The promising lines/varieties selected from the PYT and GYT by the breeding institutions were submitted to the National Legume Technical Committee of the Philippine Seedboard for inclusion in the RYT.

For crop year 1988-89, 13 entries including two standard checks (one national and one regional) were evaluated during the dry and wet seasons in eight cooperating stations. Each entry was planted in 10 m^2 four-row plots, distributed in a randomized complete block design with four replications. Rows were spaced 50 cm (DS) and 60 cm (WS) apart and about 15 plants per linear meter were 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. Only the results from the Economic Garden are presented in this report.

Results and Discussion

During the dry season none of the 11 entries tested outyielded the highest yielding check variety. However, during the wet season, entries AGS 129 (EGSy 129) with 3.2 t/ha and LGSy 1-13 with 2.8 t/ha significantly outyielded the highest yielding check UPL-Sy4 with 2.3 t/ha. Line AGS 129 was followed by LGSy 1-13 and AGS-208 (EGSy-208). All entries were rated resistant to moderately resistant to soybean rust and soybean mosaic, and resistant to moderately susceptible to bacterial pustule.

Sweet Potato Germplasm Collection and Maintenance

Summary

A total of 110 sweet potato lines mostly from AVRDC and local sources are maintained in the station. This collection serves as a source of materials for yield trials at POP and other government and private research institutes.

Introduction

The germplasm collection and maintenance of any crop is a prerequisite in any breeding work. This activity, therefore, has been part of the AVRDC-POP collaborative program to continuously provide breeders with germplasm materials for screening to develop high yielding varieties resistant to pests and diseases.

Materials and Methods

Each entry collected from foreign and local sources is maintained in 6 m^2 nursery plots at AVRDC-POP in Los Baños, Laguna.

Results and Discussion

A total of 110 sweet potato lines/accessions mostly from AVRDC and from local sources are maintained in the station. This collection serves as a source of research and production materials for both government and private agencies.

Preliminary Yield Trial on Sweet Potato

Summary

Twenty-four AVRDC sweet potato lines were evaluated under the PYT to identify those with high tuber yield potential and other desirable agronomic characters.

During the dry season trial, only CN 1423-438 with a marketable tuber yield of 42.9 t/ha outyielded the check, BPI-Sp2 but no significant difference was observed. The grand mean of all entries was 25.5 t/ha.

On the other hand, the check BPI-Sp2 produced the highest marketable tuber yield of 20.6 t/ha during the wet season.

Introduction

Lines received from AVRDC were multiplied at POP and entered in the preliminary yield trial to evaluate their tuber yield potential and reaction to scab infection. The selected materials will be further tested in the GYT.

Materials and Methods

Twenty-four entries were evaluated against the check, BPI-Sp2 in two plantings (6 December 1988 and 26 May 1989 for the dry and wet seasons, respectively). Each entry was planted in double-row 6 m^2 subplots distributed in a randomized complete block design with three replications. Planting distance was 75 × 25 cm between rows and hills.

Cultural management practices and data collection procedures employed were according to AVRDC recommended procedures on sweet potato.

Results and Discussion

CN 1423-438 with a marketable tuber yield of 42-89 t/ha outyielded the check, BPI-Sp2 but no significant difference was observed. On the other hand, the wet season trial showed that BPI-Sp2 was still the best variety. Further, BPI-Sp2 produced the largest tubers compared to other entries. Tuber diameter ranged from 4.0 to 7.6 cm during the wet season trial.

General Yield Trial on Sweet Potato

Summary

This trial was designed to confirm the results of the selected materials from the PYT. Results showed that the check, BPI-Sp2, was still the best variety, yielding 61.0 t/ha during the dry season cropping. However, CI 946-25, which ranked second in terms of marketable root yield, also showed great promise with 43.3 t/ha during the dry season. Like BPI-Sp2, CI 946-25 also produced wide tuber diameter. There were no significant differences between the two varieties.

Materials and Methods

Seventeen AVRDC sweet potato accessions were evaluated during the wet season (10 August 1988) and dry season (20 December 1988). In both trials, the entries were planted in double-row 6 m^2 subplots distributed in a randomized complete block design in four replications. Cultural management and data collection were based on the AVRDC recommendations.

Results and Discussion

During the wet and dry season trials, no entries outyielded BPI-Sp2 with marketable tuber yields of 23.8 and 61.0 t/ha, respectively (Table 7). However, considering the national average yield of about 8.0 t/ha, other entries could be rated high yielding. CI 946-25, which ranked second in terms of marketable tuber yield during the dry and wet seasons, showed great potential.

Other yield components taken were root diameter and root length. LS 27-12 significantly produced the widest tuber. The longest tuber was obtained from BPI-Sp2 which contributed to its high yield.

Table 7. Tuber yield and some yield components of 10 highest yielding AVRDC sweet potato lines in the general yield trial during wet and dry seasons, 1988-89.[z]

Entry	Marketable tuber yield (t/ha)		Non marketable tuber yield (t/ha)		Tuber diameter (cm)		Tuber length (cm)	
	DS[y]	WS[x]	DS	WS	DS	WS	WS	DS
BPI-Sp2 (ck)	23.8 a	61.0 a	2.2 cd	1.2 c-g	5.2 b-d	6.8 a-c	14.9 a	14.4 a-c
CI 946-25	20.1 a	43.3 b	0.8 f	1.0 fg	5.5 b	7.5 a	14.2 a-c	13.8 a-d
LS 27-12	19.3 ab	29.1 cd	0.5 f	1.6 c-g	6.4 a	6.5 a-d	12.4 b-f	13.7 b-d
CI 950-27	14.3 bc	29.2 cd	2.0 c-e	3.6 a	4.3 c-e	5.2 e	12.0 b-f	13.1 b-e
CI 916-46	13.5 c	25.1 c-e	0.9 ef	1.0 fg	5.5 b	6.2 b-e	14.2 ab	12.1 e
CI 916-66	11.7 cd	32.4 c	5.4 a	1.7 c-g	4.9 b-d	5.6 de	13.6 a-d	13.1 b-e
CI 951-6	11.0 cd	26.5 cd	1.1 d-f	1.5 d-g	5.2 bc	6.6 a-d	12.2 b-f	15.6 a
CI 551-3	11.0 cd	21.3 de	3.0 bc	3.0 ab	4.7 be	6.0 b-e	12.7 a-f	14.6 ab
Kinastanyas	10.0 c-e	27.0 cd	1.1 d-f	1.3 e-g	4.6 c-e	7.1 ab	11.9 d-f	12.2 de
CI 946-30	9.2 c-e	34.2 c	1.3 d-f	2.7 a-c	4.4 c-e	5.9 c-e	11.4 d-f	12.5 c-e
Grand Mean (17 entries)	10.0	26.5	1.6	1.8	4.7	6.0	12.6	13.9
CV (%)	36.1	24.1	45.9	35.9	12.3	12.1	10.6	8.5

[z]Average of three replications. Means in column followed by a letter are not significantly different at 5% probability level by DMRT. [y]Planted 10 August 1988 and harvested 3 January 1989. [x]Planted 20 December 1989 and harvested 18 April 1989.

Sex Pheromone for Sweetpotato Weevil Control

Summary

The use of sex pheromone to reduce weevil population was promising. Initial number of male weevils trapped during the third and fourth week of the first and second planting, respectively was very high, tapering off towards the end of the study. Weevil damage on tubers at the end of the trial was 18%.

Introduction

Sweetpotato weevil (*Cylas* sp.) is considered as the major insect pest of sweet potato, extensively attacking both stems and roots of the crop. The farmers' traditional practice of using pesticides to control the insect pest is usually ineffective, hazardous to human health and harmful to the beneficial organisms. An integrated approach to effectively control sweetpotato weevil using sex pheromone was recommended by AVRDC. This study was conducted to evaluate the effectiveness of using sex pheromone in controlling sweetpotato weevil under Philippine conditions.

Materials and Methods

A 450.8 m^2 field, previously cleared of sweet potato debris and alternate hosts of the weevil, was prepared and planted to BPI-Sp2 cuttings presoaked overnight in an insecticide solution. Two weeks after planting, five traps each with pheromone-coated septa were strategically placed 20 m apart in the field against wind direction. Weekly counts of the trapped weevils were made and the traps were moved around the experimental field until completion of the study.

At harvest, 2 kg of tubers were randomly collected from each sampling area. The sampled tubers were sliced into 1-cm thick pieces and weevil larvae inside counted. The weight of the damaged and undamaged tubers were taken and the percent of insect damage was calculated.

Results and Discussion

The number of weevils trapped by sex pheromone during the third and fourth week of the first and second planting was very high compared to the later part of the study. This suggested that many immature weevils become adults during the third and fourth weeks after planting which coincided with the life cycle of the weevil (20-25 days from egg to adult). After reaching the peak populations, few weevils were observed, indicating that low reproduction rate may be due to low male weevil population in the area. Further, the effectiveness of using sex pheromone was confirmed by the low (18%) weevil damage on the tubers (Table 8).

Table 8. Number of larvae and weight of damaged and undamaged fleshy roots.

Sampling	No. of larvae/ 2-kg sliced sample	Weight of fleshy roots[z]	
		damaged (kg)	undamaged (kg)
I	15.8	0.2	1.8
II	4.8	0.1	1.9
III	12.3	0.2	1.9
Mean	10.9	0.2	1.8

[z]Average of 2-kg sample and mean of four sample plots.

Regional Programs

AVRDC-Thailand Outreach and Regional Training Program

Seed Production of Chinese Cabbage Hybrid 62

Introduction

To further promote the adoption of Hybrid 62 and make seeds available to farmers, F_1 hybrid seed production was carried out in three experimental stations: AVRDC-TOP field at Kamphaeng Saen, Nakhon Pathom; Pak Chong Station at Pak Chong, Nakhon Ratchasima; and Ang Khang Royal Project Station in Chiang Mai.

Materials and Methods

Vernalization is required at AVRDC-TOP and Pak Chong Station. Seedlings were kept at 5°C for 21-28 days before transplanting to a netted house with bee pollinator.

Results and Discussion

Results indicated that seeds produced from Pak Chong are the largest. Due to unfavorable weather conditions prevailing at Kamphaeng Saen, the seedlings were transplanted in pots whereby plant nutrient was insufficient, thus affecting seed yield. Furthermore, the plants were also damaged by diamondback moth and anthracnose during harvesting. In Chiang Mai, seeds were promising; however, yields were low because of low bee population.

Maintenance of B-18 and E-7 Parental Lines. Self-incompatibility of parental lines used was broken with the spraying of 2% NaCl solution during flowering.

The B-18 line had good podding quality with 3-5 seeds per pod. However, leaf defoliation occurred with the spraying of NaCl. Furthermore, the harvested seeds were small and turned reddish-brown due to very high temperature (maximum of 32°C and a minimum of 20°C) at podding stage.

The E-7 has a strong self-incompatibility which requires vernalization longer than 21 days. On the other hand, the seed yields of E-7 were low.

The use of 2% NaCl solution with bee pollination was found more practical than manual pollination which requires highly skilled labor.

Performance Test for Locally Produced Hybrid 62. Two experiments were carried out at AVRDC-TOP field in Kamphaeng Saen to test the performance of crops grown from the locally produced Hybrid 62 seeds. Experiment 1 was aimed at comparing the yields of crops grown from seeds produced at Pak Chong, AVRDC-TOP and AVRDC. Experiment 2 was designed to compare the yields of crops grown from seeds produced at Ang Khang, AVRDC-TOP and AVRDC.

The first set of crops was transplanted on 21 February 1989 at a spacing of 50 × 50 cm^2, while the second was transplanted on 2 May 1989 at a spacing of 40 × 30 cm^2.

In Experiment 1, the seedlings of E-7 as mother line produced in Pak Chong and AVRDC-TOP were smaller than seedlings with B-18 as mother line. Seedlings of both mother lines produced were smaller than the seeds from AVRDC headquarters.

After transplanting, however, seedlings from all seed sources grew comparatively well. These were harvested 34 days after transplanting. The yields and average head weights of crops produced from locally produced seeds were not different from those produced by AVRDC. Seeds from Pak Chong had about 0.5% impurity which is not far from the 0.2% impurity found in AVRDC materials.

Harvest from Experiment 2 carried out during the hottest period of the year was delayed from 41-42 days after transplanting. Percentage of nonheading was as high as 30-34%. Heads were small with an average weight from 330 to 369 g. The crop yields from different seed sources were not significantly different from each other.

Seeds of Hybrid 62 produced in three different locations in Thailand developed smaller seedlings than those from AVRDC, particularly for seeds of E-7 mother line. However, there were no differences in the performance of seedlings from all sources after transplanting.

Dissemination of Hybrid 62 Seeds to Farmers. Hybrid 62 was released in Thailand last year as April Jade. In summer 1989, about 5-kg samples of Hybrid 62 seeds were distributed to 110 farmers in different regions of Thailand to evaluate Hybrid 62's acceptance.

Farmers who grew these seeds expressed their satisfaction with the growth and heading performance of Hybrid 62 which they found better than the commercial variety. Nine farmers indicated their interest to plant Hybrid 62 on a commercial scale.

Dissemination of Tomato Seeds

About 51.2 kg of seeds of AVRDC-TOP heat tolerant tomato lines, Seedathips 1 and 2, were distributed to 224 farmers in Thailand from February to September 1989. Most seeds were planted in the Central Region, especially in Nakhon Pathom province. About 80% of more than 40 kg of seeds distributed to farmers were grown in different districts of this province which altogether covered an area of about 800-1000 rai. The 1986-87 statistical record of DOAE showed that there were 3100 rai planted to tomato in Nakhon Pathom. This indicates that Seedathips 1 and 2 are well accepted by farmers in this province as these varieties have replaced one-third of the area formerly grown to old Seeda variety.

New Tomato Variety — Seedathip 3

The heat-tolerant Seedathip 1 released in 1987 yielded much higher than the old Seeda variety (Table 1). However, the latter still has higher demand because of the market preference for its color. Seedathip 1 is pinkish-orange. Seedathip 2, also pinkish, was released in 1988 but is not as high-yielding as Seedathip 1. To achieve high yields and pink fruits, color improvement for the old materials was carried out in 1988-1989. The sought-after characteristic was found to have been stabilized on the seventh generation.

Results of two performance tests in summer (April – August, 1989) and early rainy season (June – September, 1989) showed that the new variety is capable of giving the same yield level as Seedathip 1 and produce pink fruits as Seeda and Seedathip 2. This new variety was named Seedathip 3 of which the seed multiplication program began by end of 1989. On-farm trial will be conducted in summer 1990.

Table 1. Yield and fruit characters of Seedathip 3 vs the old Seeda and Seedathip lines.

Variety	Yield (t/ha)		Fruit characteristics	
	April-August	June-September	size (g)	color
Seedathip 1	15.5	27.1	17.3	pink-orange
Seedathip 2	11.0	23.7	20.3	pink
Seedathip 3	16.9	33.2	16.4	pink
Seeda	4.3	8.0	18.4	pink

Selection of Processing Tomato Lines

Yield trials for processing tomato since 1987 have shown PT 3027 or Tainan Selection 3 to be high yielding and acceptable for processing. Compared with the present commercial processing tomato varieties, PT 3027 has smaller fruits, inferior color, hardness, thickness and soluble solid content. However, this introduced line is more tolerant to bacterial wilt and heat.

In August 1989, the processing tomato crop in the Northeast region was severely infected with bacterial wilt. Only PT 3027 and TW-3 (from private company) survived. Unfortunately, these two surviving lines were later attacked by late blight such that no harvest was obtained. Seeds of line PT 3027 was multiplied for further evaluation.

Sweet Potato Varietal Trials

Sweet potato trials were carried out mainly by the seventh Regional Training Program training scholars from China and Sri Lanka. The first experiment was on varietal trial while the second was on the effect of nitrogen fertilizer on root yield. A laboratory experiment on growth and organ formation of *in vitro* tissue-cultured sweet potato was also conducted.

Ten sweet potato varieties (7 from AVRDC, one from Pak Chong Research Station, one from China and one local variety) were evaluated. Variety I 6 from AVRDC gave the highest marketable root yield, total yield and mean root weight. It grew vigorously, resulting in a dry matter content of 22%. It was found suitable for growing in Thailand. Other AVRDC lines, CN 2129-1, CN 1058-10 and AIS 0122-2 had the same yield level as the check Xuzhu 18 which was significantly higher than the local variety, Ungbuay. Both CN 1058 and AIS 0122-2 had orange flesh indicating high vitamin A content.

Effects of Nitrogen Fertilizer Application on Root Yield

The effects of N fertilizer at 0, 40, 80 and 120 kg/ha when applied half as basal and half as top dressing on root and vine were evaluated. Yield of sweet potato cultivars, CN 1028-15, CN 1489-89 and Ungbuay were studied during the first quarter of 1989. Results showed that N-fertilizer application at 120 kg/ha significantly led to high vegetative biomass production and reduction of marketable and total roots resulting in low yield and low harvesting index (Table 2).

Overall results showed that the optimum N requirement of sweet potato entries when grown in Kamphaeng Saen, Nakhon Pathom is 80 kg/ha.

Table 2. Effect of nitrogen rates on the total number of roots, marketable root weight and vine weight of three sweet potato cultivars.

Cultivars	Nitrogen fertilizer	Total weight of roots		Total number of roots		Marketable root weight		Number of marketable roots		Weight of vines
	kg/ha	kg/12 m^2	t/ha	/12 m^2	t/ha	kg/12 m^2	t/ha	/12 m^2	/ha	kg/12 m^2
CN 1028-15	0	26.5	22.1	150.0	125.0	20.6	17.2	102.5	85.4	11.1
	40	31.6	26.3	156.8	130.4	26.3	21.9	107.8	89.8	12.7
	80	31.4	26.2	185.3	154.4	25.4	21.2	124.0	130.3	13.9
	120	34.8	29.0	138.3	115.2	29.0	24.1	99.8	83.1	14.0
CN 1489-89	0	22.1	18.4	163.3	136.0	18.3	15.2	123.3	102.7	14.9
	40	24.1	20.1	159.8	133.1	20.6	17.1	116.8	79.3	17.8
	80	25.9	21.6	204.5	170.4	22.5	18.8	143.3	119.4	18.9
	120	31.1	25.9	160.3	133.5	29.0	24.2	151.0	125.8	22.1
Ungbuay	0	15.9	13.3	121.3	101.0	8.1	6.8	58.0	48.3	5.9
	40	13.6	11.3	118.5	98.8	7.7	6.4	47.3	39.4	6.3
	80	17.2	14.4	148.5	123.8	12.2	10.1	105.8	88.1	7.0
	120	16.1	13.4	123.3	102.7	8.5	7.1	54.5	45.4	7.0

Apart from the above trials, TOP activities for sweet potato were mainly on germplasm collection. A total of 84 varieties/cultivars are being maintained at TOP field for future experiments and as sources of seed materials for farmer cooperators.

Pepper

TOP activities for pepper in 1989 were mainly on germplasm collection and preliminary yield trials. Preliminary studies on both sweet pepper and chili were carried out by the seventh RTP training class. Follow-up trials were also conducted.

Mungbean

This report includes the findings on the average yield and yield components of mungbean cultivars in three years.

Results showed that there was a high interaction between cultivars and dates but the pattern was unpredictable from year to year. Seed yields of the cultivars were diverse from as low as 600 kg/ha in late planting, December 1988. Regardless of the planting dates, KPS 1, KPS 2 and Uthong 1 yielded 1.4, 1.2 and 1.1 t/ha of seeds, respectively. The former two cultivars outyielded the latter by 20.5 and 8.8%, respectively. Other traits like plant height, days to first flower, days to first ripe pod, number of plants per square meter, lodging score, powdery mildew score and Cercospora leaf spot were also investigated. It was found that Uthong 1 grew taller, tolerant to lodging and had higher incidence of Cercospora leaf spot than the other two cultivars.

Chainat 60 was included in the experiment in November 1988 and January 1989; however, it did not perform well under Kamphaeng Saen conditions. On the other hand, PSU 1 which was tested for the first time appeared promising and worthy of further study.

Data also suggested that yielding ability and stability are high when the crop was sown from September to November and also from February to March if irrigation is available. The yield instability of crop sown from December to January was due to low temperature while those from late April to August experienced heavy rain which induced not only foliar diseases but also resulted in poor seed quality.

The seventh RTP group conducted varietal and IMN trials to determine or identify promising lines for possible release in the future.

Evaluation of Elite Mungbean Lines

Four AVRDC mungbean lines were released as Kamphaeng Saen 1 (VC 1973A), Kamphaeng Saen 2 (VC 2778A), Chainat 60 (VC 1178) and Prince of Songkhla University 1 or PSU 1 (VC 2768A). The Field Crops Division of the Department of Agriculture under the leadership of Chainat Field Crops Research Center (CNRC) tested another elite mungbean line, VC 1628A. Unfortunately, the line did not draw the attention of breeders when it was first introduced to Thailand. Since it consistently gave stable yield with large seeds, AVRDC-TOP worked closely with CNRC in evaluating this line across environments.

Post-emergence Herbicide Trial on Mungbean

Weed control in mungbean field in Thailand is almost impossible because over 90% of Thai farmers broadcast mungbean seeds. It is believed that weeds and insects are the most important constraints

in mungbean production. Pre-emergence herbicides are hardly used by farmers since they do not see any weeds in the field when they broadcast seeds. Farmers usually spray post-emergence herbicide once they see weeds extensively growing in the field. However, the amount of weeds is beyond the threshold level.

Imazethapyr AC 263499 is a new broad-spectrum imidazolinine herbicide which was recently introduced to Thailand early this year. An experiment was conducted to determine whether this herbicide can be used with TOP new recommended cultivars CN 60, KPS 1 and KPS 2. The herbicide was applied 11 days after sowing (first true leaf stage).

Hand weeding was done once at 20 days after application and weed cover percentage was evaluated again 24 days after application.

At 24 days after application, toxicity was less and finally the herbicide showed no adverse effect on yield, number of pods per plant, number of seeds per pod and 1,000 seed weight (Table 3).

This herbicide can be used to control 7-10-day-old weeds when applied post-emergence. Yield differences were random and reflected no effect on mungbean yield and its components.

Table 3. Yield and yield components of three mungbean cultivars treated with pre-emergence Imazethapyr in early rainy season, Kamphaeng Saen, Nakhon Pathom, 1989.

Treatments	Yield (t/ha)	Number of		1000-seed weight (g)
		pods/plant	seeds/pod	
CN 60 × 125 g ai/ha	1.5 a-d	21.5 a	10.9 ns	69 abc
KPS 1 × 125 g ai/ha	1.6 ab	12.4 d	11.0 ns	73 a
KPS 2 × 125 g ai/ha	1.5 a-e	15.7 cd	11.1 ns	65 abc
CN 60 × 250 g ai/ha	1.5 abc	20.4 ab	11.5 ns	69 abc
KPS 1 × 250 g ai/ha	1.7 a	14.9 cd	10.9 ns	67 abc
KPS 2 × 250 g ai/ha	1.5 a-f	15.6 cd	10.9 ns	62 c
CN 60 × handweeded (20 DAA)	1.1 efg	16.0 cd	10.1 ns	73 ab
KPS 1 × handweeded (20 DAA)	1.2 b-g	14.3 cd	10.6 ns	69 abc
KPS 2 × handweeded (20 DAA)	0.9 g	17.1 bc	10.9 ns	69 abc

Use of Chemicals for Damping-off Control in Mungbean

Mungbean grown during the rainy season in Thailand is always attacked by damping-off disease. An experiment was conducted to test the locally recommended fungicides against damping-off of mungbean in rainy season (July-September) of 1989. The fungicides used were copper quinolate, patafol, lycine deutuo, ofatanm and amines.

None of the fungicides was found injurious to mungbean. However, fungicide application to control the disease was not really effective.

Soybean Evaluation Trial

The yield and other agronomic characters of 16 selected soybean lines were evaluated at AVRDC-TOP.

Results showed that line KUSL 20014 derived from the cross William × SJ 4 gave the highest yields of 2.5 t/ha (Table 4). Lines KUSL 20010, 20040, 20034 and 20018 also gave good yields which were higher than SJ 4 and NW 1. Seed yields expressed strong correlation with the number of pods per plant than with 100-seed weight or number of seeds per pod. The yields obtained from this experiment were rather high although plants of all lines grew shorter than when planted in rainy season. Plant height varied from 42.9 cm in NW 1 to 57.1 cm in KUSL 20018. All entries were harvested 87 to 99 days after planting. KUSL lines were more resistant to downy mildew than the check cultivars.

Table 4. Average yield and some agronomic characters of 16 soybean lines grown at TOP field, Kamphaeng Saen Campus, dry season 1988.

Variety name or Pedigree	Yield (t/ha)	100 seed wt (g)	Seeds/ pod	Pods/ plant	Plant height (cm)	Days to flowering	Days to maturity	Downy mildew
KUSL 20014	2.5 a[z]	14.0 bc	2.2 bcd	36.0 abc	48.5 de	39.9 a	98.7 a	1.0 d
KUSL 20010	2.5 ab	14.8 bc	2.4 ab	35.4 abc	57.5 a	34.3 bc	92.3 c	1.6 c
KUSL 20040	2.4 abc	13.3 bc	2.6 a	37.0 abc	45.7 de	39.5 a	96.3 abc	1.0 d
KUSL 20034	2.3 abc	13.6 bc	2.3 ab	36.3 abc	46.7 de	39.7 a	96.3 abc	1.0 d
KUSL 20018	2.2 a-d	14.4 bc	2.4 ab	35.2 abc	57.1 a	34.0 c	94.5 abc	1.6 c
SJ 5	2.2 a-d	14.5 bc	1.9 e	43.3 a	55.5 ab	33.7 a	96.3 abc	2.8 b
KUSL 20047	2.1 a-d	13.1 c	2.4 ab	32.9 bc	47.4 de	39.5 a	96.5 abc	1.0 d
KUSL 20050	2.0 a-d	13.3 c	2.3 abc	36.0 abc	48.9 cd	39.7 a	95.7 abc	1.0 d
KUSL 20004	2.0 a-e	15.2 b	2.4 ab	33.9 bc	55.7 a	34.0 c	93.3 bc	1.5 cd
KUSL 20038	2.0 b-e	13.5 bc	2.2 bcd	33.9 bc	49.0 cd	39.5 a	97.0 abc	1.1 d
KUSL 20043	1.9 c-f	13.7 bc	2.2 bcd	34.1 bc	49.9 bcd	39.7 a	97.5 ab	1.0 d
KUSL 20067	1.9 c-f	12.3 c	2.3 abc	31.3 bc	49.1 cd	39.5 a	96.0 abc	1.0 d
Noi Khan	1.8 c-f	13.3 bc	1.3 de	40.1 ab	57.8 a	39.7 a	98.0 ab	3.0 b
KUSL 20033	1.7 def	13.3 bc	2.3 abc	28.7 cd	49.9 cd	40.0 a	94.3 abc	1.0 d
SJ 4	1.6 ef	12.8 c	1.4 cde	33.7 bc	54.4 abc	40.0 a	95.5 abc	3.1 b
NW 1	1.5 f	17.0 a	3.5 ab	23.3 d	42.9 e	34.7 b	87.0 d	5.0 a
CV (%)	15	8.3	8.2	14.5	7.1	1.2	3.0	19.5

[z]Mean of each trial followed by same letter are not significantly different at 5% probability level by DMRT.

Effects of Cytozyme and Pix Growth Regulator in Soybean

The study was conducted to determine the effects of crop plus cytozyme and Pix growth retardants (mepiquat chloride) on yield and its components and some other agronomic characters of six recommended soybean cultivars.

Crop Plus is a biologically derived foliar product used to augment efficient utilization of available or applied nutrients. Pix (mepiquat chloride) is normally used to promote yield of cotton while retarding the plant's growth.

Results in all trials showed that Pix and Cytozyme had no significant effects on soybean growth. The differences detected from these treatments could be attributed to varietal effects rather than hormonal effects. SK 1 was the best yielder. SJ 4, CM 60 and DK showed good yields while SJ 5 and NW 1 had rather low yields. Data for other traits also reflected varietal differences.

Minimizing Salt Problem Through Seedbed Management

A long-term experiment was designed to compare permanent and temporary seedbeds planted to either soybean or mungbean year-round with minimum disturbance to the soil before each sowing. Rainfall and irrigation water were believed to wash salt away from the beds. In the newly and continuously prepared beds, the underground salt was turned over with the soil allowing the salt to resurge to the root zone in each preparation.

Preliminary findings (after a year) indicated that the permanent bed had less salt than the continuously prepared beds.

On-farm Trials of AGS 129

Forty trials of AGS 129 soybean were conducted by Charoen Pokphakdi Group (CP), the largest local and international agribusiness company in Thailand. Since the area for planting is situated in a downy mildew and bacterial pustule disease-prone area, AGS 129 which is resistant to both diseases should perform better compared to the local cultivars. Results are still under compilation for determination whether AGS 129 can be planted commercially under Thailand conditions.

Home Garden

In 1989, three home gardening cropping patterns were evaluated: 1) an area of 5 × 5 m^2 divided into 3 of 2 m^2 area beds for growing different kinds of vegetables including climbing type of vegetables; 2) same pattern as 1 but covered with a nylon net to reduce insect damage; and 3) one-half of the garden planted with vegetables similar to pattern 1 and the other half planted to spices and herbs. Planting period for all patterns covered 10 months (from 1 January to 31 October 1989).

Data showed that yields of vegetables grown under nylon net especially the climbing fruit vegetables such as bitter gourd, angled loofah and yardlong bean are lower than those grown in the open. This indicated that fruit bearing vegetables are not suitable for growing under nylon net or shade. Low yield was attributed to fewer chances for insect pollination.

Home garden cropping patterns in Sri Lanka, Nepal and that of the North Eastern Region of Thailand were compared with the standard home garden pattern developed by AVRDC-TOP. The practice of intercropping and use of border crops in Sri Lanka were found to produce more than enough kinds of vegetables for a family.

Seed production for commonly grown vegetables in home garden under lowland condition was evaluated by one of the training scholars of the seventh RTP from the DOAE of Thailand. The study was conducted to obtain preliminary information and statistics needed for the implementation of DOAE's large-scale home gardening program in the northeast.

Seventh Regional Training Program

The seventh training course of AVRDC-TOP was completed on 15 March 1989. Participants were composed of 27 training scholars from six different countries in Asia (China 8, Nepal 3, Philippines 1, Sri Lanka 4, Thailand 4, and Vietnam 7). Activities accomplished by these scholars were included in the 1988 progress report.

Eighth Regional Training Program

The eighth training program commenced on 15 October 1989. A total of 20 training scholars composed of researchers and extension workers from six countries in Asia attended the course.

This course was another accomplishment toward AVRDC's aim of establishing cooperative linkage with various socialist countries through training. Through the sponsorship of the Government of Switzerland, two agricultural researchers from the People's Democratic Republic of Laos attended the course.

Feedbacks from China and Vietnam indicated that AVRDC-TOP alumni are now all frontliners in research and extension work in their respective national programs and many have made significant contributions to the improvement of their agriculture.

In-country Workshop

The second in-country workshop was planned to be held in Pakistan. An alternative plan of conducting a series of in-country workshops in Indonesia, Malaysia and the Philippines was considered. China has proposed to co-sponsor an in-country workshop on a very small scale in 1990. Negotiations with concerned authorities are in progress. Support from other international funding agencies such as IDRC and GTZ was sought for an intensive in-country workshop in China.

Publication

In addition to the seventh training report, AVRDC came up with four technical bulletins and a book on Major Diseases of Crucifers. Revision of the Technoguide on Home Gardening is ongoing and the revised volume is expected to be published in 1990.

Infrastructure Improvement and Equipment Procurement

The ADB financed laboratory/storage building which houses two laboratories, technical staff office, lecture hall and two cold-storage rooms was finally dedicated in April 1989.

Facilities for the cold rooms were acquired through assistance from IDRC. Other equipment such as new PC, vehicle, photocopying machines, etc. were also procured. The infrastructure and facilities provided by ADB in addition to the operation funds totaled to US$210,761.

Germplasm Collection and Distribution

TOP is continuously collecting different planting materials from different countries in the region especially, China, Vietnam and Laos. Over 200 kg of seeds were received and distributed to more than 30 research entities in 1989.

Other Activities

The Director/Resident Scientist and some AVRDC-TOP staff members attended several meetings in Thailand and abroad.

In September 1989, the Director/Resident Scientist visited China with the new AVRDC Director General to assess the progress of AVRDC-TOP China Cooperative Program and strengthen AVRDC-TOP/China cooperation.

AVRDC-TOP also cooperates with KU and other agricultural agencies in Thailand in the implementation of Southeast Asian Vegetable Network Program. In addition, the Resident Scientist, on behalf of AVRDC facilitated the screening of Thai training candidates prior to their acceptance to the JSIF-funded Training Program at AVRDC headquarters.

Africa Vitamin A Gardening Project

Project Completion

The project aimed to increase the production and consumption of vegetables rich in vitamin A in the Sahel region of West Africa. The target countries were Burkina Faso, Mali, Mauritania and Niger. The project conducted assessment studies; established networks with other organizations in the region involved in vitamin A activities; carried out adaptive gardening research and conducted regional workshops and training programs.

The three-year project, which began in 1986 was funded by a grant from the Office of Nutrition, United States Agency for International Development (USAID).

In 1989, regional training on vegetable gardening and nutrition was conducted at the project's host institution, the Institut Pratique de Developpement Rural (IPDR) in Kollo, Niger, from 4 January to 23 February 1989.

Sixteen African extension agents from four countries responsible for village-level training on vegetable gardens attended the training program.

The training program aimed to improve the technical and extension skills of the trainees in vegetable gardening and provide them with an understanding of basic nutrition concepts. Trainees were selected from nongovernment institutions.

The project ended in August 1989.

Genetic Resources and Information Services

Genetic Resources and Seed Unit

Germplasm Introduction

A total of 861 accessions were introduced in 1989 (Table 1). AVRDC received the base collection of 379 pepper accessions from the Centre for Genetic Resources (CGN) in the Netherlands. The Center continued to introduce germplasm into the Asian and the Pacific sweet potato repository. An interesting set of local leafy Chinese cabbage accessions (38) mostly of the subspecies *parachinensis* was generously donated to AVRDC by the Lembang Horticultural Research Institute (LEHRI). The set of mungbean germplasm (from request in 1986) received from NBPGR was a duplication of the existing mungbean collection.

Table 1. New germplasm introductions in 1989.

Source	No. of entries[z]							Total
	Glycine spp.	*Vigna* spp.	*Brassica* spp.	*Lycopersicon* spp.	*Ipomoea* spp.	*Capsicum* spp.	Others	
Bhutan	–	–	–	–	–	18	–	18
Chile	–	–	–	13	–	–	4	17
China	–	–	5	4	8	4	1	22
Cook Islands	–	–	–	–	11	–	–	11
Fiji	–	3	–	–	–	2	5	10
India	–	106	–	–	–	3	–	109
Indonesia	4	11	38	–	–	–	–	53
Japan	–	–	–	–	10	–	–	10
Malaysia	–	–	–	5	20	3	25	53
Maldives	–	–	–	–	–	52	–	52
Nigeria	–	–	–	–	–	12	1	13
Philippines	4	5	–	–	–	1	16	26
Sierra Leone	–	–	–	–	–	1	30	31
Spain	–	–	–	–	–	212	–	212
Sri Lanka	4	4	–	–	2	–	2	12
Syria	–	–	–	–	–	10	–	10
Taiwan	–	–	–	–	–	2	9	11
Thailand	4	4	–	–	–	–	13	21
USA	–	–	–	1	66	–	5	72
Zambia	–	–	–	–	–	46	–	46
Others	1	7	–	3	8	29	4	52
Total	17	140	43	26	125	395	115	861

[z]All entries are temporarily numbered.

Conservation

The germplasm collections maintained at AVRDC are reflected in Table 2. Many temporary accessions of *Vigna* species were given permanent numbers after multiplication. The sweet potato temporary accessions included 70 clones selected from crosses between *Ipomoea batatas* and its wild relatives.

The base collection in long-term storage is shown in Table 3. The mungbean, tomato and pepper accessions that had been multiplied were finally packed and put into storage. The original germination

test was done for all mungbean and Chinese cabbage in long-term storage. These will be monitored in five years. Presently, GRSU concentrates on the multiplication of pepper and tomato for long-term storage.

In sweet potato, the set of 42 Thai accessions released from the virus indexing scheme were included in both *in vitro* and field genebank. The *in vitro* sweet potato genebank had 979 accessions, of which 165 were set aside for meristem culture. The transfer of *in vitro* collection into slow-growth media using 0.5% mannitol was carried out. It has been sucessful to date. Presently, 300 accessions have been completed.

Table 2. Germplasm maintained in 1989.

Crop	Accessions	Missing	Available	Temporarily numbered accessions	Suspected duplicates[z]
Principal crops					
Soybean	12,505	920	11,585	155	2,111 (10,394)
Mungbean	5,274	202	5,072	801[y]	985 (4,289)
Tomato	5,815	138	5,677	324	40 (5,775)
Sweet potato	1,436	38	1,398	252	9 (1,427)
Chinese cabbage	856	42	814	475	– (856)
Pepper	5,040	110	4,930	401	– (5,040)
Subtotal	30,926	1,450	29,476	2,408	3,145 (27,781)
Other crops					
Adzuki bean	125	–	125	25	– (125)
Amaranth	86	–	86	18	– (86)
Black gram	408	–	408	339	– (408)
Rice bean	72	–	72	223	– (72)
Others	–	–	–	459	– (–)
Subtotal	691	–	691	1,064	– (691)
Total	31,617	1,450	30,167	3,472	3,145(28,472)

[z]Figures in parentheses indicate the total number of accessions from which the duplicates were counted. [y]Including 357 accessions (lines) of wild black gram purified from four populations.

Table 3. Status of base collection in long-term storage in 1989.

Crop	Accessions stored (no.)	Total accessions (%)	Storage room (units)	Seeds/[z] accession (no.)	Moisture content (%)	Germination test done (%)
Soybean	2,620[y]	22.4	5	4,000	8	0
Mungbean	5,252	100.0	5	4,000	8	100
Tomato	1,243	21.9	5	12,000	5	12
Chinese cabbage	341[x]	42.4	5	12,000	5	100
Pepper	802	16.3	5	12,000	5	70

[z]Recommended number of seeds per accession. [y]Non-USDA accessions. [x]Open-pollinated varieties.

Characterization and Evaluation

Work focused on pepper and tomato. On sweet potato, the previous characterization data on the above ground parts were reconfirmed in the field. Dry hot pepper sample of each accession was prepared for capsaicin analysis. Screening for anthracnose resistance was carried out.

Documentation

A computerized data management system was set up and became operational during the year. The mungbean catalog was prepared for publication. The soybean catalog for non-USDA accessions was prepared. A sweet potato catalog was planned and will be prepared when the root characteristics are reconfirmed in 1990.

Distribution

A total of 8959 seed samples of both germplasm and breeding lines were distributed to 77 countries. The main crops distributed reached a total of 8260 samples. The list of seed recipients is included in this report. Virus-indexed sweet potato clones were made available to national cooperators.

Improved Distribution Method of Sweet Potato Meristem Culture

Summary

The international distribution of sweet potato germplasm faces the problem of strict national quarantine regulations. AVRDC has adopted the policy to distribute only virus-indexed tissue culture plantlets and botanical seeds to avoid dissemination of sweet potato diseases. Studies discussed in this report aimed to improve the transportability of the cultures and the transfer of plantlet from tube to pot. It was found that media with an agar concentration of 0.95% in grooved tubes would best conserve the media because groove stops the harder media from slipping up the tubes. The experiment indicated that sweet potato shoot culture grew well in 0.95% agar, and the plantlets were healthy and survived well during transplanting. A new distribution method for sweet potato tissue culture was developed.

Introduction

AVRDC is mandated to promote sweet potato production and utilization in the Asia Pacific regions. Toward this end, AVRDC has been designated as the repository for the Asia Pacific sweet potato germplasm by the International Board for Plant Genetic Resources (IBPGR). To date, the collection consists of 1372 accessions.

The existing method of conservation is in field genebank. Each accession is maintained in an eight-cutting plot. Planting is done every six months from shoot cuttings. Maintenance requires a large area and the work is labor intensive. The germplasm is exposed to biotic and abiotic hazards. An *in vitro* genebank was thus initiated through meristem-culture which was adopted because of its genetic stability.

The international distribution of sweet potato germplasm faces the problem of strict national quarantine regulations. In some countries, entry of vegetative materials is completely prohibited. To solve the problem, AVRDC developed a virus elimination and indexing scheme (Green 1986). AVRDC has adopted the policy to distribute only virus-indexed tissue culture plantlets and botanical seeds to avoid dissemination of sweet potato diseases.

The virus-indexed tissue culture plantlets will only be sent out upon receiving an official import permit from the recipient. An AVRDC self-imposed health certificate attesting that the plantlets are healthy is being issued.

In the past, healthy plantlets from meristem cultures with roots ranging from 4-8 cm were distributed. The standard medium used was made of MS salt base with 7.5 g/l agar (0.75% agar). The tube was capped with two layers of aluminum foil and cellophane. These layers were fastened to the tube with a rubber band. After distribution of the first few batches by air parcel post, feedback indicated that the media disintegrated and some of the caps and tubes were broken. These experiments aimed to improve the transportability of the cultures, and to transfer plantlet from tube to pot.

Materials and Methods

Experiment I. A three replicated 3 × 2 × 2 factorial experiment arranged in a randomized complete block design was used. Each replicate consisted of five tubes per treatment, making 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:
  (a) Normal test-tube
  (b) Tube with an indented groove around the circumference of the tube at 2.5 cm from the base
(3) Flaming of test-tube neck before packaging:
  (a) Flaming
  (b) Nonflaming

Each replicate of 60 tubes with the standard medium of MS salt base (Kuo et al. 1985) but without any plantlets inside was packed with rubber sponge in a carton box. The three boxes (i.e. replicates) after packaging were thrown from a height of two meters on to a concrete floor 15 times each. The boxes were then kept in storage for a month before they were opened for inspection.

Experiment II. A comparison between two agar concentrations of 0.75% (7.5 g/l) and 0.95% (9.5 g/l) of the MS salt base media (Kuo et al. 1985) was carried out with a CRD of 120 culture tubes per treatment. The sweet potato line CN 1489- 89 was used. Plantlet height, number of branches, plantlet leaf number, plantlet root density and root position, at 16 days and 30 days after subculturing were measured. Root density was scored on a 0-3 scale with 0 for absence and 3 for dense. Root position was scored from 0-3 where 0 - no root; 1 - root at top section of media; 2 - roots at middle section of media; and 3 - roots at bottom section of media. Callus formation at the base of the subculture was evaluated at 16 days. The culture room was set at 25°C with white fluorescent light of 1500 photolux for 16 h.

Experiment III. The cultures from Experiment II were used for plant-out experiment. The factors studied were:

(1) Concentration of agar in the media:
  (a) 0.75%
  (b) 0.95%
(2) Types of potting mixture:
  (a) AVRDC regular potting mixture (i.e. sterilized soil: fine sand: compost mixture at 1:1:1 ratio)
  (b) Jiffy-7
  (c) Perlite: Vermiculite mixture at 1:1 ratio
(3) Post-transplanting treatments:
  (a) Check – soft black plastic pot (6 cm diameter and 7.5 cm height)
  (b) Water tray – same pot in standing water tray with 1 cm water level
  (c) Water tray and plastic cover – same pot in standing water tray with 1 cm water level and bagged them with perforated clear plastic bag

Tissue cultures were acclimatized at ambient environments for a day before transplanting into the pots. After transplanting, the pots were left in the shade for a day before moving out to the greenhouse. The transplants were kept moist all the time. The temperatures and relative humidity of the greenhouse ranged from 25 to 42°C and 55% to 95% RH, respectively during the experiment.

The 12 transplants for each treatment were arranged into three replicates of four transplants each.

Results and Discussion

Experiment I. One tube was broken at the neck. This indicated that packaging can 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 was contaminated because the tube was broken while the other two because of the flame treatment from two different replicates. Flaming of the tube neck before packaging is, therefore, not necessary.

The more important factors considered were agar concentrations and types of tube used. It appeared that media with an agar concentration of 0.95% in grooved tubes would best conserve the media in the tubes because groove stops the harder media from slipping out of the tubes.

Experiment II. The vigorous growth of plantlets in terms of leaf size and color in both 0.75% and 0.95% agar media were similar at 16 and 30 days after subculture. However, the harder media significantly reduced the plantlet height by 0.27 and 1.0 cm at 16 and 30 days after subculture, respectively (Table 4). Branching of plantlets in both media showed no significant difference in 16 days. Number of leaves per plantlet and root density were slightly less in the harder media but significantly different from the softer one. The root tended to accumulate in the middle section of the media 30 days after subculture. The rate of callus formation was lower (6.7%) in the 0.95% agar media compared to 14% in the regular 0.75% media.

Table 4. Growth of CN 1489-89 in 0.75% and 0.95% agar MS salt media at 16 and 30 days.

Duration:	16 days			30 days		
Agar concentration:	0.75%	0.95%	t-test	0.75%	0.95%	t-test
Plant height (cm)	1.05	0.78	4.27 ***	2.67	1.67	8.06 ***
Branch number/plantlet	1.43	1.35	1.07 ns	–	–	–
Leaf number/plantlet	4.41	3.97	2.60**	7.77	7.23	2.43**
Root density[z]	1.43	1.20	2.83***	1.35	1.17	2.89 ***
Root position[y]	1.43	1.28	1.79 ns	1.98	2.27	2.58**
Callus formation (%)[x]	14.20	6.70	–	–	–	–

[z]Scored on a 0-3 scale with 0 for absence and 3 for dense. [y]Scored on a 0-3 scale with 0 for no root, 1 for root at top section of media, 2 for roots at middle section of media and 3 for roots at bottom section of media. [x]Percentage of culture with callus formation.

Experiment III. Survival of tissue culture plantlets after transplanting was best in perlite: vermiculite mixture. With Jiffy-7, 42 plantlets survived out of 72 transplanted. AVRDC potting mixture (steam sterilized) was not a suitable medium with only three survivals out of 72 transplanted. Mortality was due to rotting caused by poor drainage of the mixture. Survival of plantlets from both 0.75% and 0.95% agar media seemed to follow the same trend and survival of transplants was comparable. Transplants in both water-tray treatments and without gave comparable performance. However, treatment with water-tray and enclosed in perforated plastic bag gave poorer results because of dampness which favored rotting.

The two concentrations of agar in the media and the combinations of transplanting treatments did not affect branching. The general vigor of the transplants was better from tissue culture plantlets grown in 0.95% agar medium. The perlite: vermiculite mixture gave a symptom of lack of plant nutrient 30 days after transplanting. The few transplants that survived in the AVRDC potting mixture grew vigorously. This was also observed in plantlets on Jiffy-7.

The common media used to propagate sweet potato from tissue culture employ the Murashige and Skoog salt with 0.7% agar. There was no report on the use of hard media with 0.95% agar. The experiments indicated that sweet potato shoot culture grew well in 0.95% agar, and the plantlets were stouter and survived well during transplanting.

Storage of Vegetable Soybean at Different Temperatures and Seed Moisture Conditions

Summary

The storage of three vegetable soybean lines, 205, AGS 292 and 305 with AGS 129 as check under different conditions was evaluated. The storage conditions were the combinations of three

temperatures, 10, 20 and 30°C, and three seed moisture contents (mc), 8%, 10% and 12%. This study aimed to find a commercial storage condition ideal for vegetable soybean seed suited for plantings in about 10 months. It was found that big-seeded vegetable soybean can be stored equally well for eight months at 10 to 20°C and 8 to 12% moisture content.

Introduction

Vegetable soybean (*Glycine max* L.) is big-seeded. Germplasm with 100-seed weight of around 30 g at 8% seed moisture content and acceptable eating quality can be used. It is highly valued for its immature green pods (at $R_{7.6}$ stage when about 80% of the pods reach the full expansion of the potential seed size) as vegetable or snack in the Far East and as cash crop. The pods can be frozen. It can be grown during rainy season when supply of other vegetables is short. It is an excellent source of protein, thiamine and other nutrients.

Recently, this crop has gained acceptance in many subtropical/tropical countries such as Taiwan, Thailand, and the Philippines. Seed storage of vegetable soybean has not been previously studied. However, for grain soybean (seed size of 15 g/100 seeds), a two-year storage is possible at high temperature of 30°C if the seed mc is maintained at low level of 8% (wet basis). This study aimed to determine the storageability of vegetable soybean seed at different temperatures and seed moisture content combinations to simulate natural storage conditions and compare its storage life with the regular grain soybean.

Materials and Methods

The three vegetable soybean lines popular in Taiwan and an improved grain-type line (as check) used in this study (including harvesting dates) were as follows:

Lines	Pedigree	Date of Harvesting
1. 205	Tzurunoku	28 December 1987
2. AGS[z] 292	Taisho Shiroge	17 December 1987
3. 305	Ryokkoh	22 December 1987
4. AGS 129 (check)	Shih Shih × SRF 400	17 December 1987

The vegetable soybean lines were graded into two sizes with a 0.6 × 2.5 cm oblong screen before having been subjected to nine storage treatments which resulted from the factorial combinations of three storage temperatures at 10, 20 and 30°C, and three storage seed moisture content of 8%, 10% and 12%. The treatments were initiated on 5 February 1988. Germination tests were carried out on 200 seeds (divided into 50 seeds per replicate) in sand in air-conditioned room at 25°C. Germination counts were done at day five and eight according to ISTA rules (ISTA 1985). The seed viability was monitored in 2, 4, 6, 8 and 10 months. Seed samples for germination test were equilibrium in the laboratory ambient environment for 24 h before testing to reduce seed injury due to fast rehydration.

Data on germination were transformed by arsine before subjecting to statistical analysis.

Results and Discussion

The initial germination rates of seven seed lots, 205-S (S for small seeded fraction), 205-B (B for big seeded fraction), AGS 292-S, AGS 292-B, 305-S, 305-B and AGS 129, were 99.75%, 99.75%, 99.25%, 96.75%, 99.75%, 99.5% and 98.5%, respectively. These means were not significantly different. The 100-seed weights for 205-S, 205-B, AGS 292-S, AGS 292-B, 305-S, 305-B and AGS 129 were 20.5 g, 30.1 g, 18.7 g, 26.5 g, 24.3 g, 33.8 g and 14.9 g, respectively.

AGS 292 appeared more suited for storage than 205 and 305. After six months of storage, AGS 292-B showed no significant difference from AGS 129 which is a good grain for storage purposes (Annual Report 1988). However, AGS 292-S deteriorated quickly if kept at 30°C with 12% seed mc. Similarly, the small seeded fraction of 205 and 305 appeared to behave as AGS 292 after six-month storage. There was no significant difference between storage at 10 and 20°C. The three storage

seed moisture contents (8%, 10% and 12%) were significantly different from each other with 8% moisture content given the best storage life. Interactions among all factors were highly significant.

After 10 months of storage, the small seeded fraction appeared to be better storing seeds. AGS 292-S and 305-S maintained an average germination rate of 79.1% and 78.3%, respectively. However, they were significantly poorer than AGS 129 with 85.5% viability. The three levels of storage temperatures and seed moisture content were significantly different from each other.

Germplasm Recipients 1989

Argentina

AER-Piloto Metan
Universidad de Buenos Aires

Australia

Commonwealth Scientific and Industrial Research Organization (CSIRO)
Department of Agriculture
Pacific Seeds

Bahamas

Ministry of Agriculture, Fisheries and Local Government

Bangladesh

Bangladesh Agricultural Research Institute (BARI)
Bangladesh Institute of Nuclear Agriculture (BINA)
Regional Agricultural Research Station
Seed Multiplication Project

Barbados

Caribbean Agricultural Research and Development Institute (CARDI)

Belgium

Faculte des Sciences Agronomiques de L'Etat

Belize

Belize College of Agriculture
Caribbean Agricultural Research and Development Institute (CARDI)

Bhutan

Applied Research Centre, Yusipang (BNPP)

Botswana

Department of Agricultural Research

Brazil

Estaçao Experimental de Anapolis

Brunei

Sinaut Agricultural Training Centre

Burma

Agricultural Research Institute

Cameroon

Antenne du C.U. Ds a Ebolowa
USAID/UF

Canada

Agriculture Canada

China

Beijing Municipal Academy of Agriculture and Forestry Science
Jiangxi Academy of Agricultural Science

Colombia

Centro Internacional de Agricultura Tropical (CIAT)
Compania Envasadora del Atlantico Ltda.

Costa Rica

Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)
Coalicion Costarricense de Iniciativas de Desarrollo (CINDE)

Denmark

The Royal Veterinary and Agricultural University

Egypt

Aswan Governorate
Faculty of Agriculture

Ethiopia

Agricultural Research Centre
ETH/87/001, FAO
Institute of Agricultural Research
Ministry of State Farms Development

Fiji Islands

Delanoa Nursery
Sigatoka Research Station
Teidamu Central Nursery
Vuda Garden Ltd.

France

Andre Blondeau Selectionneur-Obtenteur
Institut national de la recherche agronomique (INRA)
Verneull recherche

Gambia

Catholic Relief Services/The Gambia Program
Momodou A. Sey
Yundum Experimental Station

Germany, Federal Rep. of

Bayer AG
Biologische Bundesanstalt für Land und Forstwirtschaft
Institut für Angewandte Genetik der Universität Hannover
Lehrstuhl für Gemusebau

Honduras

Instituto Nacional Agrario (INA)

India

Annamalai University
Assam Agricultural University
Bihar Agricultural College, Sabour
Central Agricultural Research Institute
Desai Agricultural Farm
Food Specialties Ltd.
Himachal Pradesh Agriculture University
Horticultural Research Station
Indian Agricultural Research Institute (IARI)
National Bureau of Plant Genetic Resources (NBPGR)
National Research Centre for Soyabean
Navalakha Seed Pvt. Ltd.
Nimbkar Seeds Private Ltd.
Nu Tech Farm
Punjab Agricultural University
Punjab Agricultural University, Regional Research Station
Sakthi Soyas Limited
Sri Venkateswara Hybrid Seeds Co.
Tamil Nadu Agricultural University

Indonesia

Bantul Agricultural Secondary School
Central Research Institute for Horticulture
Directorate of Food Crops Extension
Directorate of Horticultural Production
ESCAP CGPRT Centre
Fakultas Pertanian, Universitas Lampung
Food Crops Extension
Jeff and Ruth Gucker
Kepala Badan Penelitian dan Pengembangan Pertanian
Lembang Horticultural Research Institute (LEHRI)
Malang Research Institute for Food Crops (MARIF)
Metro Agricultural Secondary School
Nabire Junior Technical School
Nganjuk Agricultural Secondary School
P.T. Tanindo Subur Prima
P.T. Tanindo Subur Prima
Pematang Raya Agricultural Secondary School
PT Summa Surya
Rantau Agricultural Secondary School
Salatiga Agricultural Secondary School
Sawit Agricultural Secondary School
Sekolah Menengah Teknologi Pertanian Sidenreng Rappang
Sidrap Agricultural Secondary School
Sitiung Agricultural Secondary School
SMT Pertanian Sidrap
Takengon Agricultural Secondary School
Vocational Education Development Center for Agriculture
WUAE Project-UNILA

Iraq

FAO

Ireland

University College

Italy

ENEA
FAO
Sementi Nunhems S.R.L.

Japan

Chiba University
Japan Tobacco Inc.
Kagome Co., Ltd.
Mikado Seed Growers Co., Ltd.
Ministry of Agriculture, Forestry and Fisheries (MAFF)
Nihon Horticultural Production Institute
Snow Brand Seed Co., Ltd.
Sumito Chemical Company
TARC, MAFF
Tokita Seed Co., Ltd.
Tokyo University of Agriculture

Kenya

Egerton University
National Agricultural Laboratories

Korea

CES/RDA
Chungbuk Office of Rural Development Administration
Horticultural Experiment Station
Korea Seed Association
Rural Development Administration (RDA)
Seoul National University

Laos

Project of Integrated Rural Development Sekong/Dakchung, UNDP

Lesotho

PLENTY

Malawi

Bvumbwe Research Station

Malaysia

Agricultural Chemicals (M) Sdn. Bhd.

Agricultural Research Centre, Semongok
Agriculture Research Station
Cawangan Pembangunan Komoditi
Department of Agriculture, Malaysia
Harrisons Malaysian Plantations Berhad
Malaysian Agriculture Research and Development Institute (MARDI)
Stesen MARDI Jalan Kebun

Mali

Section de recherches sur les cultures vivrieres et oleagineuses

Mauritius

Mauritius Sugar Industry Research Institute

Mexico

Centro de Investigaciones Agricolas del Pacifico Norte (CIPAN)
Instituto Nacional de Investigaciones Sobre Recursos Bioticos (INIREB)

Nepal

Khumaltar Agricultural Farm/NARSC
PVBP Project

Netherlands

Bruinsma Seeds B.V.
Deruiter Zonen B.V.
Zoadunie B.V.

Niger

Faculty of Agronomy
Projet horticole vitamine A en Afrique
USAID/Niger

Nigeria

Ahmadu Bello University
Ministry of Agriculture and Natural Resources
Obafemi Awolowo University

Pakistan

M/S Zaidis International
N.W.F.P. Agricultural University
National Agricultural Research Centre
Nuclear Institute for Agriculture and Biology

Panama

Instituto de Investigación Agropecuaria de Panamá (IDIAP)
Nestlé Panama, S.A.

Peru

Agronomy Department — UNAS
Autoridad Autónoma de Majes
Estacion Experimental Agropecuaria "EL Porvenir"
International Potato Center (CIP)
Programa de Investigación en Oleaginosas
Universidad Nacional de Educacion

Philippines

Agricultural Training Institute (ATI)
AVRDC/POP
Benguet State University (BSU)
Don Severino Agricultural College
Farms Training Center
Hortanova Farm
Institute of Plant Breeding, UPLB
Mariano Marcos State University
National Training Center, BSU
PCARRD
Regional Training Center, Isabela State University
University of the Philippines at Los Baños (UPLB)

Romania

Agricultural Research Station Suceava

Saudi Arabia

Aba-Husayn Development Co., Ltd.
King Faisal University
Ministry of Agriculture and Water

Seychelles

Ministry of Agriculture

Sierra Leone

Rice Research Station, Rokupr

Singapore

Eastreco (Pte.) Ltd.
Sembwang Field Expt. Station
West District Agrotechnology Division

Solomon Islands

Lagoon Farm Enterprises
Chinese Agricultural Technical Mission

Somalia

UNDP/FAO Project SOM/86/018

South Africa

Starke Ayres (PTY) Limited

Spain

Intersemillas, S.A.

Sri Lanka

C.A.R.I.
Department of Agriculture
Development Alternatives, Inc.
Diversified Agricultural Research Project
Eastern University

St. Kitts

Chinese Agricultural Technical Mission

Suriname

Ministry of Agriculture, Animal Husbandry and Fishery

Swaziland

Malkerns Research Station
Ministry of Agriculture and Cooperatives

Taiwan, China

Ace Seed Company
Chiayi Branch, TARI
Evergrow Seed Company
First Seed Company
Fu Jen University
Harvest Farm Magazine
Hualien DAIS
Kaohsiung DAIS
Taichung DAIS
Taiwan Agricultural Research Institute (TARI)
Taiwan Seed Improvement and Propagation Service
Taiwan Seed Improvement and Propagation Station
Taoyuan DAIS

Tanzania

Same District Council
Sokoine University of Agriculture

Thailand

Agricultural Development Research Center in Northeast Thailand (ADRC)
Chiang Mai Field Crop Research Center
Church World Service
Cooperation internationale pour le developpement socioeconomique (CISDSE-PNH)
Department of Agricultural Extension (DOAE)
Department of Agriculture
Field Crops Research Institute
IMC Project Development and Management (Thailand) Ltd.
Indo Swiss Ltd.
Institute of Technology and Vocational Education
Kasetsart University
Mu Ban Suan Nuansri
Nakhon Sawan Field Crops Research Center
Provincial Agricultural Extension Office
Seed Center No. 7
Southern Agricultural Extension Office
Provincial Agricultural Office
TOP/AVRDC
Vegetable Seed Production Section, Seed Center No. 7
Western Regional Agricultural Extension Office

Trinidad and Tobago

Caroni (1975) Limited

Turkey

Tokat Ziraat Fakultesi

United Kingdom

Nottingham University
University of Bath
University of Reading

USA

BHN Research
Cornell University
Dairyland Seed Co., Inc.
DNA Plant Technology Corporation
Harvard University
Heinz USA
Land O'Lakes, Inc.
Mississippi Agricultural and Forestry Experiment Station
Oklahoma State University
Oregon State University
Peto Seed Co., Inc.
Plant Germplasm Quarantine Center, USDA
Rodale Research Center
Texas A & M University
The Ohio State University
University of Hawaii at Manoa
University of Illinois
University of Minnesota
University of Nevada-Reno
USDA
Washington State University

Uganda

USAID

Uruguay

Centro de Investigaciones Agricolas

Vietnam

Hung Loc Agricultural Research Center
University of Cantho

Western Samoa

Office for Tokelau Affairs

Yemen

El-Kod Agr. Res. Center

Zambia

Ministry of Agriculture and Water Development

Zimbabwe

Chiredzi Research Station
FAO
Horticultural Research Centre
University of Zimbabwe

Office of Information Services

Publications

During 1989, 12 publications were printed (total print run of 19,050) (Table 1). An additional publication (492 pages) was in the final stage of preparation.

Table 1. AVRDC publications under preparation in 1989.

Author/Editor	Publication
	DOCUMENTS
	1987 Progress Report
Tsay/Yang S.T.	Extension Bulletin No. 1 – Hydroponics Home Vegetable Gardening
	1989 Progress Report Summaries
AVRDC	Strategic Plan: Towards the 21st Century
Green	TB – Viruses Infecting Pepper in the Tropics and their Characteristics
Tay	Int. Guidesheet – Tomato Seed Extraction and Cleaning
Tay	Tomato Pollination for Hybrid Seed Production
	1988 Progress Report
Talekar	Bibliography of Diamondback Moth
Hartman	TB – Screening Procedures of Vegetables for Resistance to Bacterial and Fungal Diseases
Kuo et al.	TB – Tomato Production in the Humid Tropics
Tay/Huang	Soybean Germplasm Catalog
Tay	Int. Guidesheet – Pepper Pollination for Hybrid Seed Production
	BROCHURES/LISTS
Sedlacek	10 training booklets
	Publication Lists
	COPUBLICATIONS
AVRDC/PCARRD	Vegetable Production Training Manual
Talekar (Wiley Eastern)	Sweetpotato Weevil Monograph
Talekar (Wiley Eastern)	Bibliography: Sweetpotato Weevils

In 1989, the Office of Information Services (OIS) conducted a survey at the Germplasm Improvement Subnetwork Planning Meeting of 20 AVNET external network collaborators to determine their perceived information needs. With the information obtained OIS prepared a proposal for the publication of a biannual AVNET Newsletter to keep network partners abreast of relevant research and other activities. The AVNET Newsletter will contain information on research, training opportunities, new publications available, upcoming meetings, bibliographic references (without abstracts), and worldwide variety releases and new germplasm collected of tomatoes, peppers, garlic, shallot onions, yard-long beans and cucumbers. An editorial committee composed of the technical coordinator from each participating country was created.

Centerpoint, AVRDC's newsletter, continues to be an effective medium for disseminating information about the Center's activities. OIS receives annually many requests for follow-up information on items reported in the pages of Centerpoint.

Journals published

Twelve journal papers (Table 2) written by AVRDC scientists were published or accepted for publication. Also during the year, 26 symposium/workshop presentations were made by AVRDC scientists (Table 3).

Table 2. Journal papers published or accepted for publication, 1989.

Author(s)	Title	Journal
G.C.J. Fernandez, H.K. Chen and J.C. Miller, Jr.	Adaptation and environmental sensitivity of mungbean genotypes evaluated in the international mungbean nursery	Euphytica 41:253-261
J.C. Miller, Jr., S.M. Barineau, D.G. Smallwood, D.C. Scheuring, G.C.J. Fernandez, H.G. Park, C.S. Ahn, A.T. Tschanz and S. Shanmugasundaram	'TexSprout' mungbean	HortScience 24(4):715-716
S.K. Green, C.Y. Lou and D.R. Lee	Elimination of sweet potato latent virus from *Nicotiana benthamiana* with ribavirin	Plant Protection Bulletin (Taiwan)
S.K. Green and C.Y. Lou	Elimination of sweet potato yellow dwarf virus (SPYDV) by meristem tip culture and by heat	Journal of Plant Diseases and Protection
S.K. Green and D.R. Lee	Occurrence of peanut stripe virus (PStV) on soybean in Taiwan – effect on yield and screening for resistance	Tropical Pest Management 35(2):123-126
S.K. Green, Y.H. Hsu and D.E. Lesemann	Sweet potato leaf curl disease – further investigation and association of gemini-type particle with the disease	Plant Protection Bulletin (Taiwan) – Abstract
G.L. Hartman and C.H. Yang	Occurrence of three races of *Xanthomonas campestris* pv. *vesicatoria* on pepper and tomato in Taiwan	Plant Disease Note
A. Sajjapongse and M.H. Wu	Some aspects of cultural practices in mung-bean (*Vigna radiata* (L.) Wilczek)	Thai. J. Agric. Sci. 22 (April 1989):169-183
A. Sajjapongse and M.H. Wu	Effect of some climatic factors on sweet potato yield	Kasetsart J. (Nat. Sci.) Vol. 23:86-92 (1989)
N.S. Talekar, R.M. Lai and K.W. Cheng	Integrated control of sweetpotato weevil at Penghu Island	Plant Protection Bulletin (Taiwan) 31:185-191
N.S. Talekar and J.C. Yang	Characteristics of parasitism of diamondback moth by two larval parasites	Entomophaga
N.S. Talekar, and S.T. Lee	Studies on the utilization of a female sex pheromone to control sweetpotato weevil (Coleoptera: Curculionidae)	Bulletin of the Institute of Zoology, Academia Sinica 28:281-288

Table 3. Symposium papers/presentations made in 1989.

Author(s)	Title	Symposium/Workshop/Meeting
S.K. Green, Y.H. Hsu and D.E. Lesemann	Characterization of the agent causing tobacco leaf curl disease	Annual Meeting of the Plant Protection Society (Taiwan), Taichung, 8-9 December
G.C. Kuo	Quality vegetable production and light management	Improvement of Production and Marketing of Vegetables, Taoyuan DAIS, Taipei, 24-27 April
S.H. Lai, L.C. Chang, J.T. Chen, and J.J.S. Tsay	Year-round production of Chinese cabbage and tomato in Taiwan	Off-season Production of Horticultural Crops, FFTC, Taichung, 28 November-2 December
R.T. Opeña	Genetic improvement of selected vegetables in the tropics and subtropics	International Symposium on Production of Vegetables in the Tropics and Subtropics, Min. of Agric., Fisheries, and Forestry, NIVOT, Japan 16-26 September

Table 3. Continued.

Author(s)	Title	Symposium/Workshop/Meeting
Y. Ota and D.L. Wu	Improvement of hydroponic tomato culture system for the tropics	2nd Congress on Horticultural Production under Structure, TARI and the Chinese Society for Horticultural Sciences, TARI, 23-24 February
Y. Ota, H. Kobayashi, C.L. Wu and Y.F. Yang	The evaluation of peppers for tolerance to both flooding and drought using sloping bed fields	6th International Congress of SABRAO, Tsukuba, Japan, 21-25 Augutst
S. Shanmugasundaram	Global cooperation for the improvement of soybean research and development	World Soybean Research Conference IV, Argentina, 5-9 March
S. Shanmugasundaram	Vegetable soybean in the east	World Soybean Research Conference IV, Argentina, 5-9 March
S. Shanmugasundaram	Breeding leguminous vegetable crops	Breeding Course for Horticultural Crops, TARI, Taichung, 9-10 November
H. Takagi	Genetic resources and strategies of AVRDC sweet potato improvement program	Improvement of Root and Tuber Crops in Tropical Countries in Asia by Induced Mutation, IAEA, Bangkok, 20-24 February
N.S. Talekar	The beanfly pest complex of snap bean in the tropics	International Conference on Snap Beans in the Developing World, CIAT, Cali, 14-16 October
N.S. Talekar	Use of parasitoids for the control of diamondback moth	Seminar on the Use of Parasitoids and Predators in Biological Control, FFTC, Japan, 2-10 October
N.S. Talekar, C.P. Lin and C.C. Huang	Insect resistance in the management of soybean and mungbean pests	Workshop on Varietal Improvement of Chickpea, Pigeon pea, and Other Upland Crops in Rice-based and Other Cropping Systems. ICRISAT and IRRI, Kathmandu, Nepal, 19-22 March
N.S. Talekar	Sex pheromone as an integrated part of an IPM for *Cylas formicarius*	Sweet Potato Insect Pest Management Conference, CIP and the University of Florida, Miami, USA, 18-23 June
N.S. Talekar	Breeding sweet potato for weevil resistance	Sweet Potato Insect Pest Management Conference, CIP and the University of Florida, Miami, USA, 18-23 June
N.S. Talekar	Biology and management of sweetpotato vine borer	Potato Insect Pest Management Conference, CIP and the University of Florida, Miami, USA, 18-23 June
N.S. Talekar, J.C. Yang and S.T. Lee	Control of major insect pests of vegetables in Taiwan	Symposium on Quality Vegetable Production and Marketing, PDAF and COA, Taipei, April
N.S. Talekar and J.C. Yang	Biological control of diamondback moth: 1. Use of parasitoids	Symposium on Integrated Control of Vegetable Insect Pests, Entomological Society of ROC, Pintung, 22-23 September
N.S. Talekar and J.C. Yang	Integrated control of diamondback moth	First Asia-Pacific Conference on Entomology, Thai Department of Agriculture Kasetsart University and Plant Protec. Society of Thailand, Chiang Mai, Thailand, 6-14 November
D.C.S. Tay	Resource conservation and utilization concept and practice	Breeding Course for Horticultural Crops, TARI, Taichung, 9-10 November
D.C.S. Tay	Information management system at AVRDC genebank	6th International Congress of SABRAO, Tsukuba, Japan, 21-25 August

Table 3. Continued.

Author(s)	Title	Symposium/Workshop/Meeting
J.J.S. Tsay	Cropping systems studies in AVRDC	Symposium on Yield Losses Due to Continuous Cultivation of Major Economic Crops, FFTC, Suweon, Korea 13-19 August
J.J.S. Tsay	Quality vegetable production: the cropping systems' point of view	Improvement of Production and Marketing of Vegetables, Taoyuan DAIS, Taipei, 24-27 April
S.S.C. Tsou	Application of NIRS as a mass screening technique at AVRDC	Infrared Spectroscopy Conference, Association of NIRS, Tsukuba, Japan, 29 May - 2 June
T.C. Wang	The occurrence and control of diseases for high quality vegetable production	Improvement of Production and Marketing of Vegetables, Taoyuan DAIS, Taipei, 24-27 April

Editing

During 1989 OIS prepared *Centerpoint*, Vol. 7, and the *1990 AVRDC Publication Catalog*, and compiled the *1988 Progress Report Summaries*. Editorial services were also provided for six major documents, four issues of periodicals, 10 journal papers, 24 symposium presentations and 20 informal documents.

Copublication

AVRDC was involved in a copublication agreement with Wiley Eastern Ltd. of New Delhi to publish N.S. Talekar's monograph, *Beanflies of Food Legumes in the Tropics*. The book is due off the press in late 1990.

AVRDC also entered into a copublication agreement with Centro Internacional de Agricultura Tropical (CIAT) to copublish N.S. Talekar's Bibliography: Agromyzid Pests of Tropical Food Legumes. This working document was published by CIAT's Network on Bean Research in Africa.

Public Awareness

As part of its public awareness program, AVRDC issued four press releases in 1989, and staff met with journalists from Paraguay, the PTV 4 (Philippines) film crew and press group led by Mr. Bob Johnstone, technology reporter for the *Far Eastern Economic Review*, and arranged for senior staff numbers to be interviewed by BBC's "The Farming World" for worldwide broadcast.

Mailing List

The Center maintains a computerized mailing list which serves as the basis for AVRDC's contacts with its collaborators worldwide. About 450 agricultural libraries throughout the world act as a depository for all Center technical/scientific materials.

Photo Services

Over 21,000 technical and general photographs were taken in over 1000 separate sessions in the fields, laboratories, greenhouses and studio.

Distribution

In 1987 AVRDC established a Publication Distribution Fund and obtained a grant from the Technical Centre for Agricultural and Rural Cooperation (CTA) for 1988-89. This money

was used to mail complimentary copies of AVRDC publications to African-Caribbean-Pacific (ACP) and European Community (EC) countries. Having these funds available allowed the Center to expand its complimentary distribution, particularly to collaborators in Africa. AVRDC looks forward to continued cooperation with CTA.

OIS consolidated its entire automatic complimentary distribution in 1989. The use of consolidated mailings in combination with the selective dissemination of publications (SDP) initiated in 1988 provided AVRDC with the maximum cost efficiency under the existing tariff structure.

Sales

Total sales of AVRDC publications in 1989 remained at about the same level as in 1988, maintaining the five-fold increase in sales since the implementation of a cost-effective publication policy in 1986. The distributors contributed a significant portion to the sales in 1989. A performance evaluation of our distributors was carried out in 1989, and some changes were made to increase the effectiveness of the agents.

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

TRIOPS. Tropical Scientific Books
Toeche-Mittler Distribution
6100 Darmstadt
Hindenburgstr, 33
Fed. Rep of Germany (Orders for Europe)

Agribookstore
1611 N. Kent Street, Suite 600
Arlington, VA 22209
USA (Orders for North America)

Publishers International Corp.
2nd Floor, Newfield Building
42-3 Ontsuka 3-chome
Bunkyo-ku, Tokyo 112
Japan

INFO-LINE
GPO Box 506
Sydney, N.S.W. 2001
Australia
(Orders for Oceania)

LDC Distributors

World Universities Press
B-5/132, Safdarjung Enclave
New Delhi - 110 029, India

Africa Book Services, Ltd.
Quran House
Mfangano Street
P.O. Box. 45245
Nairobi, Kenya

Publications Section
CGPRT Centre
Jalan Merdeka 99
Bogor 16111, Indonesia

University of Malaya Co-Operative
Bookshop, Ltd.
P.O. Box 1127
Jalan Pantai Baru, 59.700
Kuala Lumpur, Malaysia

INDEX, Book Promotion &
Service, Ltd.
Ploenchit Road, Pathumwan
Bangkok 10500, Thailand

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.
1988 Progress Report. 414 p.
1989 Progress Report. 351 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.
1989 Progress Report Summaries. 108 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)

Green, S.K., T.D. Griggs and B.T. McLean (eds.) Tomato and Pepper Production in the Tropics: Proceedings of the International Symposium on Integrated Management Practices. 600 p. (HDC $35.00; LDC $22.50).

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)

TB 13 Shanmugasundaram, S. 1979. Varietal development and germplasm utilization in soybeans. 36 p. (HDC $5.00; LDC $3.50)

TB 14 Caldwell, J.S. and D.W. Newsom. 1984. Vegetable consumption and production in two municipalities in Ilocos Norte, Philippines. 24 p. (HDC $4.00; LDC $3.00)

TB 15 Green, S. K. 1984. Guidelines for diagnostic work in plant virology. 43 p. (HDC $5.00; LDC $3.50)

TB 16 Caldwell, J.S. 1987. Assessing rainy season vegetable production alternatives: A case study in 'upstream' farming systems research. 50 p. (HDC $5.00; LDC $3.50)

TB 17 Opeña, R.T., C.G. Kuo and J.Y. Yoon. 1988. Breeding and seed production of Chinese cabbage in the tropics and subtropics. 92 p. (HDC $7.50; LDC $4.00)

Bibliographies

Talekar, N. S., H. C. Yang, S. T. Lee, B. S. Chen and L. Y. Sun (comps.). 1985. Annotated Bibliography of Diamondback Moth. 469 p. (Gratis, limited stock distributed selectively.)

Hwang, P. L., F. C. Chen and C. C. Wei (comps.), Saadaoui, M., A. T. Tschanz and J. W. Soderlund (eds.). 1987. Soybean Rust Bibliography. 103 p. (HDC $7.50; LDC $5.00)

AVRDC. 1988. Disease and Insect Pests of Mungbean and Black Gram: A Bibliography. 254 p. (HDC $17.50; LDC $10.00)

Directories

Yoon, Jin-Young. 1988. Directory of Chinese Cabbage Researchers. 62 p. (HDC $6.00; LDC $3.50)

Shanmugasundaram, S. 1989. Directory of Mungbean and Soybean Researchers. 140 p. (HDC $12.00; LDC $8.00)

Monographs

Bressani, R. 1982. World needs for nutrition and the role of vegetables and legumes. 22 p. (HDC $4.00; LDC $3.00)

Chandler, R.F. 1983. The potential for breeding heat tolerant vegetables for the tropics. 10 p. (HDC $3.00; LDC $2.00)

Choudury, B. 1984. Vegetables and the quality of life in the year 2000. 7 p. (HDC $3.00; LDC $2.00)

Innes, N. L. 1983. Breeding field vegetables. 34 p. (HDC $5.00; LDC 3.50)

Liu, M. S. and P.C. Ma. 1983. Postharvest problems of vegetables and fruits in the tropics and subtropics. 14 p. (HDC $3.00; LDC 2.00)

Wittwer, S.H. 1983. Frontiers for science and technology in vegetable production. 19 p. (HDC $4.00; LDC $3.00)

Miscellaneous

Van der Goot, P. 1930 [translated 1984]. Agromyzid Flies of Some Native Legume Crops in Java. 102 p. (HDC $7.50; LDC $4.50)

Franssen, C. J. H. 1934 [translated 1987]. Insect Pests of Sweet Potato Crop in Java. 24 p. (HDC $4.00; LDC $3.00)

Shanmugasundaram, S., T. S. Toung and L. F. Chen. 1985. AVRDC Soybean Evaluation Trial (ASET) 1980 & 1981. 62 p. (Gratis, limited stock distributed selectively.)

Ahn, C.S., J.H. Chen and H.K. Chen. 1985. International Mungbean Nursery (IMN) 1981 & 1983. 86 p. (Gratis, limited stock distributed selectively.)

Shanmugasundaram, S. 1988. A Catalog of Mungbean Cultivars Released Around the World. 20 p. (HDC $4.00; LDC $3.00)

International Guide Sheets

78-63 Park, H.G. 1978. Suggested cultural practices for mungbean. 2 p. (Gratis)

78-64 Park, H.G. 1978. Procedures for mungbean evaluation trials. 4 p. (Gratis)

78-65 Villareal, Ruben L. and S.H. Lai. 1978. Pollen Collector. 2 p. (Gratis)

78-66 Riley, James J. 1978. AVRDC crop environment. 2 p. (Gratis)

78-101 Villareal, Ruben L. and S.H. Lai. 1978. Procedures for tomato evaluation trials. 4 p. (Gratis)

79-112 Shanmugasundaram, S. 1979. Suggested cultural practices for soybean. 2 p. (Gratis)

79-121 Hubbell, J.N. and M.Y. Chiang. 1979. Suggested cultural practices for sweet potato experiments. 2 p. (Gratis)

79-125 Shanmugasundaram, S. 1979. Evaluating AVRDC soybeans. 4 p. (Gratis)

79-127 Kuo, C.G. and S.H. Lai. 1979. Suggested cultural practices for tomato. 3 p. (Gratis)

80-134 Villareal, R.L. and H.F. Lo. 1980. Procedures for sweet potato evaluation trials. 4 p. (Gratis)

80-144 Opeña, R.T. and S. H. Lo. 1980. Procedures for Chinese cabbage evaluation trials. 6 p. (Gratis)

85-234 Kuo, G.C. 1985. Handling of sweet potato germplasm. 2 p. (Gratis)

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Newsletters

Centerpoint — This newsletter of AVRDC provides up-to date information on research, training, publications, etc. (Gratis)

TVIS News — This journal was prepared by the Tropical Vegetable Information Service (TVIS) through AVRDC. It provided a platform of exchange of information for scientists working with mungbean, soybean and Chinese cabbage. (HDC $4.00/issue; LDC $2.00/issue)

Vol 1., Nos. 1, 2; Vol. 2, No. 1; Vol. 3, Nos. 1, 2

Soybean rust newsletter — This annual newsletter is published by the International Working Group on Soybean Rust through AVRDC. (HDC US$5.00/issue; LDC US$2.00/issue)

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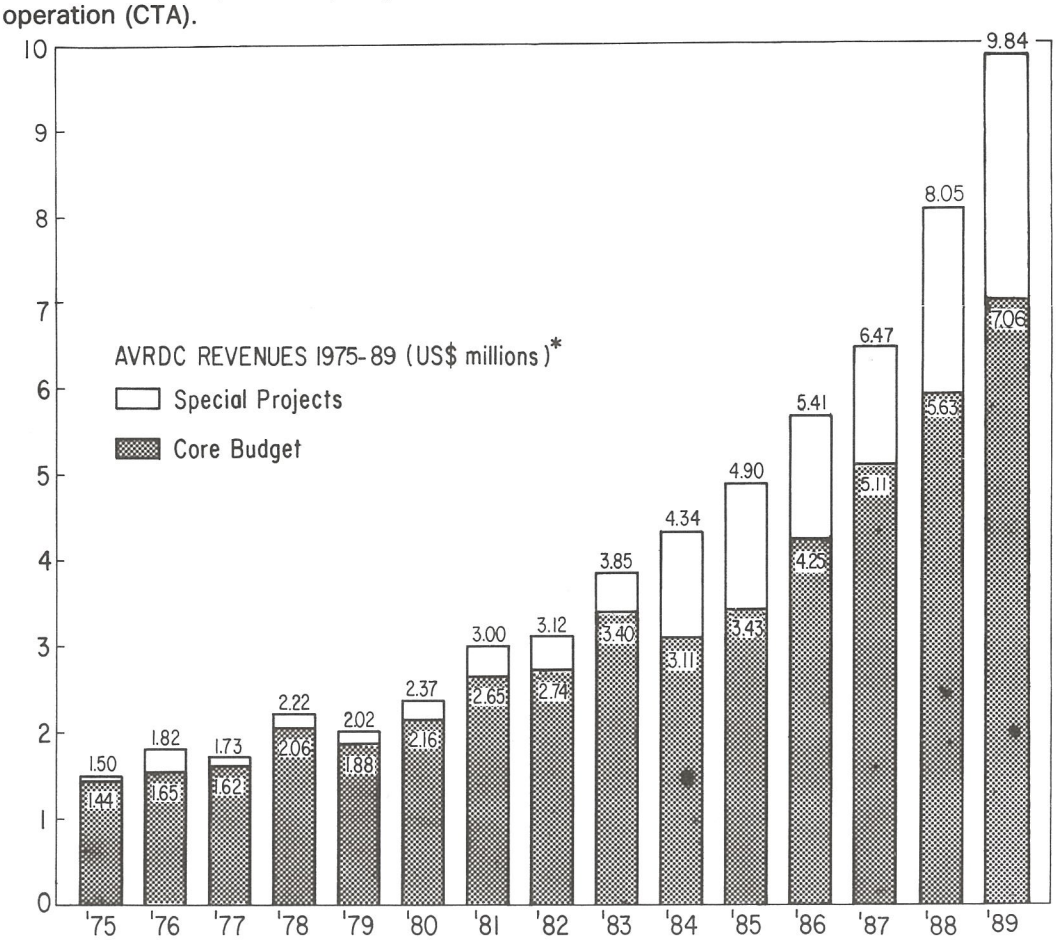
† Arrived during 1989.
‡ Left during 1989.
‡‡ Reinstated after advanced study leave.
** Promoted in 1989.
*** Acting personnel.

Finances

AVRDC's projected budget for 1989 was US$7,730,000 compared with an actual income of US$9,841,492 and total expenditures of US$9,121,027. In 1989 AVRDC received support from the following:

- 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
- the World Bank

Grants and other forms of assistance were also received from (among others): 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 OICD/U.S. Department of Agriculture, 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).



* A total of US$ 6.79 million was received for 1971-74 of which US$ 4.2 million was for capital expenditure.