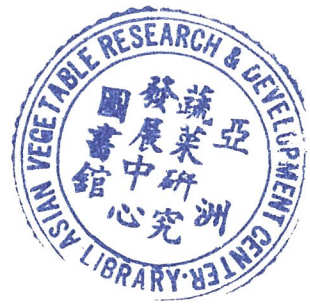
1990 PROGRESS REPORT

Asian Vegetable Research and Development Center



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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)
-CONVERDS -Collaborative network for Vegetable Research and Development in Southern Africa
-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

-OPC -Office of Publications and Communications

-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

-SAVERNET -South Asia Vegetable Research Network
-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

Improving the Maturity of Open-pollinated Tropical Cultivars

Summary

Preliminary comparisons of the maturity ranges of three different generations derived through maternal line selection (MLS) indicated that MLS is effective in reducing the wide dispersion in maturity of open-pollinated Chinese cabbage cultivars. The maturity range of the MLS derivatives has been reduced by about 4 to 5 days after five cycles of MLS. The obvious effect of MLS is concentrating the maturity of the populations by delaying the earliest harvest while at the same time hastening the maturity of the latest maturing plants. The best MLS5 families will be planted for further selection to see if further response could still be elicited without adverse effects on traits like yield.

Introduction

Breeding was continued to improve the uniformity of maturity of two AVRDC-bred open-pollinated cultivars, 77M(3)-27 and 77M(3)-35. These cultivars have widely dispersed maturity but possess good heat tolerance and resistance to downy mildew. Both populations were subjected to maternal line selection (MLS) procedures to achieve the objective. Five MLS cycles were completed by the 1989-90 cool season. To determine the effectiveness of the MLS in reducing the maturity gaps of the populations, the intervening breeding cycles were replanted and compared for maturity and other horticultural characters in late summer 1990.

Materials and Methods

The first trial planting of this experiment was destroyed by a typhoon and therefore the experiment had to be replanted.

Three MLS cycles of the two populations, MLS0 (original population), MLS3 (cycle 3) and MLS5 (cycle 5), were planted in a split plot experiment with the main plot alloted to the variety factor and the subplot to the MLS generation factor. The experiment was laid down using a randomized complete block design with four replications. Individual plots consisted of four rows, 6 m long each, 1.5 m from the center of one bed to the other. Each bed had two rows of plants, with plants within the row 40 cm apart and rows within the bed 50 cm apart. Total dimension of each plot was 18 m^2. Data on maturity, yield, head weight and other horticultural characters were collected on individual plants of each plot.

Results and Discussion

An analysis of the plant maturity data indicated that the MLS method was effective in reducing the wide dispersion of maturity in both open-pollinated populations (Fig. 1). The effect of MLS was significant in both populations; the range of maturity (expressed as the difference in number of days between the first and last harvest) of these populations has been reduced by nearly 4 to 5 days.

The apparent effect of MLS was reduction of the maturity gaps between the populations by delaying the earliest harvest while also hastening the maturity of the latest maturing plants (Fig. 2 and 3). Such

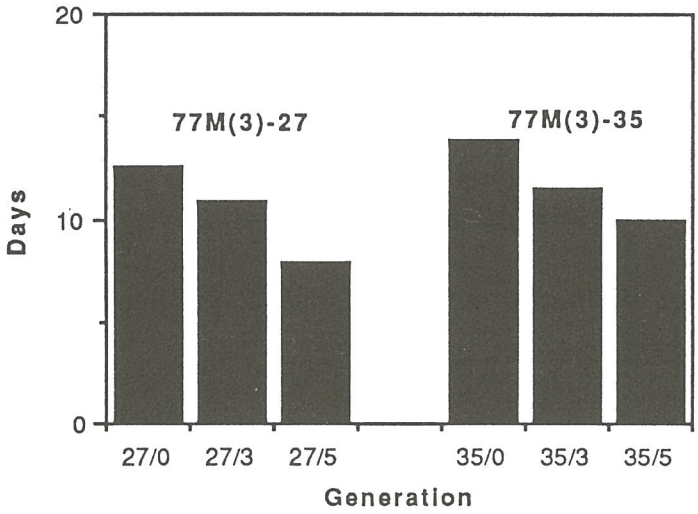

Fig. 1.
Comparative range of maturity (days) between progressive MLS generations of two open-pollinated Chinese cabbage populations (Note: number after slash indicates the generation of maternal line selection).

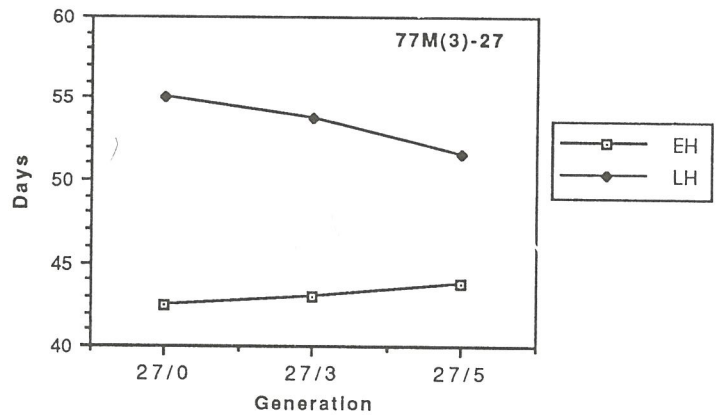

Fig. 2.
Progressive concentration of maturity in MLS populations of 77M(3)-27 (Note: EH = earliest harvest; LH = latest harvest)

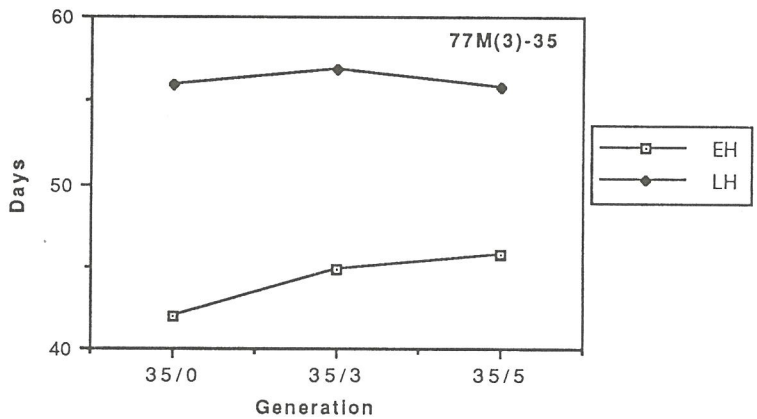

Fig. 3.
Progressive concentration of maturity in MLS populations of 77M(3)-35 (Note: EH = earliest harvest; LH = latest harvest)

a response could be expected since the first MLS cycle had been subjected to normalizing selection. In this process, only plants with intermediate maturities are selected in the intervening MLS generations; extremely early and extremely late plants in every MLS cycle are always discarded.

MLS was found effective in reducing the wide dispersion in maturity of the breeding populations but whether it came at no expense to other important traits such as yield will have to be determined.

Often, uniform maturity results from some form of inbreeding which has a depressing effect on characters like yield.

Development of Cytoplasmic Male-Sterile (CMS) Lines

Summary

Seven selections with better seed yield potential than the normal check line, CT1-27, were taken from Batch I materials derived from radish CMS.

From the derivatives of mustard CMS, six selections were obtained from Batch II. The best family, 89W33, gave generally better seed yield and heavier seeds than the check and other selections. In Batch III, six selections which had comparable pod and seed attributes as the check, CT1-32, were taken. There were more good families in Batch IV CMS than in the other batches, so, more selections were taken from it than from the others. Selections in this batch were generally better than the checks in seed weight and seed yield per plant.

Seeds from these selections were sown for further selection using a similar two-step selection process — one is based on morphological characters such as absence of chlorosis at seedling stage followed by selection for seed yield potential in the field following natural pollination of the CMS plants by honeybees.

Introduction

The commercial production of F_1 hybrid seeds of Chinese cabbage has exclusively employed the sporophytic self-incompatibility mechanism. This system is not only difficult to apply in many tropical countries but it is also known to break down under high temperatures. If hybrid seeds and hybrid seed production are to be widely introduced in tropical countries, it is essential to develop a simpler and a more stable system of hybridity.

Studies in the past explored the introduction of cytoplasmic male sterility from radish, *Raphanus sativus*, and mustard, *Brassica juncea*, as an alternative hybridity mechanism for tropical Chinese cabbage lines. This study aimed to transfer the trait into tropical Chinese cabbage lines (those not possessing self-incompatibility) through repeated backcrossing. In the 1989-90 cool season, the selection of good cytoplasmic male-sterile genotypes from various backcross families was continued. The most important criteria for selection were normal green leaf color and good seed production potential under natural bee pollination conditions.

Materials and Methods

Four batches of backcross-derived CMS materials from radish and mustard sources were planted in the field during the 1989-90 cool season for further observation, selection and seed production. Prior to field planting, initial selections were made in the seedling nursery for important traits such as normal green foliage color, good vigor, etc. Further details about the different materials are given below.

Source of CMS	Batch	Generation	Sown/planted	No. of families	Total plants
R. sativus	I	BC_6F_3	10/6−11/1/89	14	840
R. sativus	I	BC_5F_4	10/6−11/1/89	12	720
B. juncea	II	BC_8F_1	10/10−11/1/89	10	2,033
B. juncea	III	BC_2F_2	10/6−11/2/89	19	1,900
B. juncea	IV	a	10/6−11/3/89	17	1,020

[a]Families originated from intercrosses with a normal, male-fertile derivative which arose from one of the backcross families; following the cross, each family has been open-pollinated twice by the original recurrent parents, CT1-32 and CT1-56.

The CMS families were randomly arranged in the seed production field. Planting was carefully designed to ensure that each CMS progeny was always surrounded in the field by four male-fertile pollen source (normally, the common recurrent parents of the families being tested). In this manner, the seed production potential of each CMS progeny could be fairly evaluated and used as an objective selection criterion. Additional beehives were distributed strategically in the field to add to the natural bee population. It was assumed that there were more than enough bees in the field to minimize the nonrandom pollination of test plants. CMS plants were selected based on the apparent pod and seed production ability in the field. Data on seed yield, seed size, seed vigor, etc. were taken from a five-branch sample of each field-selected CMS plant for use in the final selection of progenies for further breeding.

Results and Discussion

The summary of selections from Batch I CMS materials is shown in Table 1. It is clear that the selections had better seed yield potential than the check line, CT1-27. However, the seeds produced by the selections and the check were still generally small and lighter than usual partly because of suboptimal plant development. General infestation of the planting by diamondback moth was severe, causing premature defoliation in many plants.

Table 1. Pod and seed characteristics of selections in Batch I of CMS materials from original crosses with radish as source of cytoplasmic male sterility; 1989-90 winter.

Family	No. of selections	Pod No.	Seed No.	Seed weight (g)	1000-seed weight (g)	Seed yield (g/plant)
89W01	2	136	1155	2.1	1.8	14.6
89W05	3	155	1722	2.6	1.5	15.7
89W10	2	145	2022	3.4	1.7	16.2
CT1-27 (CK)		158	2433	2.6	1.1	8.5

Selections from Batch II CMS materials are given in Table 2. The best family in this batch was 89W33 which gave generally better seed yield than the check and other selections. It also appears that the seed weights of selections from Family 89W33 were much better than those of others.

Six selections were taken from Batch III CMS materials derived from crosses with *Brassica juncea* as the CMS source (Table 3). Most of the CMS selections were comparable to the check CT1-32 in pod and seed characters. Selections from family 89W70 were slightly better than others.

More selections were taken from Batch IV CMS materials compared to other batches (Table 4). With the exception of family 89W116, selections from other families were generally better than any of the two checks in seed weight and seed yield per plant.

Table 2. Pod and seed characteristics of selections in Batch II CMS materials from original crosses with mustard as source of cytoplasmic male sterility; 1989-90 winter.

Family	No. of selections	Pod No.	Seed No.	Seed weight (g)	1000-seed weight (g)	Seed yield (g/plant)
89W31	1	89	826	1.4	1.7	4.2
89W32	1	142	874	1.5	1.8	4.9
89W33	4	147	1891	3.5	1.9	11.8
CT1-32 (CK)		127	1890	2.7	1.4	8.6

Table 3. Pod and seed characteristics of selections in Batch III CMS materials from original crosses with mustard as source of cytoplasmic male sterility; 1989-90 winter.

Family	No. of selections	Pod No.	Seed No.	Seed weight (g)	1000-seed weight (g)	Seed yield (g/plant)
89W61	1	132	1615	2.3	1.4	8.0
89W62	1	142	1973	2.4	1.2	7.6
89W65	1	131	2169	2.6	1.2	8.9
89W70	3	170	2010	3.0	1.4	10.2
CT1-32 (CK)		127	1890	2.7	1.4	8.6

Table 4. Pod and seed characteristics of selections in Batch IV CMS materials from original crosses with mustard as source of cytoplasmic male sterility; 1989-90 winter.

Family	No. of selections	Pod No.	Seed No.	Seed weight (g)	1000-seed weight (g)	Seed yield (g/plant)
89W108	3	201	1571	3.1	1.9	11.5
89W109	2	124	1453	3.1	2.1	21.2
89W115	3	182	1820	4.1	2.2	18.2
89W116	2	163	1575	2.8	1.8	8.6
89W117	4	185	1827	4.0	2.1	12.2
CT1-32 (CK)		127	1890	2.7	1.4	8.6
CT1-56 (CK)		178	1472	2.2	1.5	7.3

Seeds produced from the above selections were sown in October for further selection using a similar two-step selection process — one on morphological characters such as absence of chlorosis at seedling stage, followed by selection for seed yield potential in the field following natural pollination of the CMS plants by honeybees.

International Cooperation

In 1990, a total of 553 seed packets of Chinese cabbage were distributed to 102 cooperators in 41 countries. Most of the seeds consisted of open-pollinated and/or F_1 hybrid cultivars, together with local checks and AVRDC's standard heat-sensitive check. A limited number of shipments to national programs of parental lines of F_1 hybrids for in-country seed production experiments was also made. Reports of promising performance of AVRDC breeding materials from a few cooperators were received during the year and summarized below.

China. K. P. Chang of CAAS, Shia-men City, Fujian Province reported the excellent performance of ASVEG 1 in his 1989 hot season trial for disease resistance and yield. Normally, problems of high temperature, typhoon, heavy rains and diseases such as soft rot and viruses make it difficult to grow a successful Chinese cabbage crop during this season. Mr. Chang believes that ASVEG 1 could be extended to Fujian Province and other parts of southern China which have similar climates as Taiwan. Parental stock seeds of ASVEG 1 and other promising hybrids have been provided to Mr. Chang for further hybrid seed production. In Jiangsu province, Mr. Yuan Zi-han of the Jiangsu CAAS reported receiving seeds of the parent stocks of ASVEG 1 which he expected to use in producing 3 to 4 t of hybrid seeds for commercial production. He also planned to produce 10 kg each of the parental stocks for future hybrid seed production.

Papua New Guinea. Mr. M. E. Millar, Head of the Agricultural Science Department of the Pacific Adventist College in Boroko obtained best performance from AVRDC 82-46 and 77M(2/3)-43 when compared with Tropical Delight and Saladeer, both commercial cultivars from Japan.

Vietnam. The Scientific Federation of Seed Multiplication in Ho Chi Minh city, through its Dong Tien Station, reported that ASVEG 1 did extremely well in their 1989 hot wet season trial. Two

kilograms of hybrid seeds have been ordered through the FAO Vegetable Project in the country for large scale farm demonstration trials in 1990. Attempts are also being made to develop the local capacity for vegetable seed production, including that of Chinese cabbage, in the highland vegetable production area of Dalat.

Chinese Cabbage Entomology

Demonstration of Integrated Pest Management of Diamondback Moth on Farmers' Fields in the Lowland and Highland Areas of Taiwan

Summary

An integrated pest management (IPM) package to control diamondback moth (DBM), *Plutella xylostella*, was tested during 1990 in the lowlands and highlands of Taiwan. In the lowlands where crucifers are grown between October and May, one egg parasite, *Trichogrammatoidea bactrae*, two larval parasites *Apanteles plutellae* and *Diadegma eucerophaga*, a sex pheromone and *Bacillus thuringiensis* were used as IPM control materials. Egg parasitism ranged from 2.4% immediately after first egg parasites were released to 42% at the end of the season. *Apanteles plutellae* parasitism was higher early in the season but declined thereafter. In contrast, *D. eucerophaga* parasitism which was low soon after planting increased as the season progressed. All three parasites combined with sprays of *B. thuringiensis* controlled diamondback moth. Diamondback moth parasitism declined in neighboring fields as their distance from the IPM field decreased. In the highlands, *D. eucerophaga* has been established for the past 4 years. Stopping the use of chemical insecticides in IPM fields resulted in increase in parasitism, bringing down diamondback moth populations throughout the season. As a result, DBM was not able to inflict any significant damage on the crucifers.

Introduction

Diamondback moth (DBM), *Plutella xylostella* L. (Lepidoptera: Yponomeutidae) is the most destructive insect pest of crucifers throughout the world, adversely affecting the quality and quantity of the produce. In the tropics, where the climate is ideal for the growth of both the plant and the insect, DBM attacks crucifers throughout the year. At present farmers use only chemical insecticides to control this pest. Insecticide use is intensive throughout the tropics, especially in Southeast Asia. The incessant use of chemicals and the fecundity and rapid turnover of DBM generations caused this insect to develop resistance to practically all chemical insecticides presently being used. Since no alternate control measures are available, farmers continue to use increasing dosages of chemicals, often mixtures, and applying them ever more frequently. This has increased the cost of production, environmental pollution, health hazards and has aggravated the resistance problem.

AVRDC aims to develop an integrated pest management program to control this pest with minimum use of chemical insecticides. In this respect AVRDC has imported one larval parasite *Diadegma eucerophaga* Horstmann from Indonesia and an egg parasite *Trichogrammatoidea bactrae* Nagaraja from Thailand to combat DBM in Taiwan and elsewhere. These parasites and *Apanteles plutellae* Kurdjumov, which occurs locally in Taiwan, either individually or in combination, have given satisfactory control of DBM in the laboratory, greenhouse and limited field studies at AVRDC. The usefulness of these parasites in combination with sex pheromone and *Bacillus thuringiensis* was investigated in the farmers' fields in the lowlands and highlands of Taiwan in 1989-90. In addition to the research, the AVRDC IPM project aimed to demonstrate to the farmers that crucifers can be grown successfully without much use of chemical insecticides.

Material and Methods

Lowlands. This experiment was done in farmers' fields in Luchu township (elevation 10 m above sea level) in Kaohsiung county. A 0.2-ha experimental field, planted half to cauliflowers and half to broccoli, was chosen. This field and the surrounding fields in the area were infested with DBM throughout the season. All the farmers tending the fields used chemical insecticides.

The farmer tending the vegetables bought seedlings of local cultivars from a local professional seedling raiser. He was encouraged to use all local cultural practices to grow the crop, but was prohibited from using chemical insecticide without AVRDC's prior permission. The farmer was advised to spray *Bacillus thuringiensis* whenever necessary.

To control DBM the following IPM components were used:

Egg parasite. *T. bactrae* was released once a week for 6 weeks starting within a week after transplanting the crucifers in specially designed release stations distributed throughout the field. The number of egg parasites released were: 19 January, 100,000; 26 January, 142,000; 2 February, 88,000; 9 February, 57,000; 13 February, 53,000; and 22 February, 35,000.

Larval parasites. Two larval parasites, *A. plutellae* and *D. eucerophaga*, were raised in the laboratory on DBM larvae and the parasitized pupae were released in the field. A total of 6,000 cocoons of *A. plutellae* and 18,000 of *D. eucerophaga* were released over the 0.2-ha area.

Sex pheromone. Ten ordinary sticky paper traps baited with 100 μg female sex pheromone were placed randomly in the field and replaced twice during the season. The trapped DBM were replaced with fresh ones twice to sustain continuous trapping of DBM male adults.

Bacillus thuringiensis. A commercial product, SAN415, was purchased locally and applied at the rate of 0.5 kg product/ha, once every week starting within a week after transplanting. Pirimicarb 50 WP was applied once to control aphids.

Highlands. The highland crucifer area was in Nanshan Township in Ilan county in Taiwan's central mountain range (the elevation is between 800 and 1200 m above sea level). Two farmers, one from Nanshan and the other from the neighboring town of Szji, were selected as cooperators. At each location, an area of 0.2 ha planted to common cabbage was used for the IPM experiment. *Diadegma eucerophaga* and *A. plutellae* have been established in this area. All farmers in the two towns planted common cabbage exclusively from late March to early July and common cabbage, Chinese cabbage, radish and spinach between July and October. In both towns no sex pheromones were used, but the release of *A. plutellae* and *D. eucerophaga* was continued. An occasional application of *B. thuringiensis* was recommended. A chemical insecticide, methamidophos, was applied only once to combat an unknown lepidopterous pest.

DBM larval population and parasitism by both larval parasites in the IPM field are summarized in Figure 1. *Apanteles plutellae* parasitism was higher early in the season, but declined soon after. In contrast, *D. eucerophaga* parasitism increased as the season progressed. DBM larval and pupal population which peaked 2 weeks after transplanting declined thereafter and remained low until harvest. This population density did not cause any economic yield loss.

Observations

In Luchu, 50 plants from the whole field were monitored every week. The density of DBM eggs, larvae, and pupae were recorded. Each week, the total number of DBM eggs parasitized by *T. bactrae* was recorded. At Nanshan only two larval parasites were observed once every 2 weeks on the experimental plots as well as in other fields in the vicinity where farmers continued to use chemical insecticides.

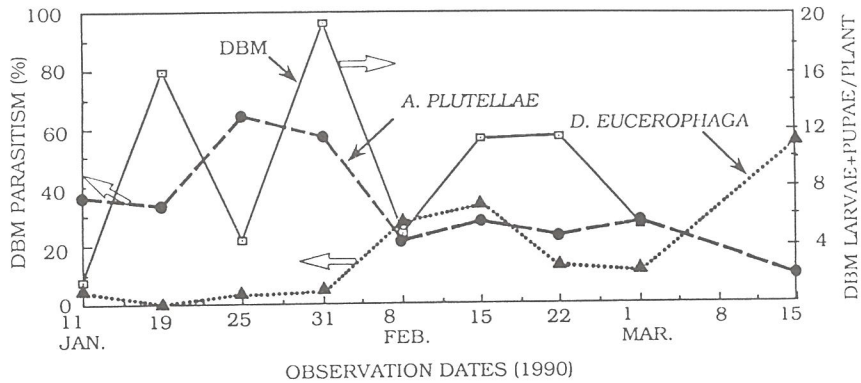

Fig. 1. Population of DBM and two larval parasites in crop season in the lowland.

Demonstration

IPM experiments were given maximum publicity through personal visits to farmers. Public lectures giving the details of IPM procedures were given in Nanshan. A field day for farmers was held before harvest.

Results and Discussion

Lowlands. Table 1 shows the DBM egg density and parasitism of the eggs by *T. bactrae*. Egg density which was fairly high soon after transplanting up to the sixth week declined sharply thereafter possibly due to the reduced DBM population. Population reduction resulted from the combined effect of egg and larval parasitism and larval mortality due to frequent sprays of *B. thuringiensis*. Egg parasitism ranged from 2.4% soon after planting to 42 % 4 weeks after planting.

Table 1. Density of DBM eggs and rate of parasitism by *T. bactrae*.

Date	No. egg parasites released	No. DBM eggs/plant	DBM eggs parasitized (%)
19 January	100,000	24.0	2.4
26 January	142,000	25.8	4.3
2 February	88,000	31.7	26.0
9 February	57,000	25.5	41.8
13 February	53,000	29.8	18.9
22 February	35,000	30.0	28.5
3 March	0	13.3	20.4

Planting date: 5 January 1990. Harvest date: 7 March 1990.

Various mortality factors that affected the DBM population in the IPM field and two neighboring fields were observed and recorded (Fig. 2). Neighbor 1 field was located in the immediate vicinity of the experimental field and neighbor 2 field, 200 m away. Farmers of both fields continuously used chemical insecticides. In the IPM field, all three parasites were active throughout the season whereas in both neighboring fields parasite eggs were absent. *Diadegma eucerophaga* cocoons were observed only twice in neighbor 1 field. In neighbor 2 field, neither parasite eggs nor *D. eucerophaga* was found. *Apanteles plutellae* was present throughout the season in all fields but its rates of parasitism of DBM larvae in the neighboring fields were less than in the IPM field, possibly due to the frequent use of chemical insecticides in both neighboring fields.

Larval mortality not associated with the two larval parasites was considered to be due to natural mortality factors and insecticides. In the IPM field the mortality factor was *B. thuringiensis* and in the neighboring fields it was insecticide. In the IPM field, where *B. thuringiensis* was applied once

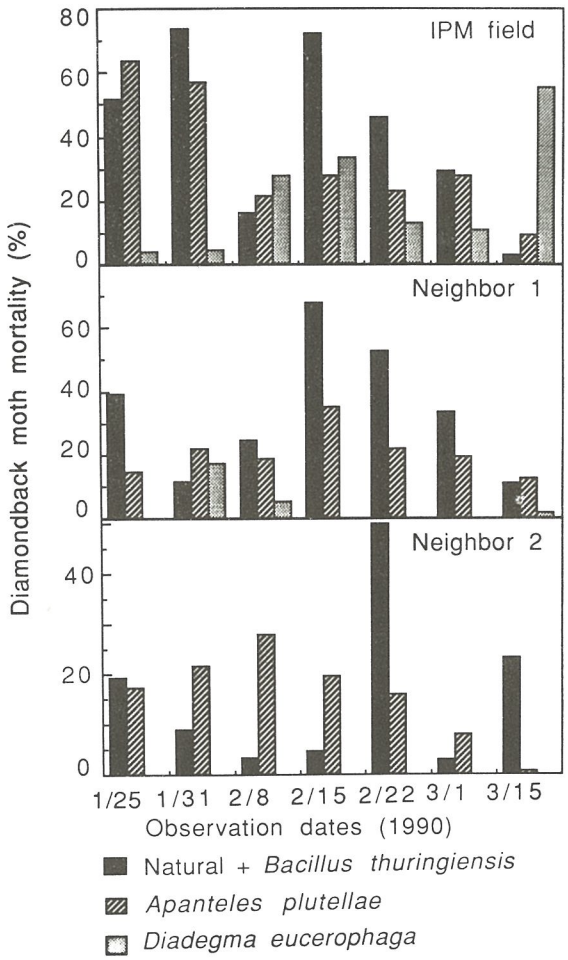

Fig. 2.
Various mortality factors that influenced the mortality of DBM in the IPM and neighboring fields. Neighbor 1: Field in the vicinity of IPM field; Neighbor 2: Field 200 m away from IPM field.

a week, natural mortality was high practically throughout the season, and especially soon after planting when the first instar DBM larval population was particularly high. In the neighboring fields, however, farmers frequently sprayed chemical insecticides, occasionally mixed with *B. thuringiensis* every day or at intervals of 3 or 4 days. The presence of *A. plutellae* in the neighboring fields, despite heavy use of chemical insecticides, indicated the possibility that this parasite also had developed resistance to insecticides.

In most of the larvae which died of natural causes, parasite eggs and larvae or pupae were present, indicating parasitism and not necessarily the effect of natural factors such as diseases. In all but one observation the larval survival fell below 10%. On one occasion when larval survival reached 16%, the absolute number of larvae reached 11/plant. At this stage the plant was mature and larval number was not considered the cause of any significant damage.

A large number of DBM male adults were trapped in the sex pheromone traps. However, it was difficult to judge the impact of this in reducing DBM damage. The traps proved to be reassuring to the farmers though.

In the IPM field the farmer got 10.5 t cauliflower and 7 t broccoli/ha, which, according to the farmer, was normal. However, for the first time the farmer was able to harvest the crop without using toxic chemicals.

Highlands. In the IPM fields farmers did not use any chemical insecticides, except once during the season; in check fields, farmers used a variety of chemicals frequently throughout the season.

During the entire season DBM population was very low. This is believed to be due to the establishment of *D. eucerophaga* in the area. Whether the cold weather at the beginning of the season played any significant role in checking the DBM population needs to be studied further.

Observations on DBM parasitism by the two parasites in two locations are summarized in Table 2. Because of the unusually low DBM larval population, parasitism by both *A. plutellae* and *D. eucerophaga* was very erratic. Damage to cabbage was insignificant. This experiment will continue during the second crucifer season which lasts from July to October when DBM population is usually higher.

Table 2. Parasitism of DBM by *D. eucerophaga* and *A. plutellae* at two locations.

Date	Parasitism (%)							
	Nanshan				Szji			
	Diadegma eucerophaga		*Apanteles plutellae*		*Diadegma eucerophaga*		*Apanteles plutellae*	
	IPM	Check	IPM	Check	IPM	Check	IPM	Check
2 May	–	–	–	–	50	0	0	15
23 May	20	20	0	0	10	0	0	0
13 June	–	–	–	–	19	19	35	29

Planting date: Nanshan, 14 March; Szji, 2 April 1990.

Demonstration

In Luchu, neighboring farmers frequently visited the IPM fields and discussed pest control practices with the IPM farmer. The field day organized for the farmers before the harvest was well attended. Details of the IPM and the results obtained in IPM experiments were explained. Most farmers were willing to try IPM on their own during the coming season as most Luchu farmers are receptive to new ideas.

In Nanshan, although the initial meeting organized before planting was attended by a large number of farmers, two other meetings failed because of low attendance.

Parasitism of Diamondback Moth in Monoculture and Mixed Cropping Crucifer Cultivation

Summary

Parasitism of diamondback moth feeding on cabbage planted in monoculture cabbage plots and in cabbage plots surrounded by noncrucifers was investigated. Crops were sprayed twice a week with broad-spectrum chemical insecticides which are highly toxic to parasites. *Diadegma eucerophaga* or *Apanteles plutellae* was present whether cabbage was planted in monoculture or in mixed cropping. Apparently spraying of neighboring noncrucifers did not affect the parasite population in the crucifer plots. In both monoculture and mixed crop fields, parasitism of *A. plutellae* was high soon after transplanting but declined during the rest of the season. In contrast, *D. eucerophaga* parasitism increased as the season progressed.

Introduction

Diamondback moth(DBM), *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae), is the most destructive insect pest of cruciferous vegetables in Southeast Asia. To develop an economical and safe method for controlling this insect, AVRDC is studying the use of two parasites: *Diadegma eucerophaga* Horstmann, imported from Indonesia, and *Apanteles plutellae* Kurdjumov, collected locally. AVRDC research in the past and verification on farmers' fields show considerable promise

in controlling DBM by these parasites. However, so far, AVRDC research has been confined to crucifers grown in monoculture where use of chemical insecticides was restricted. Under farmers' field conditions, however, crucifers and noncrucifers are grown side by side. For the protection of noncrucifers farmers often resort to using insecticides. In 1988-89 AVRDC investigated the effect of insecticide use on the parasitism of DBM by *D. eucerophaga* and *A. plutellae*. In the 1989-90 crucifer season the experiment on the insecticide application frequency was doubled to once every 3-4 days as against once every week in the 1988-89 experiment. Additional observations on the population dynamics of DBM and the parasites were also recorded.

Materials and Methods

A 1.8-ha experimental area was divided into two equal sections separated by a 1.5-m wide strip of corn, a barrier crop. Each section was divided into 12 plots of 15 m × 19.5 m with a distance of 1.5 m between two adjacent plots (Fig. 3). In one section all plots were planted to cabbage whereas in the other, four randomly selected plots were planted to cabbage. The remaining eight plots were planted to one each of okra (*Abelmoschuf esculentus* Moench), garden pea (*Pisum sativum* L.), tomato (*Lycopersicon esculentum* Mill), soybean (*Glycine max* (L.) Merill), sweet potato (*Ipomoea batatas* Lam.), brinjal (*Solanum melongena* L.), sweet pepper (*Capsicum annuum* L.), and garlic (*Allium sativum* L.). These crops were sprayed twice a week with mevinphos, methamidophos or permethrin from planting to harvest. None of the cabbage plots in either section were sprayed with any insecticide. The cabbage plants and the other vegetable crops were raised according to standard cultural practices.

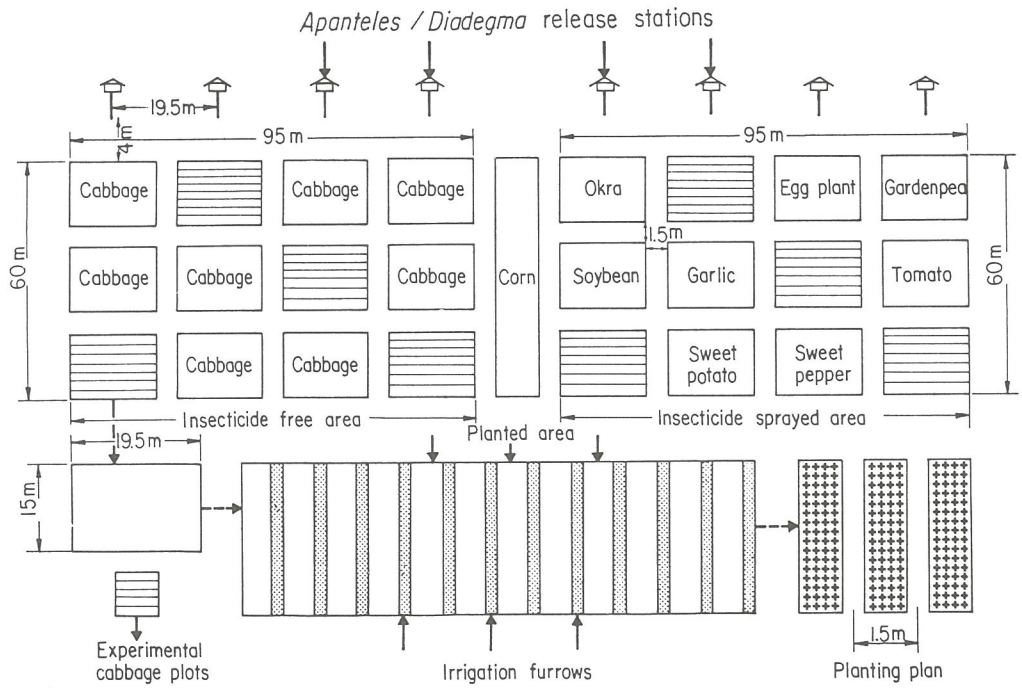

Fig. 3. Schematic diagram of experimental field design.

Eight parasite release stations were set up along the length of the experimental area. Stations were placed 4 m away from the experimental plot and 19.5 m from the adjacent stations.

DBM infestation on cabbage plants in experimental plots was assessed 1 week after transplanting. DBM infestation was found very low, so, laboratory-reared DBM adults were released simultaneously in equal numbers and at intervals in experimental cabbage plots on both sides. Equal numbers of pupae of *A. plutellae* or *D. eucerophaga* were placed simultaneously in each release station

approximately once a week or 10 days. Some 24,700 *D. eucerophaga* and 10,600 *A. plutellae* pupae were released in the parasite release stations.

Parasitism of DBM by *A. plutellae* and *D. eucerophaga* was determined by collecting third-fourth instar DBM larvae and then rearing them to pupal stage to determine the percentage of parasitism and to monitor DBM population by recording the number of larvae and pupae per 30 cabbage plant sample from each test plot from either side.

Results and Discussion

DBM population on cabbage planted in monoculture and mixed cropping remained fairly low; in most cases, below the damage threshold, throughout the season, until 2 weeks before the harvest. The reason for an abrupt increase in DBM population at this time, despite fairly high *D. eucerophaga* parasitism, was not clear. There was no significant difference in DBM population between cabbage planted in monoculture and cabbage in mixed cropping among noncrucifers treated with broad spectrum chemical insecticides twice a week.

Similarly, no significant difference in parasitism of DBM by either parasite was found between cabbage grown in monoculture and in mixed cropping with noncrucifers.

Data for both monoculture and mixed cropping were combined to study the nature of parasitism. There were distinct differences in the parasitism by two larval parasites. Parasitism by *A. plutellae* was high soon after cabbage transplanting but it decreased as the season progressed. There was significant positive correlation between plant age and DBM population. A similar positive correlation was found between plant age and DBM parasitism by *D. eucerophaga*; it was the opposite in *A. plutellae*. Although there was a tendency towards higher parasitism by *D. eucerophaga* and lower parasitism by *A. plutellae* with higher populations of DBM, these trends were not statistically significant. The role of age of cabbage plants in the parasitism of DBM by these two parasites remains to be investigated further.

Parasitism rates by both parasites at harvest in 1988 and 1989 seasons showed no significant difference. The results of the 1989 test confirmed the 1988 results. AVRDC plans to investigate effects of various insecticides, including broad-spectrum, selective IGRs and *B. thuringiensis* on the parasitism of DBM by both larval parasites (under cabbage monoculture only).

Chinese Cabbage Pathology

Evaluation of Soft Rot on Chinese Cabbage in the Field and Studies on Isolation and Quantification of *Erwinia carotovora* pv. *carotovora*

Summary

The most important disease of Chinese cabbage in the tropics and subtropics is bacterial soft rot. Control of soft rot is extremely difficult because the pathogen is soilborne, and there are no commercially available varieties with resistance. The most appropriate and practical control for growers is through crop management. In this study, soft rot was assessed in three field trials to determine its spatial and temporal distribution. Soft rot was found to occur in clusters and was not randomly distributed. In three field trials, the average incidence of soft rot was 12%. Infection of cabbage heads by soft rot caused more the unmarketability of cabbage than by the infection of the petioles in outer wrapper leaves. Soft rot bacteria were detected on potato slices from soil collected from fields grown to Chinese cabbage which were not infected with soft rot. More bacteria were isolated from the soil using potato slices which increased the number of bacterial cells and allowed for detection of the disease at slight infestation. An increase of soft rot induced on potato slices from infected soil corresponded to an increase in soft rot on Chinese cabbage in specific field plots. Bacterial movement by either capillary action or by free swimming was determined by the occurrence of soft rot on sections of carrot taproots that had been inserted into the sides of pots away from the inoculum source.

Introduction

Bacterial soft rot of Chinese cabbage, caused primarily by *Erwinia carotovora* pv. *carotovora* (Ecc), is one of the most important diseases in the tropics. Initial infection often occurs when outer petioles get into contact with infected soil. When the plant matures to form a head, the cells of the bacterium move causing infection of the head. Further decay of the host advances rapidly after initial infection of the head. Infection also occurs when free water is present. Natural openings in the plant such as hydathodes, lenticels and abscission scars are points of entry for the motile cells of the bacterium. Wounds or conditions associated with harvesting and handling heads also produce points of entry.

Environmental conditions that are conducive to soft rot development include high humidity, abundant rainfall or high soil moisture, poor drying conditions and temperatures above 22°C. The incidence of soft rot in the field was reported not to be directly related to the pathogen population in soil. Other factors that also influence the host-pathogen relationship and the distribution and movement of the bacterium include horizontal and vertical water movement in the soil, vectors like *Diptera* spp. which are known to distribute the inoculum, and activities by humans.

Selective or enrichment media, detection by phages and direct counting by fluorescent staining are all techniques that have been used to detect and isolate Ecc in soil and plant tissue. A study that differentiated *Erwinia* spp. in Taiwan showed that 100% of the strains isolated from Chinese cabbage were Ecc (Hsu and Tzeng 1981[1]).

[1]Hsu S.T. and K.C. Tzeng. 1981. Identification and Characterization of Soft-Rotting *Erwinia* in Taiwan. Plant Protection Bulletin. (Taiwan) 23:77-85.

This study monitored the incidence of soft rot in the field over time and developed laboratory assays to isolate and quantify the bacterium from the soil.

Materials and Methods

Incidence of soft rot in field plots. In the first trial, 28 open-pollinated varieties (OP) of Chinese cabbage of uniform maturity were evaluated for soft rot. Seeds were sown in August 1989. Seedlings were transplanted to the field in a randomized complete block design with three replications. Individual plots consisted of four rows, two rows per 8 m long raised bed. Spacing between rows within a bed was 50 cm with 1.5 m between beds. Interplant spacing within a row was 40 cm.

Starting at 27 days after transplanting, soft rot infection was assessed on an individual plant basis at 3-4 day intervals. The first five assessments recorded soft rot on plants before the harvest. The later assessments (6-10) were done after the harvest date of 25 October. Bamboo sticks painted with different colors were used to keep track of assessment time when infection occurred.

In the second trial, selections of open-pollinated varieties were sown in August 1989 and transplanted to the field 4 weeks later. The experimental design was a randomized complete block with two replications. Individual plots consisted of two row plots, 4 m long with 1.5 m between beds, 50 cm between rows within a bed, and 40 cm between plants within rows. Two assessments for soft rot were recorded just prior to the harvest date of 4 November.

In the third trial, the planting date and the experimental design were the same as described for the experiment on the evaluation of 29 OP lines. Two assessments were made on 2 and 5 November.

Isolation and pathogenicity of strains. Soft rot-infested tissues of Chinese cabbage were collected from the experimental field plots. The diseased tissue was washed in tap water. The outermost margin of the infected tissues was cut into small pieces (1-2 cm), dipped in 70% alcohol, washed twice in sterile distilled water, and crushed inside a sterile petri dish with a sterile glass rod. A loopful of sap was spread over the surface of 523 agar medium and incubated for 24 hours at 32°C. A single colony from each tissue sampled was transferred to 523 medium in a slant test tube.

Chinese cabbage petioles, potato tubers and carrot taproots were washed before cutting into 1-2 cm pieces with a sterile knife. Three milliliters of sterile distilled water were added to two layers of filter paper inside petri dishes. Before sterilizing, glass rods were placed on top of the filter paper. After sterilization, the cut tissues were placed on top of the glass rods. Strains were diluted with sterile distilled water, and a loopful of bacteria was spread over the surface of the potato and carrot slices. For Chinese cabbage, the petioles were cut with a sterile scalpel, then inoculated with 0.1 ml of bacterial suspension. Samples were incubated for 24 hours at 32°C and assessed for the occurrence (+) or nonoccurrence (−) of soft rot.

Sensitivity. Chinese cabbage petioles, carrot taproots and potato slices were washed with running tap water and rinsed with 70% alcohol. Sections of carrot and potato were cut into 1.9 cm diameter pieces (0.35 cm thick). Chinese cabbage petioles were cut into 1.5 × 1.5 × 0.7 cm sections. Tissues were placed on sterile watch glasses inside sterile petri dishes that had two layers of moist filter paper below.

A 0.1 ml suspension of Ecc-13, diluted to 10^1, 10^3, 10^5, 10^7 cfu/ml, and a check (SDW) were placed on the tissue. There were three petri dishes for each bacterial concentration. The experiment was repeated using 2×10^1, 2×10^3, 2×10^5, and 2×10^7 cfu/ml. Data were recorded 24-48 hours after incubation.

Baiting ratio. Soil samples were collected from field plots where either high or low incidence of soft rot had been recorded on Chinese cabbage. Three soil probes of 5-10 cm depth were sampled per area. Soil samples were sieved separately through 850 mm mesh-screen, mixed, and 20 g of each were put into petri dishes. SDW was added until the soil was saturated. Ten potato slices were placed on the soil and incubated at 32°C for 24-48 hours. Potato slices were removed from the top of the soil to plates containing 2% water agar. After incubating 24-48 hours at 32°C, soft rot on potato slices and growth of Ecc on the agar plates was recorded.

Isolation by baiting. Soil samples from a Chinese cabbage field were pooled, sieved through an 850 mm mesh-screen and split into two equal parts. One part was sterilized while the other was not. Twenty grams of soil were added to 9 ml of one of the following bacterial concentrations: 2.2×10^1, 2.2×10^3, 2.2×10^5, 2.2×10^7 cfu/ml in 125 ml flasks. Twenty-one milliliters of sterile distilled water was added, so that each suspension contained 6.6, 6.6×10^2, 6.6×10^4, 6.6×10^6 cfu/ml of the bacterium. Twenty grams of sterilized soil (check) and field-infected soil were also added to 30 ml sterile distilled water. The flasks were shaken for 30 min, allowed to settle for 5 min, and then 1 ml of the suspension was transferred to watch glasses. Two layers of potato slices were put into each watch glass. All petri dishes were incubated for 24 hours at 32°C. Data on incidence of soft rot on slices were recorded.

Movement of bacteria in soil. Chinese cabbage seedlings were transplanted into sterile soil in 19-cm diameter clay pots. Each pot had one plant of either B 141 or B 111. Within each line, there were three transplanting dates (27 September 1989 and 11 and 24 October 1989).

Holes were drilled into the sides of the clay pots 5, 8 and 11 cm from the bottom. A carrot slice (5-10 cm long) was inserted in each hole in the pots where the Chinese cabbage had been transplanted 16, 29 and 45 days earlier. The pots were placed on a plastic sheet that was formed into a trough about 5 cm below the ground. Water and a 100-ml suspension of bacterial cells (approximately 1×10^8 cfu/ml) were added to a depth of about 2 cm. Pots on another plastic sheet served as a control with water but no bacteria added to the sheet.

Results and Discussion

Incidence of soft rot in field plots. In the first field experiment, soft rot was observed on outer petioles that were in contact with the soil 27 days after transplanting. There was no significant difference in petiole infection on any of the 28 lines up to 52 days after transplanting. However, there was a significant block effect -the occurrence of soft rot was higher in block three. In most cases petiole infection did not cause head rot. The average number of petioles infected by the last assessment averaged 18%, but only an average of 5% of these plants had head rot. Most of the head rot occurred through infection developed on the top of the head. Presumably, the inoculum was carried there by insects. There was a significant difference among the lines in the incidence of soft rot caused by petiole and head infection, and in the total amount of soft rot recorded. Lines ML 3-4-8-2 (7.5%), ML 27-3-4-9-5 (8.0%), and ML 27-3-4-3-6 (9.6%) had the lowest total amounts of soft rot.

In the second field experiment, soft rot infection totalled 11%. Mortality due to petiole and head infection was 4 and 6%, respectively. ML 35-2-1-1-7 (2.5%) had the lowest incidence of soft rot.

In the third field experiment, 12% of plants had soft rot. The lines differed significantly in the number of soft rot-infected plants. ML 27-3-4-3-25 had no dead plants. There was no significant difference among lines in soft rot incidence caused by either petiole or head infection.

From the field observations, the following three types of infection were observed to occur: 1) initial infection primarily occurred on outer petioles touching the soil, 2) in a few cases internal rot was observed, and 3) infection on the top of the head. The last type was observed only close to harvest, and was almost always associated with insect feeding. Although internal rot was seen least, it did occur early and the quantity of bacterial cells produced per head seemed very high. It is likely that this early infection may be the source of secondary spread of bacterial cells by water and insects. In all cases maggots were observed on these infected heads.

Pathogenicity of strains. None of the tissues rotted when only SDW was applied. Soft rot was distinct on carrot and potato, but petioles of Chinese cabbage turned only brown and did not rot. Petioles of Chinese cabbage are normally used for assaying soft rot. However, in these experiments they were not wounded at the point of inoculation which may be the reason why typical soft rot did not occur.

Sensitivity. Soft rot did not occur on tissues that were not inoculated. Carrot slices were the most sensitive as they rotted even at lower bacterial concentrations (Table 1). Chinese cabbage and potato were not as sensitive; bacterial concentrations of 10^5 cfu/ml or greater were needed to cause 100% rot.

In these tests, carrots were more sensitive to soft rot and therefore may be a better indicator for detecting the occurrence of the bacterium in the soil.

Table 1. Percent incidence of soft rot on petioles of Chinese cabbage, and on slices of carrot and potato, inoculated or not with four concentrations of *Erwinia carotovora* pv. *carotovora*.

Concentration (cfu/ml)	Experiment 1		
	C. cabbage	Carrot	Potato
Check	0	0	0
10^1	0	0	0
10^3	0	100	20
10^5	20	100	100
10^7	100	100	100
Concentration (cfu/ml)	Experiment 2		
	C. cabbage	Carrot	Potato
Check	0	0	0
2×10^1	0	80	0
2×10^3	0	80	0
2×10^5	10	80	0
2×10^7	100	100	100

Baiting ratio. There was an increase in soft rot incidence on potato slices corresponding to an increase in soft rot on Chinese cabbage in the experimental field plots. Seven percent of the potato slices rotted in soil sampled from plots where no soft rot was recorded on Chinese cabbage. The soft rot on potato slices increased up to 43% in soil sampled from plots where 18% of the Chinese cabbage plants had soft rot (Table 2).

Table 2. Percent incidence of soft rot on Chinese cabbage plants in the field and the occurrence of soft rot on potato pieces inoculated with a soil suspension from field-sampled soil.

Field[a] (%)	Percentage of soft rot Potato slices
0	7
3	27
13	43
18	43

[a]Soil samples were removed from plots of Chinese cabbage with a known number of plants with soft rot.

Isolation by baiting. Infested field soil that was not sterilized caused 50% soft rot on potato slices (Table 3). In sterilized soil, rotting was observed in all the slices except at the lowest concentration of 6.6 cfu/ml when 83% of the slices rotted.

Baiting with potato slices caused an increase in bacterial populations, which made it easier to detect lower populations. In theory, this could be used in farmers' fields to predict whether the bacterium occurs or not. In these experiments, bacteria were detected by baiting before soft rot of Chinese cabbage was detected in the field.

Table 3. Detection of soft rot bacteria in soil infested with various bacterial concentrations using potato tissue as an enrichment medium.

Treatment	Rotted slices (%)
Check	0
Infested soil	50
6.6 cfu/ml	83
6.6×10^2 cfu/ml	100
6.6×10^4 cfu/ml	100
6.6×10^6 cfu/ml	100

Movement of bacteria in soil. After 24 hours, soft rot was detected on carrot sticks inserted in pots at the lowest point. After 42 hours, all carrot sticks had soft rot except where the sticks were inserted at the upper level in pots of 16-day-old plants.

Ecc is known to move in the soil either passively by water movement or actively by swimming freely. Carrot sticks (inserted at various heights away from the inoculum source) rotted, indicating Ecc movement but not the type of movement that occurred. This movement may also be important in the field, since bacterial cells move horizontally through moving water in ditch irrigation and vertically by capillary action caused by wetting and drying of the soil. Just after irrigation when the soil is saturated, the bacterial cells in the soil probably move and concentrate at the surface of the soil where they may come in contact with leaf petioles touching the soil.

Production and Characterization of Monoclonal Antibodies Against Strains of TuMV

Summary

Five strains of TuMV have been isolated previously from cruciferous crops in Taiwan. They were straintyped using a set of four differential *Brassica campestris* subsp. *pekinensis* cultivars. An attempt was made to further characterize these five strains to distinguish them by more rapid and reliable means. They could not be differentiated by SDS PAGE of coat proteins and by agar gel double diffusion and ELISA tests using polyclonal antisera against the five individual strains. However, when using cross-absorbed polyclonal antisera, it was possible to distinguish strain 1 from the other four strains by agar gel double diffusion and by immuno-electron microscopical decoration tests. Monoclonal antibodies (MCAs) were produced after immunizing Balb/c mice with highly purified preparations of the five strains. Eighteen TuMV-positive hybridoma lines were selected, cloned and further characterized. Eleven of these were nonspecific and reacted with all five TuMV strains in indirect ELISA. Seven were specific to strains C_2 to C_5. Three MCAs which reacted specifically with C_1 were found, but it was not possible to clone these. None of the 18 TuMV-specific MCAs reacted with 14 other potyviruses tested.

Introduction

From various *Brassica* crops in Taiwan, five strains of TuMV have been isolated (Green and Deng 1985)[2] which could be distinguished on a set of four differential *Brassica campestris* subsp. *pekinensis* cultivars. However, this method involves too much time and greenhouse space and the continuous supply of "pure" differential hosts. Monoclonal antibodies (MCAs) could provide a more reliable means of differentiating these strains. They have been shown to be a useful tool in investigating the relationship between viruses, virus strains and isolates (Sander and Dietzgen 1984)[3]. They have been used successfully to distinguish strains of BCMV (Wong 1985)[4]. Furthermore, such strain-specific MCAs should be useful in virus surveys to determine which strains are present and prevalent and to monitor the appearance of new strains. For the screening of large populations of *Brassica* spp. for multi-strain resistance, strain-specific MCAs would also be useful.

Materials and Methods

Purification of virus

The five TuMV strains were propagated in *Brassica juncea* (AVRDC Acc. B 96). Two to four weeks after inoculation the young leaves were harvested. The virus strains were purified separately

[2]Green S.K. and T.C. Deng. 1985. Turnip mosaic virus in cruciferous hosts in Taiwan. Plant Disease 69:28-31.
[3]Sander, E. and R.G. Dietzgen 1984. Monoclonal antibodies against plant viruses. Adv. Virus Res. 29:131-169.
[4]Wong, W.Y. 1985. Production and characterization of hybridoma cell lines and a broad spectrum monoclonal antibody against bean common mosaic virus. PhD thesis, Washington State University. 159 p.

or as a mixture of strains, using two methods of purification. In a modified Lisa method (Lisa et al. 1981)[5], virus-infected leaves were homogenized in 0.5 M K_2HPO_4 buffer, pH 8.5 containing 0.02 M Na_2SO_3, 0.005 M Na-EDTA and 0.01 M DIECA. Freon was used as the organic solvent. The viruses were concentrated by two cycles of low (4,000 × g) and high speed (73,000 × g) centrifugation. This was followed by one or several CsCl-density gradient centrifugations to separate the virus from the remaining plant components. The second method used was that of Koenig et al. (1973)[6]. Leaves were extracted 1:1 (W/V) in 0.5 M boric acid buffer, pH 7.8 containing 0.4% ascorbic acid (W/V) and 0.4% Na_2SO_3 (W/V). The filtered sap was treated with 0.3% $AgNO_3$, chloroform and PEG 6,000, and subjected to one cycle of low (4,000 × g) and high speed (73,000 × g) centrifugation. This was followed by one or two CsCl-density gradients.

Virus yield was calculated, using an extinction coefficient of $E_{0.1\%\ (1\ cm,\ 260\ nm)} = 2.4$, uncorrected for light scattering (Purcifull 1966)[7].

Antibody preparation

Polyclonal. New Zealand rabbits were immunized four times at weekly intervals with purified TuMV strains (one rabbit per strain) homogenized in Freunds incomplete adjuvant. Starting 14 days after the last injection, blood was collected from the rabbits' lateral ear vein. Antiserum against each individual strain and against a mixture of all five strains was produced.

Monoclonal. Balb/c mice were immunized with separate individual purified TuMV strains or with different strain combinations. Three intraperitoneal injections were administered at three weekly intervals, using Freunds complete and incomplete adjuvants for the first and second injection, respectively. For the third injection no adjuvant was used.

Three days after the last injection, the isolated spleen cells were fused with myeloma line NS-1 using 45% PEG 4,000, 50% RPMI medium and 5% DMSO as the fusion medium. Selection of positive hybridoma cells was accomplished in HAT medium. TuMV-positive cells were cloned by the limiting dilution method. Cells were distributed at a concentration of one to two per well and distributed on a sterile 96-well culture plate. Feeder cells (mouse thymocytes) were added to support cell growth. At 10-15 days after cloning, cultures which had started from a single cell colony were tested by indirect ELISA for TuMV-specific antibodies. Positive clones were frozen in liquid nitrogen.

Screening of hybridoma cells for antibody-producing cell lines

An indirect ELISA was developed, in which microtiter plates were coated with 100μl/well rabbit polyclonal antiserum specific to the five TuMV strains. The immunoglobulins were diluted 1:3,000 in coating buffer. After blocking for 1 hour with 2% skimmed milk powder in washing buffer (115 μl/well) and a washing step, 100 μl plant sap diluted 1:50 in extraction buffer was added to the wells and incubated at 37°C for 1 hour. After removal of excess antigen by washing, undiluted hybridoma cell culture supernatants (100 μl/well) were added and incubated at 37°C for 1 hour. Goat anti mouse-horse radish peroxidase (GAM-HRP) in combination with the substrate 0-phenylenediamine (OPD) was used to detect ''positive hybridomas'' (i.e., those having TuMV-specific antibodies). This test was usually performed on profusely growing hybridoma cells at 10-14 days after fusion, and on cloned positive clones at 10-15 days after cloning.

Propagation of MCAs

TuMV-specific MCAs were propagated as ascitic tumors. One week after priming of Balb/c mice with Pristane (2, 6, 10, 14 tetramethylpentadecane) about 107 hybridoma cells per mouse were injected

[5]Lisa, V., G. Boccardo, G. d'Agostino, G. Delavalle and M. D'Aquilo. 1981. Characterization of poty virus that causes zucchini yellow mosaic virus. Phytopathology 71:667-672.

[6]Koenig, R., D. E. Lesemann, A. A. Brunt, and H. Kuehne. 1973. Narcissus mosaic virus found in NErine bowendii. Identification aided by anomalies in SDS PAGE. Intervirology 1:348-353.

[7]Purcifull, D.E. 1966. Some properties of tobacco etch virus and its alkaline degradation products. Virology 29: 8-14.

intraperitoneally. Ascites were collected 7-14 days after injection of hybridoma cells by puncturing the swollen peritoneal wall of the mouse. For the purification of immunoglobulins from ascites fluid, a combination of ammonium sulfate precipitation and ion exchange chromatography was used. The OD was adjusted to 1.4 which corresponds to 1 mg Ig/ml.

Charaterization of MCAs

To test which subclass of immunoglobulins are produced by the TuMV-specific MCAs, the Hyclone Ig subclass test was used. To test TuMV specificity, the TuMV-specific hybridoma lines were tested by indirect ELISA against the five TuMV strains maintained at AVRDC, the four imported unspecified isolates of TuMV from India (Ahlawat), Germany (H.J. Vetten) and Japan (Tochihara, Nobumichi) and against 13 other potyviruses: BYMV, BCMV, SMV, FMV, SPYDV, SPLV, SPVII, SPMMV, CVMV, PVMV, PeMV, PVY and TEV.

Serological tests

Cross adsorption. Polyclonal antisera were cross-adsorbed with the heterologous TuMV strains according to the procedure described by van Regenmortel and Wechmar (1970)[8].

Agar gel double diffusion test. Gels consisted of 0.8% Noble agar, 0.5% SDS and 1% Na-azide. Leaf samples of 1 g were extracted in 1 ml distilled water and mixed with 1 ml SDS (3%) to get a final SDS concentration of 1.5%.

Decoration test. Pioloform carbon-coated nickel grids were floated on 1 drop of virus infected plant extract. After rinsing with phosphate buffer, the grids were incubated for 15 min on drops of antisera (diluted 1:50), stained with uranylacetate (2 %) and observed in the electron microscope.

Coat protein molecular weights

The molecular weights of the coat proteins of the five strains were compared by SDS polyacrylamide electrophoresis (SDS PAGE). Running buffers and gels (5 % stacking gel, 12 % separating gel) were prepared as described by Laemmli and Favre (1973)[9]. Purified antigen preparations were used at 200 μg/ml and mixed at a ratio of 1:1 in degrading buffer (0.1 M Tris-HCl, pH 7.2, 2 % SDS, 2 % 2-mercaptoethanol 10 % sucrose, 0.01 MEDTA and 0.005% bromophenolblue). After heating at 100°C for 3 min in boiling water, the coat protein preparations were electrophoresed at 25°C in a vertical slab gel apparatus. The SIGMA low molecular weight calibration kit (14,300 -66,000) was used for the protein standards. A constant voltage of 65 volt/cm for 2.5 hours was used for electrophoresis. Protein bands were visualized by staining with Coomassie Blue R-250 for 1 hour, followed by destaining in several changes of methanol: acetic acid (3:1).

Results and Discussion

Virus purification

The Lisa method yielded 24 mg virus/100 g leaves, whereas the Koenig method resulted in only 2.4 mg virus/100 g leaves. The Lisa method was consequently used for most tests, since it resulted in high particle concentrations with little aggregation of virus particles and with only minor host impurities. The adsorption spectra of the five strains between 220 and 300 nm were identical. The values for max/min and 260/280 nm ratios were also identical.

It was usually possible to distinguish strains C_4 and C_5 from strains C_1, C_2 and C_3 by their more severe symptoms and the early yellowing of the former two on inoculated *B. juncea*.

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[8] Regenmortel, van, M. H. V. and M. B. Wechmar, van, 1970. A reexamination of serological relationship between tobacco mosaic virus and cucumber virus 4. Virology 41:330-338.

[9] Laemmli, U. K. and M. Favre 1973. Maturation of the head of bacteriophage T4. I. DNA packaging events. J. Mol. Biol. 80:575-599.

Molecular weight of the coat proteins

The five strains could not be distinguished by the molecular weights of their coat proteins. The purified coat protein of all five strains migrated as a single band of an apparent molecular weight (AMW) of 33 KD.

Serology

Polyclonal antibodies. It was not possible to distinguish the five virus strains using unabsorbed polyclonal antisera produced in rabbits against individual TuMV strains. Each strain-specific antiserum reacted with all five strains in ELISA, agar gel double diffusion and immunoelectron microscopic decoration tests. However, after cross absorption with the heterologous virus strains, the antiserum produced against TuMV C_1 reacted only with C_1. On the other hand, cross-absorbed antisera produced against the strains C_2, C_3, C_4 and C_5 lost their activity during the cross-absorption process. In decoration tests, the antiserum made against TuMV C_1 which was cross-absorbed with the virus strains C_2, C_3, C_4 and C_5 decorated only particles of TuMV C_1, but not those of C_2, C_3, C_4 and C_5. In a mixture of strains 1 and 2, only particles of strain 1 were seen decorated in the electron microscope.

Monoclonal antibody production. Six fusions were made, four of which were with a mixture of five strains, one with strains C_4 and C_5 and one fusion with C_5 only. The antiserum titer of immunized Balb/c mice measured by microprecipitin drop test was usually about 1:250,000 and sometimes even higher than 1:1 million. With such high titer, a large number of antibody-producing B-lymphocytes could be expected in the spleen. The PEG fusion was usually free of contamination. The percentage of TuMV-positive clones obtained from these fusions ranged from 27 to 68 % (Table 4). Almost all of the clones obtained reacted with all five strains, irrespective of the strain or strain combinations used for the immunization of the Balb/c mice. Seven clones were selected which were able to distinguish strain 1 from the other four strains, i.e. they gave a positive ELISA reaction only with strains C_2, C_3, C_4 and C_5, but not with C_1.

Table 4. Production of TuMV-specific hybridoma lines in six fusions.

Fusion no.	Immunizing virus strain (s)	Positive (%)	
		TuMV-specific	Healthy
I	C_1-C_5	27	73
II	C_1-C_5	68	32
III	C_1-C_5	45	55
IV	C_5	62	38
V	C_1-C_5	58	42
VI	C_4-C_5	54	46

Eleven clones which reacted with all five TuMV strains were also selected. The IgG subclass which was determined for 11 hybridoma lines is shown in Table 5. The hybridoma lines produced MCAs of the IgM and IgG type. IgA types were not present.

The TuMV C_1-C_5 specific hybridoma lines reacted with all four foreign TuMV isolates tested. Of the TuMV C_2-C_5 specific hybridoma lines, three lines (II1A1, I2CI and I4F1) also reacted with all four foreign TuMV isolates. However, one hybridoma line, I7E6 only reacted with T_1 and T_5, suggesting that these two isolates are serologically different from the other three isolates and the five Taiwan strains of TuMV.

None of the TuMV antibody-producing hybridoma lines reacted by indirect ELISA with any of the 14 other potyviruses tested.

The results so far obtained from AVRDC's work with monoclonal antibodies are consistent with the findings on polyclonal antibodies. Of the five strains of TuMV, only strain C_1 seemed to be sufficiently different in that it can be distinguished by MCAs after their cross-absorption with the heterologous viruses. The reasons why the other four strains of TuMV were more difficult to distinguish and why MCAs specific to these strains have not yet been found, are not understood. It is possible that strains 2, 3, 4, 5 share the same surface epitopes. Another explanation could be that these four

strains may have lost the ends of their protein coats during the purification process and thus have lost their antigenic specificity. In previous studies, TuMV 1 was shown to be the most stable of the five strains, keeping its infectivity (both in the frozen state and dried over $CaCl_2$) much longer than the other four strains.

Previously, strain C_1 was also shown to differ from the other four strains, in that it is more infectious than these. Although symptoms induced by strain C_1 were not as pronounced as those of the other strains, particularly those of C_4 and C_5, the titer of strain C_1 in *B. juncea* was usually significantly higher as measured by local lesions on *C. amaranticolor*.

Table 2. Characteristics of selected TuMV-specific hybridoma lines.

	Strain used for immunization	Specificity	IgG Subclass	Reaction with				
				7 different potyviruses	T1b	T3	T5	T10
I 7G4	all	C_1-C_5	IgG	–	+	+	+	+
I 3H4	all	C_1-C_5	Ig2a	–	+	+	+	+
I 2C2	all	C_1-C_5	Ig2b	–	+	+	+	+
I 8B3	all	C_1-C_5	IgM	–	+	+	+	+
I 2H12	all	C_1-C_5	IgG3	–	+	+	+	+
I 4E7	all	C_1-C_5	NT[c]	–	NT	NT	NT	NT
I 4D5	all	C_1-C_5	NT	–	NT	NT	NT	NT
I 3C10	all	C_1-C_5	NT	–	NT	NT	NT	NT
I 10F2	all	C_1-C_5	NT	–	NT	NT	NT	NT
V 5B1	all	C_2-C_5	NT	–	NT	NT	NT	NT
II 1A1	all	C_2-C_5	IgM	–	+	+	+	+
I 5H3	all	C_2-C_5	NT	–	NT	NT	NT	NT
I 2C1	all	C_2-C_5	IgG1	–	+	+	+	+
I 7E6	all	C_2-C_5	IgG2b	–	+	–	+	–
I 4F1	all	C_2-C_5	IgM	–	+	+	+	+
I 5B1	all	C_2-C_5	NT	–	NT	NT	NT	NT
V 5H3	all	C_2-C_5	IgG2a	–	NT	NT	NT	NT

[a]BYMV, BCMV, SMV, SPFMV, SPYDV, SPLV, SPV II, SPMMV, CVMV, PVMV, PeMV, PVY, TEV. [b]T_1 = TuMV isolate obtained from Dr. Ahlawat, India. T_3 = TuMV isolate from Dr. H. J. Vetten, BBA, Germany. T_5 = TuMV isolate obtained from Dr. Tochihara, Fukumoto, Japan. T_{10} = TuMV isolate from Dr. Nobumichi, Sako, Japan. [c]NT = not tested.

Mungbean Breeding

Evaluation of New Germplasm for Powdery Mildew Resistance

Summary

Eight mungbean mutants from India were evaluated in the field and the greenhouse results from the previous season were confirmed. All of them were highly resistant to powdery mildew and can be used as new sources of resistance. However, they have several undesirable characteristics, such as low yield, photoperiod sensitivity, black seed coat color, small seed size, and susceptibility to Cercospora leaf spot.

Introduction

Resistance to powdery mildew in mungbean at present is only moderate and seems to be controlled by more than a single gene. Since the resistance varies with season, more durable resistance should be developed. The development of durable resistant lines requires the availability of genetically diverse sources of resistance. Therefore, the purpose of this evaluative study was to identify new resistant sources and utilize them in the breeding program.

Materials and Methods

Eight powdery mildew resistant mutants, namely RUM-1, 5, 7, 11, 20, 21, 22 and 33, were received from Dr. S.E. Pawar, the Bhabha Atomic Research Center in Bombay, India. They were planted in the field on 15 August 1989 and 14 March 1990. However, the 1990 spring data could not be collected because most of the plants died during the seed maturing stage. There were two replications in spring 1989 with 3 m $\times$ 1 m plots arranged in a randomized complete block design.

Observations were made on total yield, days from sowing to 50% flowering and maturity and 1000-seed weight. They were also scored for Cercospora leaf spot and powdery mildew resistance. Moisture content of the seed was determined and the yield was expressed on a 12% moisture basis.

Results and Discussion

All the RUM entries were highly resistant to powdery mildew (Table 1). However, these entries had several undesirable features like photoperiod sensitivity, low yield, black seed coat color, small seed size and susceptibility to Cercospora leaf spot.

These results confirm those obtained from the greenhouse in spring 1989. So far, only a moderate level of resistance to powdery mildew has been incorporated into advanced lines; a higher level of resistance is required. These mutants can therefore provide a higher level and genetically diverse sources of resistance. These entries will also be included in the genetic studies to determine the inheritance and number of genes governing resistance.

Hybridization Program

To create genetic variability and select genotypes with high yield, uniform maturity and disease resistance, the 39th crossing block with 20 parents were planted in summer 1990. The objective was

Table 1. Evaluation of eight powdery mildew resistant mutants in the field.

Entry	Yield (kg/ha)	Days to (50%) flowering	Days to (50%) maturity	1000-seed wt. (g)	Cercospora[a] leaf spot	Powdery[a] mildew
RUM-1	433.3	79	95	17.5	4.5	1.0
RUM-5	375.0	73	95	18.0	4.5	1.0
RUM-7	398.3	75	96	18.5	4.0	1.0
RUM-11	243.3	74	96	18.5	3.5	1.0
RUM-20	170.0	78	100	18.5	3.5	1.0
RUM-21	365.0	75	96	18.0	4.0	1.0
RUM-22	205.0	79	99	19.5	4.0	1.0
RUM-33	246.7	76	97	19.5	4.0	1.0
CV (%)	34.6	2.4	1.9	3.5	12.5	0
LSD (0.05)	248.9	4.2	4.3	1.6	1.2	0

[a]1 = highly resistant, 2 = resistant, 3 = moderately resistant, 4 = susceptible, 5 = highly susceptible.

to combine high yield, resistance to Cercospora leaf spot and powdery mildew, photothermo-insensitivity, and early and uniform maturity of AVRDC breeding lines. Sixty-one crosses were made and more crosses will be done in the fall with the same parents. F_1 and segregating populations in the advanced generation from these crosses will be under the appropriate selection procedures.

Since 1986 the population improvement program with intermating has been conducted to maximize recombination and to break linkage blocks. All the 219 lines from the four cycles reached F_7 generation in fall 1990. These lines have been selected based on vigorous vegetative growth, disease resistance, large pod size, early and synchronized maturity, nonlodging and photoperiod insensitivity. These intermated populations will be evaluated and selected at AVRDC, and distributed to the national programs.

Evaluation of an Interspecific Hybrid Between *Vigna radiata* and *V. glabrescens* and Comparison of *V. glabrescens* Germplasm from Two Sources

Summary

The progenies from the interspecific cross between *Vigna radiata* and *V. glabrescens* were selfed and selected for disease resistance. Four progenies which had only a moderate level of beanfly resistance were evaluated and advanced to BCS_5.

V. glabrescens germplasm from two different sources which were highly resistant to major diseases and having similar traits except for plant height at maturity, were compared.

Introduction

An accession (V 1160) of *Vigna glabrescens* from the Philippines is highly resistant to major mungbean diseases and insects. Since it is a natural polyploid (2n=44), the incorporation of these resistant genes into *V. radiata* was not possible using conventional breeding methods. Ms. Chen Hao-Koan and Dr. David Mok from Oregon State Univesity (OSU) made interspecific hybridization through a collaborative project between OSU and AVRDC. Twenty-five BCS_1 seeds were received for evaluation.

Another accession of *V. glabrescens* was introduced from India and evaluated to transfer resistant genes from related species and to compare the germplasm sources.

Materials and Methods

Using embryo culture technique, *V. glabrescens* (V 1160) was crossed with *V. radiata* (VC 1973A) at OSU by Chen et al. (1989)[1]. The F_1s were backcrossed to *V. radiata* and selfed. A random sample

[1]Chen, H.K., M.C. Mok, S. Shanmugasundaram and D.W.S. Mok. 1989. Interspecific hybridization between *Vigna radiata* (L.) Wilczek and *V. glabrescens*. Theor. Appl. Genet. 78:641-647.

of 25 seeds (BCS_1) was sent to AVRDC and advanced to BCS_5. BCS_5 seeds were sent to the entomology unit to test their resistance to beanfly. The resistant families will be selfed two more times and then selected for beanfly resistance. The resistant lines will be screened for other desirable traits.

The germplasm of *Vigna glabrescens* from two sources were planted on 15 August 1989 in a randomized complete block design with three replications. Observations on total yield, plant height at maturity, days to 50% flowering and maturity, number of pods per plant, number of seeds per pod, and 1,000-seed weight, were recorded and scored for Cercospora leaf spot (CLS), powdery mildew (PM) and beanfly resistance.

Results and Discussion

All the progenies from the intercross lost their resistance to CLS, PM and bruchid. Only four progenies with moderate levels of beanfly resistance were advanced to next generation.

The *Vigna glabrescens* from two sources were highly resistant to major diseases (CLS, PM). Although they had different plant heights at maturity, their other traits were not significantly different (Table 2).

The progenies from the interspecific cross between *V. radiata* and *V. glabrescens* were unfortunately susceptible to both CLS and PM. Therefore, another *V. glabrescens* from India could be used as a new source of resistance. Though interspecific crossing technique has always been used since 1989, it is also possible to use the progenies (from the interspecific cross) as a bridge to backcross to *V. glabrescens*.

Table 2. Comparison of *Vigna glabrescens* accessions.

Entry	Origin	Yield (t/ha)	Plant[a] height (cm)	DF[b]	DM[c]	No. of pods/ plant	No. of pods/ pod	1000 seed wt.	Disease[d] CLS	Disease[d] PM
V 1160	Philippines	1.32	84.7 a	88	119	7.2	10.0	31	1	1
V 1160	India	1.31	61.9 b	88	119	7.2	10.2	29	1	1

[a]Means having different letters are significantly different from each other by t-test at 5% level. [b]DF = Days to 50% flowering. [c]DM = Days to 50% maturity. [d]CLS = Cercospera leaf spot resistance score; PM = Powdery mildew resistance score; 1 = Highly resistant.

Yield Trials

Summary

A series of yield trials was conducted. Thirty-two entries for intermediate yield trials (IYT), 37 for advanced yield trials (AYT) and 21 for the international mungbean nursery (IMN) were evaluated in spring and summer. Thirteen beanfly-resistant lines were evaluated in fall 1989. Due to continuous rain in April and May, there was flooding and excessive moisture and as a result, yield of most of the entries in all the yield trials was low. The resistance to Cercospora leaf spot was highly stable through all the yield trials.

In IYT, VC 4152-B-1-3B had a high total yield and good level of powdery mildew resistance. In AYT, none of the entries yielded significantly higher than the check VC 3890A in both seasons, but one entry, VC 3920-2B-4-2-1-B, had large seeds. In the 18th IMN, there were several promising entries with high yield and/or large seeds. Among the high yielding lines, VC 4066A and VC 4152A improved in PM resistance, and VC 3092 had the highest 1,000-seed weight (69 g). Except for two lines, VC 2839-70 and V 4281, all the entries including the beanfly-resistant breeding lines showed large reductions in yield when they were not sprayed with insecticide.

Introduction

Outstanding breeding lines were evaluated through different levels of yield trials in different seasons. In addition to yield, the selections were also evaluated for disease resistance and other important traits. An experiment was conducted to evaluate the yield potential of beanfly-resistant materials.

Materials and Methods

In fall 1989 season, a split plot trial with and without insecticide was conducted to evaluate the yield potential of beanfly-resistant materials.

The series of yield trials conducted in 1990 included intermediate yield trials (IYT), advanced yield trials (AYT) and the 18th international mungbean nursery trials (IMN). AVRDC's suggested cultural practices were used in the trial except for the evaluation of beanfly-resistant materials. The parentage of AVRDC breeding lines was evaluated in beanfly-resistant trials, AYT and IMN. Observations were made on total yield adjusted to 12% moisture, first harvest percentage [(first harvest yield/total yield) × 100], days to 50% flowering and maturity and 1000-seed weight. Due to continuous rain at harvest, harvesting was done only once in spring.

Results and Discussion

Intermediate yield trial (IYT)

Twelve entries in spring yielded higher than the check, VC 3890A. However, none of the selections in summer outyielded the check. Considering both the spring and summer seasons, VC 4152-B-1-3B (selection from the cross between VC 1973A and VC 3261A) was the most promising in terms of high yield and powdery mildew resistance (Table 3). Most of the entries were resistant to CLS.

Table 3. High yielding entries from the intermediate yield trials, 1990.

AVRDC no.	Yield (t/ha)			Diseases score[b]		1000-seed[a] weight (g)
	sp	su	mean	sp (PM)	su (CLS)	
VC 4152-B-1-3B	1.0	1.6	1.3	2.5	2.0	59
VC 4250-4-1-3B	0.9	1.5	1.2	3.8	2.0	58
VC 4227-4B	0.9	1.4	1.2	4.5	2.0	56
VC 4426-B-2-2B	0.9	1.6	1.2	4.8	2.0	57
VC 4437-B-4-2B	0.9	1.3	1.1	4.5	2.3	58
VC 4146-2-1-1-3B	0.9	1.4	1.1	4.0	2.0	51
8C 4453-3B	0.8	1.4	1.1	5.0	2.0	55
Uthang 7808	0.8	1.5	1.2	4.8	2.3	61
VC 1628A (ck)	0.5	1.2	0.9	5.0	2.0	55
VC 3890A (ck)	0.8	1.6	1.2	3.0	2.0	58
Mean of 32 entries	0.8	1.3	1.0	4.1	2.0	56.1
CV (%)	12.2	15.3	14.9	13.3	7.5	2.9
LSD (0.05)	0.1	0.3	0.2	0.8	0.2	2.7

[a]Mean of spring and summer seasons. [b]1 = highly resistant, 2 = resistant, 3 = moderatley resistant, 4 = susceptible, 5 = highly susceptible.

Advanced Yield Trial (AYT)

Five and 13 breeding lines outyielded the check VC 3890A in spring and summer, respectively. However, the yield differences were not statistically significant. The 1000-seed weight of VC 3920-2B-4-2-1-B were significantly higher than the check VC 3890A. Powdery mildew resistance has not been improved and new sources of resistance is required. All the entries showed CLS resistance.

International Mungbean Nursery (IMN)

Seven and six entries outyielded the check VC 2768A in spring and summer, respectively. The local check yielded the highest during summer (Table 4). However, the local check was highly susceptible to PM. Among the high yielding entries in spring, VC 4066A and VC 4152A were the most resistant to PM. The 1000-seed weight of VC 3902A was the highest (69 g) and its yield was also high.

Table 4. High yielding entries from the International Mungbean Nursery, 1990.

AVRDC no.	Yield (t/ha)			Diseases score[b]		1000-seed[a] weight (g)
	sp	su	mean	sp (PM)	su (CLS)	
Local variety	1.2	0.8	1.0	5.0	3.0	51
VC 4059A	1.1	1.0	1.1	3.5	2.3	61
VC 4066A	1.1	1.2	1.1	2.5	2.0	56
VC 4143A	1.0	1.5	1.3	3.3	2.0	54
VC 1168B	1.0	1.3	1.1	3.5	2.3	54
VC 3300A	1.0	1.4	1.2	3.5	2.0	60
VC 2768A	0.9	1.2	1.0	3.0	2.0	57
VC 4152A	0.9	1.3	1.1	2.5	2.0	61
VC 3092A	0.8	1.6	1.2	2.8	2.0	69
VC 2763A	0.7	1.2	1.0	3.3	2.0	61
Mean of 20 entries	0.8	1.0	0.9	3.2	2.2	53.4
CV (%)	13.1	26.1	22.2	20.4	1.4	2.7
LSD (0.05)	0.05	0.38	0.20	0.9	0.4	1.4

[a]Mean of spring and summer. [b]1 = highly resistant, 2 = resistant, 3 = moderately resistant, 4 = susceptible, 5 = highly susceptible.

International Cooperation

Summary

A total of 1,062 seed packets was distributed to 74 cooperators in 44 countries. In Botswana, four AVRDC lines were recommended to the farmers. VC 1973A performed very well in North America. AVRDC lines were found promising in Brazil, China, Fiji and Thailand. As of November 1990, 43 cultivars from AVRDC have been officially released in 18 countries. In 1989, the total area planted with improved mungbean varieties from AVRDC in China was around 83,000 ha.

Country Reports

Botswana. (Cooperator: I.A. Mayeux). Four AVRDC lines and two local checks were evaluated in three locations (Sebele, Goodhope and Mahalapye). Line VC 2778A gave the best average yield (1.2 t/ha) and the largest seed. Line VC 1973A showed high resistance to shattering. The cooperator concluded that all AVRDC lines performed well and have earlier and more determinate characteristics than the local check. Four AVRDC lines, VC 1000E, VC 1482E, VC 1973A and VC 2778A were recommended to the farmers.

Brazil. (Cooperator: Rogerio Faria Vigiva). Among the 12 entries evaluated, VC 2771A (1.2 t/ha) was the only high yielding AVRDC line.

Canada. Eight entries were evaluated at the Agriculture Canada Research Station in Harrow. VC 1973A performed best with a yield of 1.2 t/ha and 95% of total yield at first harvest. However, it was more susceptible to root rot than the check.

China. (Cooperator: Lin Guodao and Tang Xuecheng). Twenty AVRDC lines were evaluated at the experimental farm of the Center of Tropical Pasture in Hainan. Among 16 AVRDC lines outyielding the local check (1.2 t/ha), the highest yielding lines were VC 3117A (2.6 t/ha), VC 3888A (2.0/ha), VC 3300A (1.9 t/ha) and VC 2768A (1.9 t/ha).

Fiji. (Cooperator: Vikram Chand and Shakumtala Mand). Twenty-three entries were evaluated at Legalega Research Station in Wadi Airport. Ten AVRDC lines outyielded the local check; VC 2764 had the highest yield (1.3 t/ha).

Thailand. Five AVRDC selections and one released cultivar were evaluated by the Pacific Seeds Limited in Saraburi. Two entries, VC 4502C and VC 3890C, outyielded the check cultivar (KPS 2) and showed powdery mildew resistance.

U.S.A. (Cooperator: Dr. J.C. Miller, Jr.). Two 17th IMN trials were conducted in Texas A & M University, one in College Station and the other in Lubbock, Texas. The yield varied from 0.2 t/ha for VC 3945A to 0.4 t/ha for VC 1973A at College Station, and 0.3 t/ha for VC 2917A to 0.6 t/ha for VC 4111A at Lubbock. However, yield differences among the genotypes were not significant. VC 1973A was officially released as Texsprout in USA in 1989 and yielded the highest among the IMN entries.

(Cooperator: Dr. J.C. Murray). An IMN trial (16th) was conducted in Oklahoma State University. The yield varied from 1.0 t/ha for VC 4066A to 1.7 t/ha for VC 1973A.

Cultivar Releases

As of 1990, 43 cultivars have been officially released by the NARS in 18 countries using AVRDC improved mungbean lines (Table 5). VC 1000E, VC 1482E, VC 1973A and VC 2778A were recommended in Botswana. VC 1381 and VC 2917A were released in China without an official name.

Table 5. Mungbean varieties officially released by cooperating nations.

AVRDC ID	Name of cultivar	Release Year	Country
V 1380	Imara	1983	Tanzania
V 1388	King	1982	Australia
V 2013	Satin	1987	Australia
V 2773	Nuri	1983	Indonesia
V 3476	Bangasa	1980	Korea, Rep. of
V 3484	Pusa 101	1983-1984	India
V 3554	M 986	1981	India
VC 1000D	Station 46	1982	Fiji
VC 1007A	Station 25	1984	Fiji
VC 1089A	ASVEG 78	1978	Costa Rica
	Manyar	1983	Indonesia
VC 1131B	Type-77	1982	Sri Lanka
VC 1137A	Pusa 105	1983	India
VC 1160B	Station 27	1984	Fiji
VC 1160C	Gelatik	1986	Indonesia
VC 1163A	Walet	1986	Indonesia
	Boliche 451	1985	Ecuador
VC 1163D	INIAP 451	1985	Ecuador
	BPI Mg 2	1984	Philippines
VC 1168B	Filsan	1987	Somalia
	*	1988	Laos
VC 1178A	Chai Nat 60	1987	Thailand
VC 1560D	*	1982	Australia
	DX 91	1986	Vietnam
	*	1988	Laos
VC 1628A	Tainan Sel #3	1981	Taiwan
VC 1973A	Xu Yin No. 1	1985	China
	Seon Hwa Nogdu	1982	Korea, Rep. of
	KPS No. 1	1985	Thailand
	Texsprout	1989	U.S.A.
VC 1973B	BPI Mg 7	1989	Philippines
VC 2750A	*	1988	Laos
VC 2763A	DX 113	1986	Vietnam
VC 2764B	BPI Mg 4	1986	Philippines
VC 2768A	DX 102A	1986	Vietnam
	Su-Luh No. 1	1988	China
	PSU 1	1988	Thailand
VC 2768B	BPI Mg 9	1989	Philippines
VC 2770A	DX 103	*	Vietnam
VC 2778A	KPS No. 2	1985	Thailand
	Er Lu No. 2	1989	China
VC 3890A	Tainan Sel #5	1988	Taiwan
VC 4080A	SIROC (1)	1989	Solomon Islands
Total: 31	43		18

*Released name or year is unknown.

Mungbean Entomology

Characterization of Beanfly Resistance in *Vigna glabrescens*

Summary

A *Vigna glabrescens* accession, V 1160, had shown consistent resistance to beanflies, mainly *Ophiomyia phaseoli*. In field, greenhouse, and laboratory study, the mechanism of beanfly resistance in this accession was studied. Beanflies did significantly fewer feeding and made fewer oviposition punctures in V 1160 than in susceptible VC 1973A. The percentage of plants showing beanfly damage in the stems was significantly lower in V 1160 than in VC 1973A. Unifoliate and trifoliate leaves of V 1160 were significantly smaller than those of VC 1973A. The trifoliate leaves of V 1160 had significantly less trichome density than the trifoliates of VC 1973A. Stems of V 1160 were significantly thinner than those of VC 1973A. VC 1160 had glabrous stems whereas VC 1973A stems had trichomes. A combination of various morphological and possibly some physiological factors may be involved in the resistance of V 1160 to beanfly.

Introduction

Past studies have revealed that a *Vigna glabrescens* accession, V 1160, is highly resistant to beanflies, mainly *Ophiomyia phaseoli* which is a predominant species on mungbean. This accession is now actively used in AVRDC research to breed beanfly-resistant mungbean. AVRDC studied various morphological and certain physiological characteristics in V 1160 that differed from susceptible mungbean.

Materials and Methods

Preference study. A parcel of land was worked into eight 2 m × 0.75 m plots. Seeds of V 1160 were planted on the top of four alternate plots and seeds of VC 1973A, a susceptible check, in the remaining four plots. Soon after germination, when unifoliate leaves were fully opened, a large number of laboratory-bred adults of *O. phaseoli* was released in the field. Every morning, between 0800 and 1000, for seven consecutive days, plants in each plot were observed and the number of beanfly adults sitting on the unifoliate leaves recorded. Data from all observations were combined. Simultaneously 10 unifoliate leaves from plants in each plot were cut and the number of punctures made by the agromyzid on both upper and lower side of the unifoliate leaves recorded.

Beanfly infestation study. At 3 and 5 weeks after germination, 20 plants from each plot were uprooted, their stems cut open and the number of larvae and pupae and the number of plants with beanfly damaged stem and healthy stems recorded.

Foliage characters. Ten fully opened unifoliate and first trifoliate leaves were sampled. Leaf area of each unifoliate leaf and 10 leaflets from trifoliate leaves were measured on a Licor area meter. At three widely separated points on each leaf (or leaflet), away from major veins, the thickness of the foliage was recorded with the help of a micrometer. On each leaf (or leaflet) three 2.5 mm × 2.5 mm areas were chosen and the number of trichomes on the upper and lower side of the leaves recorded.

Stem characteristics. Ten 1-month old plants from each plot were uprooted. The number of trichomes on a 1-cm wide circumference of the stem in the hypocotyl, internode between cotyledon to unifoliate leaf and unifoliate to first trifoliate leaves was taken. The length of internodes between cotyledon and unifoliate leaf, unifoliate and first trifoliate leaf, and first and second trifoliate leaves was recorded. Diameter of hypocotyl, internode between cotyledon and unifoliate leaves and unifoliate and first trifoliate leaves was also measured.

Results and Discussion

Twice as many beanfly adults were found visiting unifoliate leaves of susceptible VC 1973A compared with those of resistant V 1160. This was clearly reflected in the number of feeding/oviposition punctures made by the adults in these plant parts. On both upper and lower side of the leaf surface, adults made significantly more punctures in VC 1973A than in V 1160.

The number of beanfly larvae and pupae in stems of 3- or 5-week-old plants were substantially less in V 1160 than in the stems of VC 1973 (Table 1). In fact V 1160 was practically free of insect. The percentage of plants showing visible beanfly damage inside the stems was significantly less in V 1160 than in VC 1973A 3 and 5 weeks after emergence of the plants.

Both unifoliate and trifoliate leaves of V 1160 were significantly smaller than those of susceptible VC 1973A. Unifoliate leaves were thinner and trifoliate leaves of V 1160 significantly thinner than those of VC 1973A. The unifoliate leaves of both accessions were glabrous; however, the first trifoliate leaves of V 1160 had significantly fewer trichomes than those of VC 1973A. Beanflies also laid eggs on first and, at times, second trifoliate leaves. A certain density of trichomes seemed to be essential for oviposition by most insect pests. Since the unifoliate leaves of both accessions were glabrous, the first trifoliate seemed to be a major site for oviposition. The low trichome density of these leaves seemed to contribute to fewer beanflies in the stems.

The internodes of V 1160 were substantially shorter than those of VC 1973A. The stem diameter at the hypocotyl and between unifoliate and first trifoliate leaves was significantly smaller in VC 1973A than in V 1160. The hypocotyl and stem portion between cotyledon and unifoliate leaves were glabrous in V 1160 whereas these plant parts have high trichome density in VC 1973A. Beanfly species *Ophiomyia centrosematis* laid eggs in the hypocotyl and, at times, in the stem between cotyledon and unifoliate leaves. The glabrousness of the stem probably reduced oviposition and subsequent damage by this species in V 1160.

Table 1. Infestation of *Vigna* species by agromyzid[a] flies.

Accession no.	No. larvae + pupae per 10 plants at		Damaged plants (%)	
	3 WAE[b]	5 WAE	3 WAE	5 WAE
V 1160	0.25 ± 0.75	0	22.5 ± 15.0	17.5 ± 5.00
VC 1973A	5.75 ± 4.35	2.25 ± 2.22	95.0 ± 5.77	87.5 ± 12.58
t value	2.18	1.76	7.81	8.95
Significance	NS	NS	**	**
DF[c]	6	6	6	6

[a]Mainly *Ophiomyia phaseoli*. [b]WAE: Weeks after emergence. [c]Degrees of freedom.

Screening for Resistance to *Callosobruchus chinensis*

Summary

Seeds of two F_2 populations derived from crosses between bruchid-resistant mungbean and high-yielding mungbean breeding lines and bruchid-resistant *Vigna sublobata* and high-yielding mungbean breeding lines were screened for resistance to a storage pest *Callosobruchus chinensis*. In both cases the susceptible parents were completely damaged by the insect when the resistant parent remained

unaffected or suffered only minor damage. The damage to the F_2 population was in between. Resistance, therefore, appeared to be genetic. Plant breeders were improving the selected F_2 progeny.

Introduction

A bruchid species, *Callosobruchus chinensis*, infests mungbean in storage wherever the crop is grown or used. Use of chemical insecticides to combat this pest is impractical due to the concealed nature of its habit. It also poses health hazards when contaminated seeds are consumed and when small-scale farmers store the seeds in living quarters. Research in the control of this pest, therefore, is directed at breeding bruchid-resistant cultivars. In 1988-89 two mungbean accessions, V 2709 and V 2802, were found to have moderate to high levels of resistance to *C. chinensis*. In 1990 these two accessions were crossed with five high-yielding, disease-resistant breeding lines. The F_2 population was screened for resistance to *C. chinensis*. Also screened were F_2 populations derived from crosses between a *Vigna sublobata* accession (TC 1966) and five high-yielding disease-resistant mungbean breeding lines. The *V. sublobata* accession was found to be highly resistant to *C. chinensis* in Japan.

Materials and Methods

Seeds of each entry, including susceptible and resistant parents, were confined in 50 ml Erlenmeyer flasks. Fifty newly emerged *C. chinensis* adults were released over the seeds for 1 week for oviposition. After 1 week, all insects were discarded and the seeds were maintained at 30°C for 1 month. After a month, the number of adults which emerged and the number of damaged and healthy seeds were counted. The percentage damaged seeds in each entry was computed and compared.

Results and Discussion

The results of the crosses using mungbean accessions V 2709 or V 2802 as resistant parents are summarized in Figure 1. Seeds of all susceptible parents were completely damaged. The resistant parents, as expected, were the least damaged. Damage to the F_2 population was in between. There was no apparent difference among the crosses when five different susceptible parents were used against either of the resistant parents or when the resistant accessions were used as male or female parents. Accession V 2709 has a higher level of bruchid resistance which was also reflected in the F_2 progeny which showed far less bruchid damage than the F_2 progeny derived from V 2802. Selected F_2s were returned to the plant breeder for further improvement.

The results of crosses using *Vigna sublobata* accession TC 1966 are summarized in Figure 2. Susceptible parents showed much damage. The resistant parent was not damaged. The damage to the F_2 progeny was in between. No apparent difference was observed whether the resistant parent was used as male or female parent. Crosses involving VC 2776A were always least damaged although VC 2776A itself proved to be highly susceptible. The undamaged F_2 seeds were given to the mungbean breeder for further improvement.

Isolation of Resistance Factors from Bruchid-resistant Mungbean

Introduction

Biological studies with two mungbean accessions, V 2709 and V 2802, and a blackgram accession VM 2164, have shown that the resistance of these accessions to *Callosobruchus chinensis*, a bruchid that causes considerable damage to mungbean in storage, is due to antibiotic principles in the seeds. Analysis of the seeds at CIAT failed to find any Arcelin, a protein responsible for bruchid resistance in seeds of *Phaseolus vulgaris*. A series of preliminary studies was done to isolate the resistance factors.

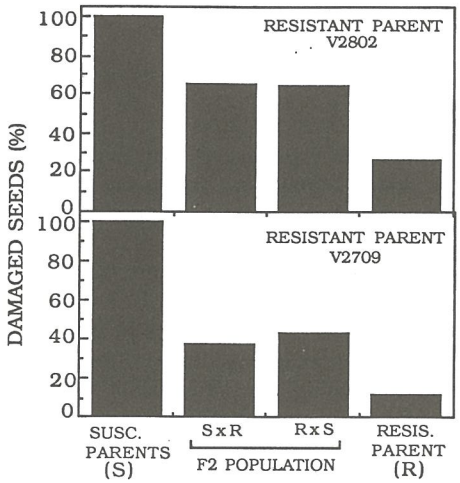


Fig. 1. Bruchid infestation of resistant and susceptible parents and F_2 population.

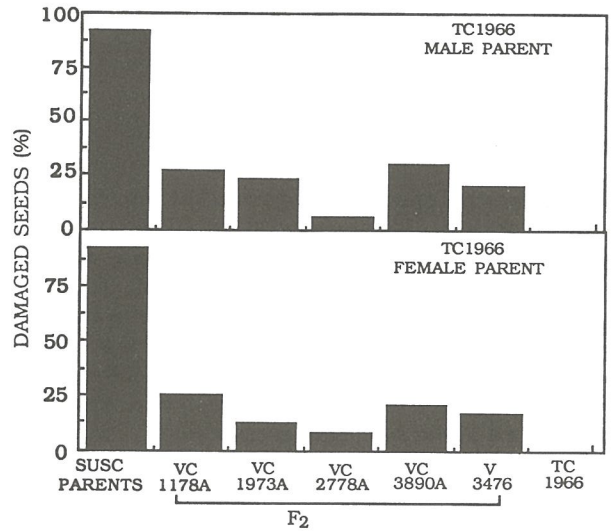
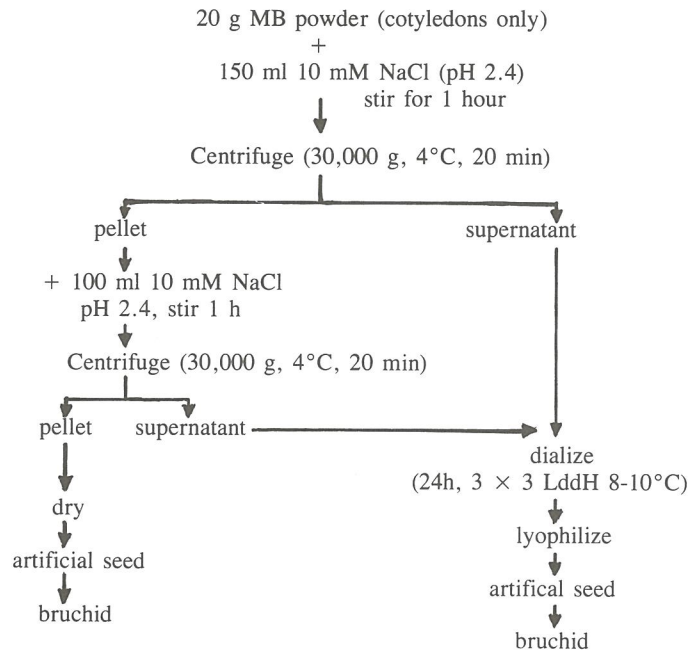


Fig. 2. Bruchid infestation of resistant and susceptible parents and F_2 population.

Materials and Methods

Seeds of three resistant accessions and a susceptible breeding line VC 1973A were soaked in water for 1 h and cotyledons were separated by peeling off the testa. Excess water from cotyledons was removed by wrapping them in blotting paper; seeds were dried at 60°C for several hours. Seeds of each accession were finely powdered and the powder was used for isolation of protein.

The protein isolation procedure used was similar to the one developed for isolation of Arcelin by Osborn et al. (1988) and is depicted in the following flow chart.



Extraction and separation of protein

The seeds were placed in 50 ml Erlenmeyer flasks and five pairs of newly emerged bruchid adults were released over the artificial seeds. After 1 week, the adults were removed and seeds were maintained at 30°C for an additional 1 month. At the end of 30 days, the number of adults that emerged from each seed sample were recorded.

Results and Discussion

Results of the emergence of first generation adults from artificial seeds made by fortifying seeds with various fractions of resistant seeds are summarized in Table 2. The addition of pellet or supernatant fraction of VC 1973A seeds to artificial seeds of VC 1973A did not affect its susceptibility to *C. chinensis*, but the addition of either pellet or supernatant fraction of the resistant accession significantly reduced its susceptibility to *C. chinensis*. Either fractions of V 2802 reduced susceptibility of VC 1973A. However in the case of V 2709, the pellet fraction had greater susceptibility-depressing effect than the supernatant fraction. The supernatant fraction of V 2802 and V 2709 had a similar effect. The opposite was noted in the case of VM 2164 where the supernatant fraction had the greatest insect susceptibility-suppressing effect; the pellet fraction of VM 2164 was comparable to the pellet or supernatant fraction of V 2802 or supernatant fraction of V 2709. It appeared that the bruchid-resistant factors in these three accessions were not identical. In V 2709 it was insoluble protein or starch whereas in VM 2164 it was albumin or globulin. The resistant factor in V 2802 seemed to be similar to V 2709, except that its concentration in V 2802 was much less than in V 2709. Further detailed research is necessary to characterize the resistant factors.

Table 2. Emergence of first generation *C. chinensis* adults from artificial seeds made from various fractions of bruchid-resistant and susceptible seeds.

Artificial seed composition	No. insects/g seeds
VC 1973A cotyledons[a]	47.50 a
VC 1973A[a] + VC 1973A pellet	38.50 b
VC 1973A + VC 1973A supernatant	36.75 b
VC 1973A + V 2709 pellet	3.50 ef
VC 1973A + V 2709 supernatant	18.00 cd
VC 1973A + V 2802 pellet	17.75 cd
VC 1973A + V 2802 supernatant	20.00 c
VC 1973A + VM 2164 pellet	10.50 de
VC 1973A + VM 2164 supernatant	1.75 f

[a]Powder from dried cotyledons of VC 1973A. Data are means of four replicates. Means in vertical column followed by the same letters are not significantly different at 5% level by DMRT.

Mungbean Pathology

Evaluation of Selected Mungbean Lines for Resistance to *Erysiphe polygoni* and *Cercospora canescens*

Summary

Two of the most important diseases of mungbean are Cercospora leaf spot and powdery mildew. A highly resistant source, *Vigna glabrescens*, was crossed with *V. radiata* to determine if the resistance could be transferred. All BC_1S_2 plants were found susceptible to powdery mildew. Mutant-generated lines from India tested for resistance to Cercospora leaf spot were all found susceptible. Retesting of resistant sources to determine whether they are durable over time, and screening germplasm for potentially new sources of resistance will be continued in future screening tests.

Introduction

Mungbean (*Vigna radiata*) is an important crop in Asia. Two of the most important foliar diseases affecting it are Cercospora leaf spot, caused by *Cercospora canescens* and powdery mildew, caused by *Erysiphe polygoni*. Both diseases are widespread, and cause serious yield losses under environmental conditions that are conducive to disease development.

There are some sources of resistance to both pathogens; however, it is not known whether there is a broad genetic base of resistance to either pathogen. One accession of *Vigna glabrescens*, a tetraploid (V 1160), was previously found to be highly resistant to both pathogens. Disease-resistant screening tests were thus conducted to 1) determine if BC_1S_2 from a VC 1973A × (V 1160 × VC 1973A) were resistant when inoculated with *E. polygoni*, and 2) identify new sources of Cercospora leaf spot resistance in mutagenic lines selected from India that had been reported resistant to powdery mildew in the 1989 AVRDC Progress Report.

Materials and Methods

Screening for resistance to powdery mildew. Seeds of 28 BC_1S_2, VC 1973A, V 1160, VC 1628A, and VC 1560D were planted in 8-cm diameter pots in the greenhouse on 29 December 1989. Plants were thinned to one plant per pot. There were 10-20 plants per entry. On 12 February, plants were dusted with infected conidia obtained from infected mungbean leaves in a mungbean field to increase the inoculum of powdery mildew.

Percent leaf area infected with powdery mildew was assessed on 23 March using the following scale: 1 = highly resistant (HR) (0%), 2 = resistant (R) ($\leq$ 10%), 3 = moderately resistant (MR) (11-30%), 4 = moderately susceptible (MS) (31-60%), 5 = susceptible (S) (61-80%), and 6 = highly susceptible (HS) ($\geq$ 80%).

Screening for resistance to Cercospora leaf spot. Seeds of eight genotypes from India (Rum 1, 5, 7, 11, 20, 21, 22 and 33), and two check lines, V 2773 and V 2010, were planted on 5 July 1989 and inoculated with *C. canescens* 40 days later. The fungus was grown on mungbean-oatmeal agar for 7 days. Culture plates were flooded with sterile distilled water and conidia were harvested. Plants were sprayed with the conidial suspension until completely moist. There were three

replications for each genotype with 10-16 plants in each replication. Disease was assessed by rating the percent leaf area infected.

Results and Discussion

Screening for resistance to powdery mildew. All plants of BC_1S_2, VC 1973A and VC 1628A were rated as susceptible to highly susceptible. VC 1560D was rated moderately susceptible. VC 1160 was highly resistant with only a few lesions on two of 10 plants.

The resistance from *Vigna glabrescens* was not transferred to the progeny of BC_1S_1. The reasons for this are not known. More interspecific crosses need to be tested to determine if this resistance can be transferred and utilized in the mungbean breeding program.

Screening for resistance to Cercospora leaf spot. Percent leaf area infected ranged from 20 to 93. All of the Rum lines were susceptible (range 58-93%). V 2773 had the lowest percent leaf area infected. It was less susceptible than the other accessions; in the past it had been reported as resistant. Since no accessions are highly resistant to *C. canescens*, and only a few have moderate levels of resistance, more accessions need to be evaluated to find new sources of resistance.

Pepper Breeding

New Crosses and Selection

Summary

Three hundred and nine new cross combinations of pepper were completed in 1990. Priority combinations were aimed at combining sources of virus resistance with sources of resistance to *Phytophthora capsici* and *Xanthomonas campestris* pv. *vesicatoria*, and with those accessions of sweet and hot pepper which are most adapted to the hot-humid tropics.

Incidence and severity of bacterial spot was high for most of the 47 F_3 families derived from six crosses between CVMV-resistant sources and early maturing hot pepper varieties observed for selection during spring 1990. Open-pollinated fruits from 24 families were selected for earliness and virus tolerance. Progenies will be bulked into phenotypic germplasm pools and new crosses were planned to introduce resistance to bacterial spot in these families.

Introduction

The major constraints to pepper production in the tropics are losses due to disease incidence and low plant productivity. Viral diseases are the most serious problems in the production of both sweet and hot pepper. Sweet pepper is not well adapted to tropical conditions despite its potential as a nutritious and high-value crop. The process of hybridization and selection for stress tolerance (heat, flooding) in sweet pepper is in its infancy, but shows promise for improvement. Resistance to bacterial and fungal diseases is also essential for adapting new varieties of hot and sweet peppers to the hot-humid tropics.

Materials and Methods

Priority combinations were aimed at combining sources of virus resistance with sources of resistance to *Phytophthora capsici* and *Xanthomonas campestris* pv. *vesicatoria*, and with those accessions of sweet and hot pepper which are most adapted to the hot-humid tropics.

Results and Discussion

Three hundred and nine new cross combinations were completed in 1990. Primary crosses were being advanced by self-pollination without selection. Three-way crosses were being advanced by self-pollination with selection for desirable horticultural traits. Subsequent progenies will be screened for respective disease resistance under controlled conditions or disease nurseries in the field.

Forty-seven F_3 families derived from six crosses between CVMV-resistant sources and early maturing hot pepper varieties were observed for selection during spring 1990. Incidence and severity of bacterial spot was high for most families. Open-pollinated fruits from 24 families were selected for earliness and virus tolerance. Progenies will be bulked into phenotypic germplasm pools and new crosses were planned to introduce resistance to bacterial spot in these families.

International Trials: Collection, Evaluation, Multiplication and Distribution of Entries for the International Hot Pepper Trial Network (INTHOPE)

Summary

The spring 1990 INTHOPE trial at AVRDC was a duplication of the entries evaluated in 1989. New entries were added for the summer and fall 1990 INTHOPE trials. The benefit of pruning plants below the main stem was tested in this year's summer trial. The test was repeated in the fall planting. Pruning plants did not seem to be beneficial to pepper production in the hot-humid season. All entries have been quantified for capsaicin content and are to be screened for reaction to the pathogens: CMV, CVMV, PVMV, PVY, TMV, ToMV, PMMV, *Xanthomonas campestris* pv. *vesicatoria*, *Phytophthora capsici*, *Colletotrichum capsici* and *C. gloeosporioides* under controlled conditions. The first global seed distribution of 30 INTHOPE entries is planned for February 1991. To date, 39 cooperators representing 20 countries have confirmed their participation in INTHOPE.

Introduction

The International Hot Pepper Trial Network (INTHOPE) was initiated in 1988 to facilitate the exchange and evaluation of popular hot pepper landraces and elite germplasm across international test environments.

Its long-term objectives are to introduce adapted hot pepper landraces and elite germplasm from different countries into appropriate regions of production; to monitor the performance of different hot pepper populations in diverse environments and to gather information on the variability of pathogenic strains involved in *Capsicum* host-pathogen relationships.

Entries with the least field tolerance to important diseases (especially viral) were prioritized.

At AVRDC, the INTHOPE evaluation trials are sown in April and September. In addition, a seed crop was sown in September to provide seed for distribution in February.

INTHOPE Trial: Summer 1990

Materials and Methods

The experimental design for the summer 1990 trial at AVRDC was a split-plot with 43 entries in the main plot treatment and two management practices (pruning vs. nonpruning) in the subplot treatment. Whole plot treatments were replicated in three randomized complete blocks with 28 plants per replication, spaced on two-row beds (width 1.5 m) with 0.5 m between rows and 0.45 m between plants.

Subplot treatments were randomized per plot in units of 14 plants. A pair of plants (pruned) served as the border between subplots. Plants were sown, transplanted and pruned on 21 April, 25 May and 11 June, respectively.

Standard cultural practices as recommended for pepper experiments at AVRDC were employed with an amendment of organic fertilizer at basal application. Mulching was conducted two times with rice straw. The local landrace selection 'Szechuan 10' was used as the check entry and a number of hybrids were included at the request of some cooperators.

Yield data for total and marketable fruits were recorded 13 times over a period of 3.5 months (18 June; 25 July; 1 , 8 , 15 , 22, and 29 August; 5 , 12 , 19 and 26 September; 2 and 9 October). Fruit shape measurements were taken when an entry was harvested for the third time.

Days to flowering were recorded when 75% of the plants in a plot were flowering at the secondary-branch nodes. Plant height was measured at the first harvest of each entry. Samples of red-mature fruits were analyzed for capsaicin content by the Chemistry unit. Healthy and culled mature fruits were evaluated by the Plant Pathology unit for latent infection of anthracnose-causing fungi; other samples of healthy fruits were inoculated to determine reaction to *Colletotrichum* species.

Incidence of bacterial spot was recorded at intervals during the growing season. Percent wilt was recorded on 25 September as an indication of survival after summer typhoons and flooding. Many wilt-inflicted plants were hosts to the fungus, *Fusarium oxysporum*, but pathogenicity tests have not been completed.

Results and Discussion

Analysis of variance for the split-plot experimental design indicated that pruning had no significant effect on most of the variables evaluated.

Main plot comparisons which compared hot pepper entries were significant in all cases. A number of entries attained fruit weights higher than the check population, 'Schechuan 10'. All of them were F_1 hybrids except for 'Atarado', which is a campanulate *Capsicum chinense* variety from Niger, and 'Lv. 1583', an Indonesian line selected for the lowland tropics. Many open-pollinated entries yielded fruit numbers greater than 'Szechuan 10', including the very pungent Indian variety, 'Punjab Lal', and a number of Indonesian populations.

Paired t-tests between capsaicin levels among plots from harvest periods 7 and 10 indicated that capsaicin levels were significantly different ($P = 0.05$) between harvest dates. Because all entries were not mature at the earlier sampling periods, a complete analysis was not made using harvest dates as a split-block treatment.

Major maturity classes of the 43 entries over all harvest periods are shown in Figures 1 and 2. Harvest periods 7 and 8 had the highest average yields, whereas the highest yielding entries tended to mature late.

INTHOPE Trial: Winter-Spring 1990

Materials and Methods

INTHOPE accessions that were collected and evaluated during 1988 and 1989 were evaluated again during winter-spring 1990. The experimental design was a randomized complete block with

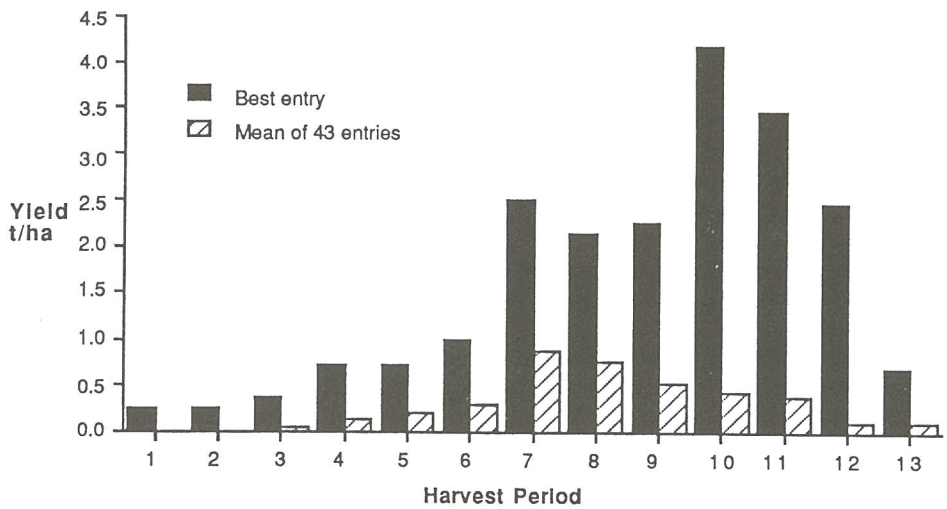


Fig. 1. Distribution of hot pepper yields during a 4-month harvest season. Harvest period: 1-18 June; 2-25 July; 1-3 Aug; 4-8 Aug; 5-15 Aug; 6-22 Aug; 7-29 Aug; 5-8 Sept; 9-12 Sept; 10-19 Sept; 11-26 Sept; 2-12 Oct; 9-13 Oct; date of transplanting - 25 May; date of last monthly fertilization - 8 Aug; yield based on fresh weight; data from 1990 international Hot Pepper Trial (INTHOPE), summer, Shanhua, Taiwan.

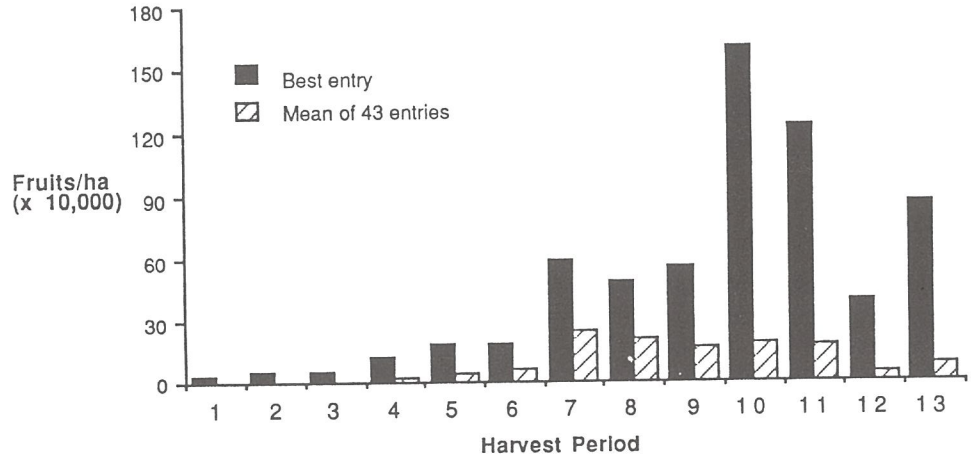


Fig. 2. Distribution of hot pepper fruit production during a 4-month harvest season. Harvest period: 1-18 June; 2-25 July; 1-3 Aug; 4-8 Aug; 5-15 Aug; 6-22 Aug; 7-29 Aug; 5-8 Sept; 9-12 Sept; 10-19 Sept; 11-26 Sept; 2-12 Oct; 9-13 Oct; date of transplanting - 25 May; date of last monthly fertilization = 8 Aug; data from 1990 International Hot Pepper Trial (INTHOPE), summer, Shanhua, Taiwan.

three replications as blocks for 16 entries. Twelve entries were evaluated in a nonreplicated trial because of limited seed quantities. Plastic mulch was used for weed control and to maintain higher soil temperatures. Plots were harvested for nine weekly periods beginning 11 May until 4 July.

Results and Discussion

Marketable yields, percent culls from total yield, and fruit characteristics were observed and analyzed. 'Szechuan 1', 'MC 5', 'Yangjiao' and 'IAC Ubatuba Cambuci' ranked highest for fruit weight (t/ha), whereas, 'Punjab Lal', 'Hua Sithon' and 'KKU Cluster' ranked highest for number of fruits. Early marketable yields, as the sum from harvests 1 to 4, were high for the entries 'Extra Long Selection' and 'Ludhiana Long Selection'.

Pooled t-tests between fruit measurements from 23 May and 27 June indicated that fruit length varied significantly ($P = 0.05$) from one harvest period to another. To improve pepper productivity genetic and management approaches to optimize fruit development at later harvest periods should be considered.

A few entries appeared to have a high level of field resistance to CMV and CVMV based on ELISA assays of leaf samples from all replications. Subsequent inoculations of seedlings under controlled conditions indicated that 'Extra Long Selection', 'Punjab Lal', PBC 199 and 'Huay Sithon' were resistant to the local strain of CMV.

'Ludhiana Long Selection' was resistant to PVY, and heterogeneous for resistance to CMV and CVMV. 'Extra Long Selection' was heterogeneous for resistance to PVY and CVMV. Other plants resistant to CVMV were found in the populations of 'Jawahar 218' and 'Punjab Lal'.

During the early stages of plant growth, 'Punjab Lal' was the only entry absolutely free of *Spodoptera* leaf-eating caterpillars. Capsaicin levels were highest for 'Chicken Heart', 'Tabasco', 'Punjab Lal', 'PBC 199', 'Huay Sithon', 'Huaruar', 'KKU Cluster' and 'Atarado'.

Intensive management practices and favorable climate contributed to extensive vegetative growth and high yields for most virus-tolerant entries. Although winter-spring did not fit in with the normal first rice cropping pattern in Taiwan, it seemed to be an appropriate season for pepper production under irrigation at AVRDC.

The winter-spring season could be used extensively for generation advancement, crossing blocks, and selection for virus resistance, whereas, late spring and summer could be utilized optimally for

fungal and bacterial disease screening nurseries, and selection for adaptation to high temperatures and flooding.

Observation and Evaluation Trials of New or Advanced *Capsicum* Germplasm

Summary

Ninety-four accessions (*C. annuum*, *C. frutescens*, *C. baccatum* and *C. chinense*) were transplanted on 25 May for characterization and observation for tolerance to the adverse conditions of Taiwan's summer. Entries C00948, 'Ama 11', 'Var. Corniforme F1-46', and 'Aji Blanco Cristal Chile' ranked highest in fruit weight, whereas, 'Red Boy', C00948 and C01729 ranked highest in fruit number. Entries C00948 and 'Aji Blanco Cristal Chile' are both *Capsicum baccatum* var. *pendulum* accessions having yellow immature fruit, and the pod separates trait. Entries 'Chili Piquin' and C01586 had the highest capsaicin values of 7.0 and 5.38 mg/g dry matter, respectively. Entries 'Pangalengan-2', 'King Gum Go Chu', 'Cheong Yang', C01511, C01421, 'Kun Ja', PBC 384, PBC 385, and PBC 389 were chosen as new candidates for the 1991 INTHOPE trial at AVRDC, based on plant development, fruit morphology and disease resistance.

Hot-humid Season Observational Trial

Introduction

An integral component of any breeding program is the observation and evaluation of new and advanced breeding lines. Observational trials are necessary to characterize unknown accessions or selections while valuation trials are needed to adequately test the performance of advanced lines at AVRDC before they are submitted for regional testing.

Materials and Methods

Ninety-four accessions (*C. annuum*, *C. frutescens*, *C. baccatum* and *C. chinense*) were transplanted on 25 May for characterization and observation for tolerance to the adverse climatic conditions of Taiwan's summer. Each plot contained 44 plants on a two-row bed, mulched with rice straw. Plots were harvested three times only.

Fruit samples were submitted to the Chemistry and Plant Pathology units to screen for capsaicin content and anthracnose resistance, respectively. Severity of bacterial spot was recorded at intervals during the season.

Results and Discussion

The entries C00948, 'Ama 11', 'Var. Corniforme F1-46', and 'Aji Blanco Cristal Chile' ranked highest in fruit weight, while 'Red Boy', C00948 and C01729 ranked highest in fruit number.

Entries C00948 and 'Aji Blanco Cristal Chile' are both *Capsicum baccatum* var. *pendulum* accessions with yellow immature fruit, and the pod separates trait. 'Chili Piquin' and C001586 had the highest capsaicin values of 7.0 and 5.38 mg/g dry matter (DM), respectively.

Twenty-one accessions had traces of capsaicin $\leq$ the levels of 'Yolo Y' (0.92 mg/g DM) and should be subjected to taste panels to confirm their absence of pungency.

'Pangalengan-2', 'King Gum Go Chu', 'Cheong Yang', C01511, C01421, 'Kun Ja', PBC 384, PBC 385, and PBC 389 were chosen as new candidates for the 1991 INTHOPE trial at AVRDC, based on plant development, fruit morphology, and disease resistance.

Cool Season Observational Trials

Summary

Preliminary evaluations of 21 sweet and 30 hot pepper accessions were conducted during the 1989-90 cool season. Sweet pepper 'Melody F_1', 'All Big' and 'Lady Bell F_1' had higher yields than the check 'Blue Star F_1' (14.4 t/ha).

Entries 'Orias Kossarvu', R7-26(17), 'Long Fruit A', P.I.215743 and 'Slam Chili' were the five highest ranking hot pepper accessions based on fruit weight and *C. baccatum* var. *pendulum* 3-4, 'Cheong Yang', 'Szechuan 8', R1-26(17) and 'Long Fruit A' based on fruit number. These accessions will be entered in the 1991 INTHOPE evaluation at AVRDC.

Materials and Methods

Preliminary evaluations of 21 sweet and 30 hot pepper accessions were conducted during the 1989-90 cool season. Each plot contained 20 plants on a two-row bed with plastic mulch.

Data were collected from one replication for five harvest periods. The second replication was harvested for a seed crop. Cross pollination was protected by covering selected branches with nylon-mesh bags.

Results and Discussion

Sweet pepper 'Melody F_1', 'All Big' and 'Lady Bell F_1' had higher marketable yields than the check 'Blue Star F_1' (14.4 t/ha). Mean marketable yield for sweet pepper was 11.9 t/ha. Later in the season, all sweet peppers were susceptible by natural infection to the local virus complex (mainly CMV and CVMV). 'Orias Kossarvu', R7-26(17), 'Long Fruit A', PI 215743, and 'Slam Chili' were the five highest ranking hot pepper accessions based on fruit weight and *C. baccatum* var. *pendulum* 3-4, 'Cheong Yang', 'Szechuan 8', R1-26(17) and 'Long Fruit A' based on fruit number. Mean fresh weight marketable yield for hot peppers was 8.2 t/ha. Capsaicin levels in all entries were below 2.6 mg/g DM. These 10 hot pepper accessions will be entered in the 1991 INTHOPE evaluation at AVRDC.

1990 Summer Evaluation Trial

Summary

Fourteen sweet pepper accessions were evaluated for yield, fruit characteristics, and adaptation to the adverse climatic conditions of Taiwan's summer season. The experimental design was a randomized complete block with two replications. All plots contained 20 plants on a two-row bed with rice straw mulch and were bordered by plots of 'Early Calwonder'. Incidence of bacterial spot was high.

Although none of the varieties were outstanding in performance, 'Redlands Sweet Sue', 'Morgold', 'Sequeira Mendes', 'All Season' and 'Sinagtala', were better than average in performance and may be considered as recurrent parents in a backcross program aimed at improving sweet pepper for the lowland tropics.

Pepper Pathology

Evaluation of Peppers for Resistance to *Colletotrichum* spp., *Phytophthora capsici* and *Xanthomonas campestris* pv. *vesicatoria*

Summary

Anthracnose and Phytophthora blight, and bacterial spot are important fungal and bacterial diseases, respectively of pepper. Most commercial growers use copper-based and other types of fungicides to control these diseases. In this study, several pepper trials in the field were conducted to assess the incidence of anthracnose on pepper fruits and the severity of bacterial spot on leaves. Lines were also evaluated for resistance under controlled conditions by inoculating pepper fruits with *Colletotrichum* spp. and inoculating pepper seedlings with *Phytophthora capsici*. *Colletotrichum* spp. occurred on 23% of the unmarketable fruits before incubation and on 13% after incubation in one of the trials. There was less infection of *Colletotrichum* on unmarketable and on inoculated fruits of Hane See Toan, Punjab Lal, Huaruar and KKU Cluster. There was a significant positive correlation between infection on unmarketable fruits and the disease indices on inoculated fruits. In a second trial, incidence of *Colletotrichum* spp. on marketable fruits that were not inoculated was 53%. Hot pepper lines had an average bacterial spot leaf area infection of 5%, while sweet pepper lines had 37%. Five accessions, C 263, C 284, C 352, C 1187 and C 1784, were classified as resistant to *Phytopthora capsici*.

Introduction

Peppers are infected by several different genera of bacteria and fungi. Anthracnose and Phytophthora blight are important fungal diseases of pepper, while bacterial spot is one of the most important bacterial diseases. Under certain environmental conditions, these pathogens are known to cause significant yield reductions.

Anthracnose is caused by several species of the fungus *Colletotrichum*. Infection occurs on most plant parts, and symptoms are readily seen on fruits as sunken lesions. The disease is most prevalent under conditions of high humidity and abundant rainfall. When these conditions persist, commercial growers use fungicides to protect fruits. Since there are no commercially available peppers with resistance to anthracnose, AVRDC has concentrated on screening germplasm for sources of resistance.

Phytophthora capsici causes collar rot and blight on branches of pepper. The fungus is soilborne and may drastically reduce the population of plants in the field. Resistant sources have been identified and are used in most breeding programs. There are 10 accessions in the AVRDC collection that have been previously rated as highly resistant.

Bacterial spot, caused by *Xanthomonas campestris* pv. *vesicatoria*, occurs wherever peppers are grown. There are several races of the pathogen, and factors relating to partial resistance are often complex. Most of the AVRDC accessions and breeding lines have not been tested for resistance to bacterial spot.

These studies were conducted to 1) assess the occurrence of *Colletotrichum* spp. on fruit and the severity of bacterial spot on leaves of hot pepper and sweet pepper entries in replicated field trials, 2) evaluate fruits of peppers for resistance after they have been inoculated with *Colletotrichum* spp. under controlled conditions, and 3) inoculate accessions with *P. capsici* to evaluate resistance to Phytophthora blight.

Materials and Methods

Anthracnose on hot pepper fruit — trial 1. Seedlings of 16 entries were transplanted to the field on 7 February in a randomized complete block design with three replications. Each experimental unit was 1.5 × 6.75 m with 15 plants in each of two rows. The plots were not sprayed with fungicides.

Twenty unmarketable fruits (diseased and/or distorted) per plot were selected randomly from each entry on 29 May, 15 June and 5 July. Fruits were examined for anthracnose symptoms and for signs of *C. capsici*, *C. gloeosporioides* and other fruit-infecting fungi. Fruits that were not infected were washed with tap water, blotted dry and placed on wire-meshed screens in plastic containers. Sterile water (30 ml) was added to each container below the screen before containers were sealed inside polyethylene bags. Fruits were incubated at room temperature for 7-10 days, and then examined. Data on incidence of *C. capsici* and *C. gloeosporioides* were converted to percentages. Data from each assessment date and the average per cent incidence of all dates were analyzed by ANOVA, and means were separated by FLSD. The incidence of *Colletotrichum* spp. on fruits of entries were ranked by entry within each replication, the ranking averaged by replication, and then ranked again by line.

Twenty marketable fruits were selected randomly from each plot on 14 June and 5 July. Fruits were washed, blotted dry and punctured once with a five-pinned inoculation pen. The inoculum was prepared by transferring a stock culture to sterilized (autoclaved) soybean leaves. These were incubated for 10 days at 28°C without light. Colonies were flooded with about 10 ml of water and conidia were harvested. The concentration was adjusted to 3×10^6 conidia/ml. A conidial drop was placed directly on the punctured portion of the fruit.

Fruits were placed inside containers and incubated for 10-14 days at room temperature. Fruits were assessed by measuring the lesion area using the following scale: 1 = no lesion, 2 = > 0.5 mm, 3 = 0.5-1 cm, 4= 1-2 cm, and 5= > 2 cm. Data were analyzed for each inoculation time separately, and means were separated by FLSD. Ranks of percent incidence by line were calculated as previously described.

Anthracnose on hot pepper fruit — trial 2. Seeds of 43 entries were planted on 21 April and seedlings transplanted on 25 May. Unmarketable fruits were assayed on 24 and 31 August, 13 September and 4 October. Fruit number for each date varied depending upon fruit availability. Incidence of *C. capsici* and *C. gloeosporioides* was recorded on pre- and post-incubated fruit. Data for the four dates were summed within each entry for analysis. Healthy marketable fruits were inoculated with *C. capsici* and *C. gloeosporioides* on 30 August, 21 September and 1 and 11 October. Fruits were inoculated, incubated and assessed. Incidence of infection not associated with the inoculation point was also recorded after incubation. Ranks of percent incidence by line were also calculated.

Bacterial spot on hot pepper leaves — trial 2. Bacterial spot was assessed on 22 June, 10 and 24 July, 14 August and 5 September. Ten randomly selected plants per plot were rated for percent leaf area infected. Within each replication and assessment date, entries were ranked by their average percent leaf area infected. The rankings from the five assessment dates were averaged. The percent leaf area infected was averaged for all assessment dates. Data were analyzed as previously described.

Bacterial spot on sweet pepper leaves. Fourteen entries were evaluated on 9 and 22 July, and on 7 September from a field-grown sweet pepper trial. Ten plants for each of two replications were assessed by rating percent leaf area infected. The percent leaf area infected of the entries was ranked by replication and date of assessment, and averaged over each to attain an overall ranking. The percent leaf area infected was averaged over dates and analyzed.

Bacterial spot on leaves — observation trial. The percent of bacterial spot leaf area infection was assessed on 7 and 23 July and on 9 September from 10 plants for each entry. For each line, the percent of leaf area infected was averaged and analyzed by ANOVA using the assessment dates as replications.

Phytophthora blight — screening for resistance. Seeds of 239 accessions were planted in a sterile soil mix in flats on 14 August. There were eight accessions per flat and 10 plants per accession in three replications. PI 201234, Szechuan and Blue Star were included as highly resistant, moderately susceptible and highly susceptible checks. Inoculum of *P. capsici* was prepared as described in the 1989 AVRDC Progress Report. Plants were inoculated on 26 September and assessed on 18 October by counting the number of plants that had no visual symptoms.

Results and Discussion

Anthracnose on hot pepper fruit — trial 1. The incidence of *Colletotrichum* spp. on unmarketable fruits averaged over all entries and assessment dates was 36%. The incidence of infection on fruit before incubation was 23% and 13% after incubation. The first, second and third sampling dates had 38%, 46% and 24% incidence of fruit infection, respectively. Punjab Lal, Haue See Toan, Huaruar, KKU Cluster and Ubatuba Cambuci generally had the lowest incidence of infection, while Long Fruit, MC 4, Gwangju and Yangjiao had the highest.

The disease index for marketable fruit inoculated with *Colletotrichum* spp. averaged 3.7 and 3.2 for the two inoculation times. Haue See Toan had the lowest disease indices for both trials. Huaruar, KKU Cluster and Punjab Lal were not significantly different from Haue See Toan in both tests. Overall, these four lines did consistently better than the other lines tested. The correlation between total fruit infection of unmarketable fruits and the indices on inoculated fruits was r = 0. 49 for batch one and r = 0.63 for batch two.

Anthracnose on hot pepper fruit — trial 2. The average incidence of *Colletotrichum* spp. on unmarketable fruit that was preincubated was 28% and on post-incubated fruit, 15%. The average incidence of *Colletotrichum* spp. on both pre- and post-incubated fruit was 43% with a range of 16 to 86%.

Marketable fruits that were inoculated had an average disease index of 4.4, and 53% of these fruits were field-infected. The disease index increased from 2.5, 3.8, 4.3 and 4.5 from assessment dates 1, 2, 3 and 4, respectively. Percent of fruit infection decreased from early to late assessment dates (1 = 53, 2 = 30, 3 = 15, 4 = 12). There was a significant negative correlation (r = -0.54) between the disease index and fruit infection.

From these studies, it appeared that there were significant host differences with regard to infection. However, more research is needed to determine which factors affect these results; i.e., are these differences related to fruit size, chemical composition, wall thickness or waxiness? It is also not known how resistance fruit infection is associated with symptomless infection of other plant parts. In tests used to evaluate fruit resistance, it appeared that it is necessary to use fruits that are not latently infected. In this study lesion sizes from inoculation tended to be smaller if the fruits were already field-infected.

Bacterial spot on hot pepper leaves — trial 2. The average percent leaf area infected was 5.4% for all assessment times and entries. Jawahar 218 had the lowest rating of 1.5%. Twenty-nine entries had ratings that were not significantly greater than Jawahar 218. The five entries that had the lowest ranking after Jawahar 218 were Lv. 2323, Keriting, Hot Beauty (F1), Cipanas and Lv. 1583.

Bacterial spot on sweet pepper leaves. The average percent leaf area infected was 37% for the 14 entries. All Season and Morgold had the lowest ratings. These two entries also had the lowest ranking in the three observation dates. The lines with the highest ratings were All Big (64%) and Gypsy (63%).

Bacterial spot on leaves — observation trial. The percent of bacterial spot averaged over three assessments and 94 entries was 12%. There was a significant difference in leaf area infected between the entries. Sixteen lines had means of less than 1 standard deviation below the average. Entries C 00948, PBC 384 and MC 5 had the lowest average percent leaf area infected at 0.7, 1.1 and 1.2%, respectively; their ranks over the three assessments were 1, 3 and 5, respectively.

All of the data reported on bacterial spot in this report are from field experiments that were not inoculated. The fluctuation of ratings between assessment periods often varied. From these trials,

selected lines will be screened for resistance using three races of *X. c.* pv. *vesicatoria*. The best of these lines will then be reassessed in the field under inoculated conditions.

Phytophthora blight — screening for resistance. Most of the 239 accessions were susceptible to highly susceptible to Phytophthora blight. Accessions C 263, C 284, C 352, C 1187, C 1784 had over 80% plant survival. These and other accessions that had been reported highly resistant and resistant will be retested using other isolates and higher inoculum doses, and screened for foliar resistance.

Management Practices for the Control of Aphid-Borne Viruses in the Field

Summary

Nonpersistent aphid-transmitted viruses have been implicated as the major factor contributing to low yields of peppers in the tropics and subtropics where aphids are abundant year-round. Before reliable sources of resistance to these viruses or their vectors can be bred into cultivated pepper lines, measures that interfere with the landing behavior of the aphids or the transmission process to achieve some control should be developed. The application of insecticides is of little use because alighting aphids generally transmit the virus before they are killed by the insecticide. Eight treatments, comprising of mineral oil alone or with biweekly, pyrethroid insecticide alone, a detergent, an antitranspirant alone and with biweekly pyrethroid insecticide or with weekly skimmed milk and yellow sticky traps were tested on a hot pepper cultivar in a replicated field trial under high virus/vector pressure.

The highest yield was obtained with the antitranspirant combined with biweekly pyrethroid insecticide, followed by the check (weekly pyrethroid insecticide) and mineral oil combined with biweekly pyrethroid insecticide. These treatments also had the lowest number of plants with no aphids and the lowest virus incidence assessed by ELISA throughout the experiment.

A significant positive and negative correlation, respectively existed between marketable yield and the number of plants with no aphids (averaged across three assessments) and between marketable yield and percent virus incidence at 103 DAT.

Despite high aphid pressure, CMV was first detected only at 54 DAT, but reached 80-93% incidence at last harvest. The two other viruses, CVMV and PVY were first detected at 103 DAT and incidence by the end of the experiment was from 4 to 19% for CVMV and from 0 to 4% for PVY. The reason for the difference in incidence of the three viruses is not known.

Introduction

Control measures for nonpersistent aphid-transmitted viruses are aimed either at the landing behavior of the aphids or at interfering with the transmission process. The use of insecticides has been of little value because in most cases the aphids transmit the virus before the insecticide can kill them.

Mineral oils are known to interfere with the transmission process. They have been tried alone or mixed with insecticides with varying results. Success of oil sprays depends on complete coverage of the foliage with the oil and on the pressure of application, being best at 400 psi. Successful control of vegetable viruses has been attained in vegetables, particularly peppers and cucurbits in the USA and Israel (Loebenstein et al. 1985[1], Simons and Zitter 1980)[2]. However, there are also reports of oil

[1]Loebenstein, G., Deutsch, M., Franketl, H. and Sabav, Z. 1966. Field test with oil spray for the prevention of cucumber mocaic virus in cucumber. Phytopathology 56:512-516.

[2]Simons, J.N. and Zitter, T.A. 1980. Use of oils to control aphid-borne viruses. Plant Disease 64:542-546.

sprays failing to control virus in the field (Walkey and Dance 1979)[3], particularly under extreme epidemic conditions, when abnormally large numbers of alates are migrating. The best effect of oil is achieved during early plant growth. At later stages during the growing period, oils lose their efficiency.

Another approach in the control of aphid-transmitted viruses is the use of reflective surfaces to repel aphids. Covering the beds with aluminum-colored polyethylene has become a common cultural practice for many vegetable growers (Zitter and Simons 1980)[4]. However, the repellent effect is reduced when the reflective surface is covered by the crop foliage.

Color baits, such as sticky yellow polyethylene sheet placed above the canopy or located outside the field, and yellow polyethylene soil mulches have been shown to reduce the spread of CMV and PVY. Aphids are strongly attracted to reflected light in the spectrum range 500-700 nm (Zitter and Simons 1980, Cohen and Marco 1973)[5].

Other nonchemical control measures include the use of barrier crops and intercropping (Zitter and Simons 1980).

In this trial, various chemical and nonchemical treatments were tried in a spring planting of hot pepper at AVRDC.

Materials and Methods

The hot pepper cultivar Passion (Known-You Company, Taiwan) was used, with the following treatments: (1) mineral oil (SUNSPRAY E) (0.75%) applied at 4 l/ha (550 l spray fluid/ha) weekly; (2) mineral oil (0.75%) weekly with pyrethroid type insecticide every 2 weeks and alternating Kestrel (10%) at 1:1000 (1 l/ha) and Decis, 2.8 EC (1:1000) applied at 0.62 l/ha (600 l spray fluid/ha); (3) detergent (SAVONA-(R)) (1), weekly; (4) ABION(R) (1:500), weekly; (5) ABION(R) (1:500) weekly, with pyrethroid type insecticide (alternating Kestrel and Decis as above) every other week; (6) ABION(R) + skimmed milk (1%) weekly; (7) IVOG yellow sticky traps (40 × 25 cm) at approximately 50 cm above the canopy (four traps per plot) the height of the traps was adjusted when necessary; and (8) insecticide alternating Kestrel and Decis as above, weekly.

All chemicals were applied with a hand pumped knapsack sprayer, except for the mineral oil treatments which were applied with a CO_2 pressurized knapsack sprayer at 3.5 bar using 800067 SS nozzles.

Preplant fertilizer was applied on 7 March as 206 kg ammonia, 140 kg calcium and 52 kg phosphorus/0.36 ha. On 8 April, chlorfluazuron (5% EC), an insect growth regulator, was applied to all plots to ward off a severe attack of fruitworm.

All plots were covered with a locally produced two-sided plastic foil, with the silvery side up. This foil is commonly used by farmers mainly for weed control and for raising the soil temperature in spring plantings. It is also said to have some effect on aphid control.

The trial was arranged in an RCBD design with three replications. Plot size was 3 m × 4.5 m. Plots consisted of two beds with double rows of 10 plants per row. Plant to plant distance was 45 cm and distance between plots was 3 m to prevent drifting of chemicals to neighboring plots.

Seed was sown in an insect-proof screenhouse on 5 January, and transplanted to the field on 8 March. Artificially/mechanically inoculated plants were planted between the ends of each row (alternating CMV, CVMV and PVY infected plants) equidistantly, 1.75 m from the end plants of each row.

Aphid population on plants. Aphid counts were conducted on 2 April (25 DAT), 16 April (39 DAT), 2 May (55 DAT) and 19 May (72 DAT) on the two middle rows of each plot. A total

[3]Walkey, D.G.A. and M.C. Dance. 1979. The effect of oil spray on aphid transmission of turnip mosaic, beet yellows, bean common mosaic and bean yellow mosaic viruses. Plant Dis. Reptr. 63:877-888.

[4]Zitter, T.A. and J.N. Simons. 1980. Management of viruses by alternation of vector efficiency and by cultural practices. Ann. Rev. Phytopathol. 18:289-310

[5]Cohen, S. and S. Marco. 1973. Reducing the spread of aphid-transmitted viruses in pepper by trapping the aphids on sticky ploye thylene sheets. Phytopathology 63:12007-12009.

of 10 plants, consisting of five plants in the middle of each of the two center rows, were counted. The number of plants with 0 and more than 100 aphids was recorded.

Aphids above the canopy. To obtain information on the numbers of aphids moving in the field from plant to plant and above the field, yellow traps were placed at 25 cm and 80 cm above the canopy on 8-9 May. Traps were placed in the center of the plots of treatment 7. New traps were placed at 0800 hours, 1300 and 1700, and were removed at 1300, 1700 and 0800, respectively. Insects were counted on both sides of the sticky traps.

Aphid species colonizing the plants. On 17 April and 12 May, one leaf of each of five plants from an insecticide-free treatment was collected for identification of aphid species colonizing the plants.

Virus incidence. Virus incidence (CMV, CVMV, PVY) was measured on the two center rows of each plot (without the end plants). One leaf from the top, middle and bottom of each plant was collected. Leaves from individual plants were pooled and tested by ELISA. Seven ELISA tests were conducted on 9 April (32 DAT = days after transplanting, 19 April (42 DAT), 1 May (54 DAT), 24 May (77 DAT), 4 June (88 DAT), 19 June (103 DAT) and 10 July (124 DAT).

Yield. Total yield, fruit number and fruit weight were measured on the two center rows of each plot.

Data were analyzed by ANOVA and means were compared by LSD ($P \times 0.05$). To seek a correlation between yield, virus incidence and plants with 0 aphids, yield data were regressed against virus incidence and against plants with 0 aphids at different assessment dates. Virus incidence (at 54, 77, 88, 103 and 124 DAT; at the combined averages of 54, 77 and 88 DAT, 54 and 77 DAT, and all five assessments) and the number of plants with 0 aphids (at 26, 40 and 80 DAT, and at the combined averages of all three assessments) were also regressed using all possible combinations.

Results and Discussion

Aphid population on the plants. On 28 March, a heavy attack of aphids was observed in the field. The aphid population remained high throughout April and May. Table 1 shows the number of plants with 0 and > 100 aphids per plant at various times throughout the experiment. At the first assessment taken on 2 April (26 DAT) three treatments (2,5,8) had a significantly higher number of plants with 0 aphids than other treatments. In the succeeding assessments, conducted 40 and 80 DAT, treatment 8 had the highest number of plants with 0 aphids followed by treatment 5 and 2. On 19 May, at 95 DAT, none of the treatments had plants with 0 aphids, suggesting that by that time the aphids had already colonized all plants. Treatment 8 also had the highest cumulative number of plants with 0 aphids (5.3). This was followed by treatment 5 and 2, with cumulative averages of 4.4 and 4.1, respectively. These same treatments (2, 5 and 8) also had the lowest number of plants with

Table 1. Aphid incidence on the plants.[a]

Treatment	2 Apr	16 Apr	2 May	19 May	2 Apr	16 Apr	2 May	19 May
	----------0 aphids----------				----------> 100 aphids---- ----------			
1	6.3 ab[b]	0 d	0 c	0	0.7 bc	7.0 ab	7.0 bc	9.7 a
2	8.3 a	6.3 c	1.7 b	0	0 c	0 d	2.7 e	7.7 b
3	5.0 b	0 d	0 c	0	1.0 ab	4.0 c	5.0 d	9.3 a
4	6.3 ab	0 d	0 c	0	0.7 bc	6.7 ab	6.3 c	9.3 a
5	8.7 a	7.7 b	1.3 b	0	0 c	0 d	0.3 f	5.3 c
6	5.3 b	0 a	0 c	0	1.7 a	6.3 b	7.3 b	10.0 a
7	5.3 b	0.3 d	0.3 c	0	1.3 ab	8.0 a	9.3 a	10.0a
8	8.0 a	9.7 a	3.3 a	0	0 c	0 d	0 f	6.3 c
CV	20.54	18.00	48.9		81.0	21.04	12.15	7.23
LSD (0.05)	2.12	0.79	0.71		0.93	1.45	0.99	1.06

[a]10 plants in the center rows of each plot were assessed. [b]The numbers are averages of three replications.

> 100 aphids. The number of plants with 0 aphids was significantly positively correlated (r = 0.864) to the numbers of plants colonized by more than 100 aphids. Thus, in future experiments only the number of plants with 0 aphids will be used for assessment.

Aphid species colonizing plants. Leaf samples collected on 17 April were colonized by two species of aphids, *Aphis gossypii* and *Myzus persicae*. The first species was the predominant one. On samples collected on 12 May, only *A. gossypii* was found.

Aphid and thrips counts above the canopy. The highest number of aphids were caught from 1700 to 0800, reflecting higher aphid activities in the early morning hours before 0800. Significantly higher numbers of aphids were trapped on the high traps, particularly from 1700 to 0800 and 0800 to 1300. This may be an indication that aphids were caught while on long distance flights and were not merely moving from plant to plant within the plot. Thrips counts were low from 0800 to 1700 and no difference was observed between the high and low traps. However, judging from the high thrips counts on the high traps from 1700 to 0800, large numbers of thrips may have been migrating over the field in the early morning hours.

Virus incidence. Virus was not detected in the first and second ELISA test, conducted 32 and 42 days after transplanting (DAT). In the third ELISA test, conducted 54 DAT (1 May), CMV was found only in treatments 1, 2, 6 and 7, where average incidence was 4.2, 2.1, 6.3 and 6.3, respectively. CVMV and PVY were not found in the field at that time. In the other four treatments CVMV infection was delayed by about 23 days. CMV appeared only 77 DAT in treatments 3, 4, 5 and 8.

At the end of the experiment, at 124 DAT (10 July), CMV was present in all treatments, ranging from 80% incidence (treatment 5) to 95% (treatment 4). The incidence of CMV at all testing dates are shown in Table 2. CVMV was also present in all treatments, although at considerably lower incidence. Incidence ranged from 16.9 % (treatment 7) to 54% (treatment 2). PVY was only present in treatments 1,2,6 and 7, where incidence was 1.9, 1.9, 4.4 and 12.5 respectively.

Table 2. Virus (CMC) incidence.[a]

Treatment	ELISA 4 May 24 (77 DAT)	ELISA 5 June 4 (88 DAT)	ELISA 6 June 19 (103 DAT)	ELISA 7 July 10 (124 DAT)
1	12.5 b	20.5 b	79.9 ab	83.3 a
2	2.1 c	4.2 d	37.5 d	83.3 a
3	8.3 bc	12.5 c	77.1 a	89.6 a
4	2.1 c	18.7 bc	77.1 a	93.8 a
5	2.1 c	10.4 cd	52.1 c	79.2 a
6	20.8 a	37.5 a	81.3 a	89.6 a
7	8.3 bc	16.6 bc	72.9 ab	89.6 a
8	4.2 c	10.4 cd	60.4 bc	81.3 a
CV	53.2	29.1	11.5	11.7
LSD	6.9	8.3	13.2	17.5

[a]Three leaves from the top, middle and bottom part of each plant of the two middle rows without the corner plants (= 16 plants) were collected, pooled and tested by ELISA. [b]Numbers represent the average percentages of virus infected plants from 3 replications.

A highly significant correlation (R = 0.838 at 6 df) was found between virus incidence (averaged across the last five assessments) and the number of plants with 0 aphids averaged across all three assessments.

Also, virus incidence at 103 DAT was highly significantly correlated (R=-0.856 at 6 df) to the number of plants with 0 aphids at 26 DAT. A significant ($P > 0.05$) correlation of R = -0.813 and R = -0.816, respectively also existed between the average virus incidence averaged across the last five assessments and number of plants with 0 aphids at 40 DAT, and between virus incidence at 103 DAT and the number of plants with 0 aphids averaged across the three assessments.

Yield. The highest marketable yield was obtained in treatment 5, followed by treatments 8 and 2. Treatment 5 also produced the highest number of fruits and the largest fruits. The lowest marketable yield was produced in treatment 3 (Table 3).

Table 3. Effect of virus control measures on hot pepper yield.[a]

Treatment	Total Yield/Plot (kg)	Total Fruit No. /Plot	Average Fruit Weight (g)
1	6.1 e	639.8 b	9.2 d
2	9.5 b	797.7 a	11.8 b
3	6.1 e	636.0 b	9.5 cd
4	7.5 cd	836.7 a	8.9 d
5	10.8 a	841.3 a	12.9 a
6	6.9 de	740.7 ab	9.3 cd
7	8.1 c	822.3 a	9.8 c
8	9.9 ab	836.0 a	11.9 b
CV	8.19	8.16	3.36
LSD (0.05)	1.15	108.6	0.61

[a]The experiment was transplanted on 8 March; harvesting started 29 May; the last harvest was conducted on 27 July. [b]Numbers are means of three replications.

A highly significant positive correlation (R = 0.896 for 6 df) only existed between marketable yield and the number of plants with 0 aphids (averaged across all three assessments). Marketable yield was also significantly but negatively correlated to percent virus incidence at 103 DAT. None of the other assessed parameters was significantly correlated with yield.

Although the aphid population in the field was high throughout the experiment, starting from the time of transplanting to the field, virus was first detectable only at 54 DAT. CMV was the first virus detected; CVMV and PVY were detected much later, at 103 DAT. The reason for this is not yet understood but may involve the higher affinity of aphid species for CMV, an isometric virus, than for the other two viruses which are elongated flexuous rods. This will be the subject of future investigation. The highest marketable yield was obtained from treatment 5, which also had the lowest cumulative virus incidence. This, as well as treatment 8, also had the significantly highest number of plants with 0 aphids at the first assessment on 2 April. However at later assessments (16 April, 2 May) the number of plants with 0 aphids was slightly lower than that of treatment 8.

It was obvious that the three treatments with the highest marketable yield (treatments 5, 8, 2) also had the lowest cumulative virus incidence and the highest cumulative number of plants with 0 aphids, compared to the other treatments.

Screening of Germplasm for Resistance to Viruses

Summary

Emphasis in the 1990 screening was on cucumber mosaic virus (CMV) because of its worldwide importance and because sources of resistance in cultivated lines are not available. Screening was also initiated with the newly isolated tobamoviruses TMV, ToMV and PMMV. Additional sources of resistance were sought to PVY and CVMV, the most prevalent viruses on peppers in Southeast Asia. Several accessions and PBC lines were identified with 0% CMV incidence. One line was found to have resistance to CVMV. Resistance to PVY was detected in two accessions, five VC entries and two breeding lines. Several entries with resistance to ToMV, TMV and PMMV were identified. The tobamoviruses induced necrotic local lesions on resistant lines. Thirteen lines were found to have resistance to both TMV and ToMV. Two lines were resistant to the three tobamoviruses. Several lines were identified to have multiple resistance to potyviruses: five lines with resistance to PVY and CVMV, and one line with resistance to three potyviruses, namely PVMV, CVMV and PVY. Resistance to PVY and CVMV was also detected in several AVNET entries from Indonesia.

Introduction

Since resistance to CMV is not yet available in cultivated *Capsicum* germplasm, screening for three tobamoviruses, TMV, ToMV and PMMV, was initiated. Although various commercial pepper cultivars have reported resistance to ''TMV'', it is not clear to which one of the six recently characterized tobamoviruses this resistance refers to. Breeders previously often did not make a distinction between TMV and ToMV, and called PMMV a pepper strain of TMV. Thus, materials with reported resistance to ''TMV'' were retested to ascertain the exact tobamovirus to which several pepper cultivars have developed resistance. A few lines were also screened for resistance to CVMV. Several lines supplied through AVNET cooperators were screened for multiple resistance to viruses.

Materials and Methods

CMV

Mechanical inoculations were conducted using the procedure described in the 1989 Progress Report. Forty-eight plants per entry were screened for resistance to the isolate P-522, previously isolated from pepper and propagated in *N. glutinosa*. Seeds were also collected from a Korean line, previously found to contain a high percentage of CMV-resistant plants. Seeds of resistant plants were collected and subjected to a second CMV screening.

Tobamoviruses

Mechanical inoculations were done at the 3-4 leaf stage. Inoculum consisted of a homogenate of one part virus-infected fresh leaves in five parts 0.01 M phosphate buffer pH 7.0. The isolates used were P 1511 for ToMV, propagated in *N. tabacum* Samsum, isolate P 1508 of TMV, propagated in *N. sylvestris* and isolate P 1504 of PMMV propagated in *N. debneyii*. Twenty-four plants per entry were inoculated. The plants were rated visually. Ten days after inoculation, a DAS ELISA of each individual plant was conducted, or *N. tabacum* 'Xanthi' was inoculated. Inoculation produces local lesions in *N. tabacum* in the presence of all tobamoviruses. Plants inoculated with the three distinct highly contagious tobamoviruses were kept in strictly separate cages to avoid contamination.

ToMV. Six accessions, seven breeding lines and 40 VC lines were screened for ToMV.

TMV. Three accessions, eight breeding lines and the same 40 VC lines used in the ToMV screening were screened for TMV.

PMMV. Six accessions, eight breeding lines and the same 40 VC lines used in the ToMV and TMV screenings were screened for PMMV.

CVMV

Forty-eight plants per entry were inoculated using isolate 1037 propagated in *N. glutinosa* at a concentration of 1:4 (w/v) in 0.01 M phosphate buffer pH 7.0 containing 0.5% Na-DIECA, 0.5% Na_2SO_3 and 0.1 g/l activated charcoal.

Seven VC lines and 107 accessions were screened for CVMV resistance.

PVY

Twenty-four to 48 plants per entry were inoculated using isolate 311 for screening and 0.03 M disodium buffer pH 7.2 containing 0.5% Na-diethyldithiocarbamate, 0.5% Na-bisulfite and 20 mg active charcoal/ml.

Detection of lines with resistance to both CVMV and CMV

Forty-eight plants of VC 16a, 17a, 33a, 34a, 36a, 37a, 40a, 41a and 58, which were found resistant to CVMV and tolerant to CMV in previous screenings were inoculated at the 4 leaf stage with CVMV. Two weeks later, the stems were decapitated below the fifth leaf and the new flush was inoculated with CMV. After another 2 weeks the plants were again decapitated and inoculated with a mixture of CMV and CVMV. Two ELISA tests were conducted on the new leaves of the new flush 3 and 5 weeks after the last inoculation.

AVNET entries

Entries from AVNET cooperators included 29 landraces from Indonesia and six lines from the Philippines which were screened for resistance to PVY, CMV, CVMV, ToMV, PMMV and TMV.

Before sowing, seeds of all lines to be screened were treated with sodium triphosphate to remove any contaminating tobamoviruses.

Results and Discussion

CMV

With the exception of six lines (C-266, C-318, C 322, C 435, C 477 and C 551), which had 0-58% infected plants, all accessions were found susceptible, with 100% of the inoculated plants systemically infected. Symptoms observed were mainly of the mottle and mosaic type. A second screening will be conducted on seeds of the resistant plants. Among the other lines screened, several were found resistant (0% infection): PBC 147 and PBC 148, two selections from India, and PBC 199, an entry from Thailand. Several other lines which contained a high percentage of CMV-resistant plants were also identified: PBC 146, PBC 157, C 756 and VC 160. A single plant selection of a Korean line (KHN-15) previously found to contain a high percentage of resistant plants, was confirmed to be resistant.

CVMV

Of the seven VC lines screened, one (VC 160 *C. frutescens* PSP 11) was found immune to the virus. Two other VC lines (VC 183 and VC 185) had a high percentage of resistant plants, with infected plants ranging from 5 to 48%. The other VC lines were susceptible. All of the accessions screened were susceptible, having 100% infected plants.

PVY

Two of the accessions, C-6 and C 574, were found immune to PVY. Seeds of these plants were saved for a second screening. All other accessions tested were susceptible. Five VC lines (VC 16a, VC 40a, VC 58, VC 91, VC 183) were immune to the virus, and three (VC 90, VC 160, VC 184) had a high percentage of resistant plants. Seeds of the resistant plants were saved for a second screening. Two of the breeding lines, PBC 411 and 414, had no infection. The other lines contained some resistant individuals which were saved for a second confirmation screening. Several of the PVY-resistant lines (VC 16, VC 40, VC 58) also carried resistance to CVMV. Line VC 58 was resistant to PVMV, CVMV and PVY.

Tobamoviruses

Two distinct symptom types occurred: mosaic or mottle and necrotic local or seldom systemic lesions, sometimes followed by death of the plant.

ToMV. All six accessions, six of the seven breeding lines and 26 of the 39 VC lines were resistant to ToMV, reacting with necrosis and/or necrotic local lesions of the inoculated leaf without systemic infection.

TMV. The seven breeding lines and three accessions screened were susceptible to TMV, showing mosaic, mottle or symptomless infection. Sixteen of the 39 VC lines were resistant and showed necrotic local lesions. Thirteen lines were identified with resistance to both TMV and ToMV.

PMMV. All six accessions screened and all VC lines except VC 110, 112, 172, 174, 177 were found susceptible to PMMV. Two lines (VC 117 and VC 172) were resistant to all three tobamoviruses.

Lines with resistance to both CVMV and CMV

Lines VC 16a, 34a, 37a, 40a, 41a and 58a had individual plants with resistance to both CMV and CVMV. Seeds of these plants were collected for confirmation of this double resistance.

AVNET lines

Indonesian lines. Lines 32 and 103 were found resistant to both PVY and CVMV. Two other lines, 42 and 20, were resistant to only PVY. All other lines were susceptible to all the viruses tested. Resistance in these lines will be verified in a second screening.

Philippine lines. Lines P 3 and P 4 had a high percentage of individuals with resistance to PVY, but were susceptible to all the other viruses tested. The other lines were susceptible to all viruses tested.

Resistance to CMV, CVMV, PVY and tobamoviruses is present in various *Capsicum* germplasm. Among the lines screened, several were identified to have multiple virus resistance: VC 16a, VC 35, VC 36, VC 58, VC 160a had resistance to PVMV and CVMV; VC 40, VC 16 and two lines from Indonesia (line 103 and 32) to PVY and CVMV; and VC 58 was found resistant to PVMV, CVMV and PVY. Seeds of all resistant plants have been collected, so that their resistance can be confirmed in a second screening next year. Resistance to PMMV seems to be rare in the lines screened so far. Since the PMMV isolate used for the inoculations corresponds to pathotype P1.2 (Boukema 1984)[6], it is assumed that pepper lines with necrotic lesions and/or that died may carry the resistance gene L3 or L4. On the other hand, lines showing mosaic/mottle type symptoms were considered to either carry no resistance gene, or the L1 or L2 gene for resistance.

Further Characterization of CVMV

Summary

The relationship of CVMV, which has so far only been found in Asian countries, with other potyviruses commonly infecting peppers, particularly PVMV and PeMV, has not been clearly established. CVMV could be readily distinguished from PVMV and PeMV by host range, the molecular weight of the capsid proteins, the nature of their inclusion bodies and by serology (ELISA and ISEM). On 19 plant species/cultivars tested, the reactions of PVMV and CVMV were similar, but on 17 other hosts, the two viruses reacted quite differently. In SDS PAGE the apparent molecular weight of CVMV capsid protein was 32.2 KD, which was 2.2 KD higher than that of PVMV and PVY, and 1.2 KD higher than that of PeMV. Both CVMV and PVMV induced scroll type cylindrical cytoplasmic inclusion bodies. However, only CVMV produced laminated aggregates which were absent in ultrathin sections of PVMV-infected tissues. The viruses also differed in their nuclear inclusion bodies, which were very large and amorphous in PVMV-infected tissues compared to few and fibrous inclusions of CVMV-infected tissues. PeMV did not produce nuclear inclusions. By light microscopy of epidermal strips, the inclusions of PVMV and CVMV could not be distinguished, but were clearly different from those of PeMV and PVY. In ELISA, PVMV antiserum reacted with the homologous antigen, but not with PeMV and PVY. In immuno-electron microscopic tests, the homologous decoration titer for CVMV was 12,800, compared to only 40 for PVMV and 10 for PeMV. No additional strains of CVMV besides the two previously found, could be detected in this year's survey.

[6]Boukema, I.W. 1984. Resistance to TMV in *Capsicum chacoense* is governed by an allele of the L-locus. Capsicum Newsletter No. 3:47-48.

Introduction

CVMV was first described in Malaysia (Ong et al. 1979)[7]. At that time the host range, using 52 plant species, the physical properties of the virus, the virus morphology, seed and aphid transmission were determined. Serological relationships were investigated by agar gel double diffusion using antisera to three potyviruses, potato virus Y (PVY), tobacco etch virus (TEV) and pepper mottle virus (PeMV). No comparisons were made with pepper veinal mottle virus, another potyvirus, commonly infecting pepper s in Africa (Brunt and Kenten 1972)[8] and sometimes also reported in Asian countries. Inclusion bodies characteristic of potyviruses had also not been studied.

This study therefore aimed to further characterize CVMV, and particularly study its relationship with PVMV and PeMV, two other commonly occurring potyviruses of pepper.

Materials and Methods

Comparison of the host range of PVMV and CVMV

Thirty-six different plant hosts were tested. Five plants each of several plant species reported to be susceptible or resistant to either virus were mechanically inoculated with CVMV and PVMV. Inoculum was prepared by grinding two parts virus-infected leaves of *N. glutinosa* in five parts 0.01 M phosphate buffer containing 0.1% Na-EDTA. Plants were checked for symptom expression for 6 weeks in an insect-proof screenhouse at 22-31°C.

Virus purification

CVMV and PVMV were propagated in *N. glutinosa*, and PeMV in *N. sylvestris. N. tabacum* var. Xanthi served as the propagation host for PVY. The viruses were purified using a modified method of Lisa et al. (1981)[9]. The purity of the virus preparations was assessed by electron microscopy.

Serological tests

ELISA. The double-antibody sandwich (DAS) ELISA test was used. Solutions containing 4.20, 100 and 500 ng/ml purified antigens were prepared in extraction buffer (phosphate-buffered saline, pH7.4, containing 0.05% Tween-20 and polyvinylpyrollidone K-25). Three wells were coated with different dilutions of virus-specific IgG at 1:500, 1:1000, 1:2000 and 1:3000 and incubated for 4 hours at 32°C; enzyme conjugates were used at the same dilutions and incubated for 5 hours. Substrate hydrolysis was done for 30 min and the reaction was measured at 405 nm. The test was repeated three times.

Crude plant sap of CVMV, PVMV, PeMV and PVY-infected leaves centrifuged at 500 rpm for 10 min was also tested with different concentrations of CVMV and PVMV immunoglobulins.

Agar gel double diffusion test. Serological reactions of CVMV, PVMV, PeMV and PVY were conducted with antisera to CVMV and PVMV in medium containing 0.9% Noble agar (Difco), 1% sodium azide, and 0.5% sodium dodecyl sulfate (SDS). Antigens in plant extracts were prepared by grinding 1 g virus-infected leaf tissue in 1 ml 0.01 M phosphate buffer pH 7.0, followed by the addition of 1 ml of 3% SDS, and filtration through cheesecloth. The whole procedure was completed within 1-2 hours. The plates were incubated at room temperature for 24 hours. Pure viruses were used at concentrations of 800 ng/ml.

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[7] Ong C. A., G. Varghese and W. P. Ting. 1979. Aetiological investigations on a veinal mottle virus of chili (Capsicum annuum L.), newly recorded from peninsular Malaysia. MARDI Res. Bull. 7, 2:78-88

[8] Brunt A.A. and R.H. Kenten. 1972. Pepper veinal mottle virus, C. M. i/A.A.B. Descriptions of plant viruses. 4 p.

[9] Lisa, V., G. Boccardo, G. d'Agostino, G. Delavalle and M. d'Aquilo 1981. Characterization of a potyvirus that causes Zucchini yellow mosaic virus. Phytopathology 71:667-672.

Immunoelectron microscopy-decoration test. Antisera to three viruses were used: pepper mottle virus (produced at AVRDC against an isolate obtained from D. Purciful, Florida), CVMV (produced at AVRDC against the Malaysian isolate) and PVMV (produced at AVRDC against an African isolate obtained from A. Brunt, U.K.). Formvar-carbon-coated nickel grids were floated for 5 min on virus-infected plant extracts and washed with 20 drops of phosphate buffer. The grids were then incubated for 15 min on drops of antisera at various dilutions. After washing with 40 drops of water, staining with five drops of uranylacetate and drying, the grids were viewed in the electron microscope. The highest dilution of the antiserum which was able to decorate the virus particle was recorded.

Molecular weight determination of coat proteins

The molecular weight of the viral coat proteins was determined by sodiumdodecylsulfate-polyacrylamide gel electrophoresis (SDS-PAGE). Running buffers and gels (5% stacking gel, 12% separating gel) were prepared as described by Laemmli and Fabre (1973)[10]. Purified virus preparations were used at 200 μg/ml and mixed at a ratio of 1:1 in degrading buffer (0.1 M Tris-HCl, pH 7.2, 2% SDS, 2% 2-mercaptoethanol, 10% sucrose, 0.01 M EDTA and 0.005% bromo-phenol blue). After heating at 100°C for 3 min in boiling water the coat protein preparations were electrophoresed at 25°C in a vertical slab gel apparatus. The SIGMA low molecular weight calibration kit (14,300-66,000) was used for the protein standards. Electrophoresis was done using a constant voltage of 65 volt/cm for 2.5 hours. Protein bands were visualized by staining with Coomassie Blue R-250 for 1 hour, followed by destaining in several changes of methanol: acetic acid (3:1).

Comparison of inclusion bodies

Electron microscopy. Cytology of infected cells was studied in ultrathin sections of leaf tissues of systemically infected *N. benthamiana* embedded in Epon (Jones et al. 1980)[11].

Light microscopy. Light microscopic comparison of inclusion bodies was done as described by Christie and Edwardson (1986[12] and 1977[13]). Fresh plant material was used. The lower epidermis was stripped off from the underlying tissue and stained in a freshly prepared solution of Azure A (0.1% in 2 methoxyethanol). After briefly rinsing the strips in absolute ethanol they were examined under the light microscope at 1000x magnification.

Investigation of necrotic symptoms

Five AVRDC accessions (104, 436, 474, 467, 487) previously found to produce necrotic symptoms upon inoculation with CVMV were reinvestigated because this symptom type had never been reported before. Two sets of 48 seeds of each accession were sown on 22 January after treatment of the seeds with trisodium phosphate (12.5%) to eliminate any tobamovirus contamination on the seed surface. On 26 February one set of 48 plants was inoculated at the 4 leaf stage with CVMV; the other set of 48 plants was inoculated first (on 26 February) with tomato mosaic virus (ToMV-isolate P1511) followed 10 days later (8 March) by inoculation with CVMV.

An ELISA test for both viruses was conducted 4 weeks after the last inoculation of plants inoculated with CVMV alone. To confirm the presence or absence of contaminating tobamoviruses, two leaves

[10]Laemmli, U.K. and M. Favre. 1973. Maturation of the head of bacteriophage T4. I. DNA packaging events. J. Mol. Biol. 80:575-599.

[11]Jones, R.A.C., R. Koenig and D. E. Lesemann. 1980. Ann. Appl. Biol. 94:61-68.

[12]Christie, R.G. and J.R. Edwardson 1986. Light microscopic techniques for detection of plant virus inclusions. Plant Disease 70:273-279.

[13]Christie, R.G. and J.R. Edwardson 1977. Light and electron microscopy of plant virus inclusion. Florida Agr. Expt. Stations Monogr. Ser. 155 p.

of all inoculated plants were also excised and inoculated on detached leaves of *N. tabacum* 'Xanthi' which produces local lesions upon inoculation with tobamoviruses. Plants inoculated with both viruses were also tested by ELISA as well as by inoculation of *N. tabacum* 'Xanthi'.

Search for CVMV strains

Capsicum lines found resistant to CVMV in previous screenings were planted in spring 1990 in farmers' fields at different locations in Taiwan. In Tainan county and AVRDC the following lines were planted: VC 16 (31 plants), VC 33 (10 plants), VC 34 (8), VC 35 a (28), VC 36 (5), VC 37a (9), VC 40a (9), VC 41a (9), VC 58 (12), VC 160 (32) and PBC 122 (90).

In Pingtung three plants each of the same lines and in Chiayi, 31 plants of VC 16a and 27 of VC 35a were planted. After 2-3 months in the field, these plants were collected and their leaves tested by DAS ELISA for the presence of CVMV.

Results and Discussion

Comparative host range

Both viruses did not infect *Chenopodium amaranticolor*, *C. quinoa*, *Cucumis sativus*, *Ocimum basilicum*, *Solanum melongena* 'Black Beauty', Farmers' Long, Majy Long and *Nicotiana tabacum* Havana 425.

Both viruses reacted with the same symptoms on the following hosts: mosaic was produced on *Capsicum annuum* Delray Bell, Yolo Y, Early Wonder, Florida VR-2, Yolo Wonder and *C. chinense* Miscucho and *Lycopersicon esculentum* TK 70; On *C. frutescens* Tobasco, *N. benthamiana* and *N. clevelandii* both viruses reacted with mottle. *N. glutinosa* reacted with systemic chlorotic flecks, and later, mosaic; systemic latent infection was produced on *Sesamum indicum*. The hosts on which the reactions of the two viruses differed are shown in Table 4.

Although the two viruses produced the same symptoms on a number of hosts, distinctive differences were observed, particularly on *Datura stramonium* and in several of the tobacco and pepper lines tested which were infected only by CVMV but not by PVMV.

Table 4. Comparative selected host range of PVMV and CVMV.

Host	Symptom[a]	
	PVMVb	CVMVc
Capsicum annuum		
Perennial HDV (VC 16)	M	–
HDA 248	M	–
HDA 210 bis (VC 33a)	M	–
HDA 230 (VC 34a)	M	–
HDA 252 (VC 37a)	M	–
HDA 295 (VC 41a)	M	–
C. frutescens		
Greenleaf Tabasco	M	Mot
Datura stramonium	–	Mot, N, Vc
Nicandra physalodes	Vc, Mot	syst.n.ring spots
N. tabacum Samsun	L	syst.c.spots
Xanthi-NC	L	syst.c.spots
Xanthi	L	syst.c.spots
White Burley	c.spots (inocul. leaves)	syst.c.spots
N. sylvestris	–	syst. cLL -> nLL
Petunia hybrida	Mot	Def, Mot

[a]Symptom symbols: M = mosaic; Mot = mottle; N = systemic necrosis; Vc = veinclearing; cLL = chlorotic local lesions; nLL = necrotic local lesions; L = latent systemic ; syst. = systemic; = no symptoms, no virus detected by ELISA; -> = developing into. [b]PVMV isolate obtained from A. T. Brunt, U.K. [c]CVMV isolate No. 1037 from Taiwan.

Virus purification

Virus yields for CVMV, PVMV, PeMV and PVY were 20, 8, 67 and 56 mg virus/kg fresh weight, respectively.

Comparison of molecular weights of coat proteins

The apparent molecular weight (AMW) of the CVMV capsid protein was about 32.2 Kdaltons (KD) very similar to that of PeMV which had an AMW of 31 KD. The AMV of PVMV and PVY, however, was smaller, about 30.0 KD. On the basis of their molecular weights CVMV differs from PVMV, PVY and PeMV.

Comparison of inclusion bodies

Electron microscopy. Scroll type cylindrical inclusion bodies were present in ultrathin sections of all three viruses (PVMV, CVMV and PeMV) tested. In addition to these, curved laminated aggregates were observed only in CVMV-infected tissues (Fig. 1a), but were absent in PVMV-infected tissue (Fig. 2a). Nuclear inclusions were found in CVMV and PVMV-infected tissues. However, they were distinctly different in that the nuclear inclusions of PVMV-infected tissue were large amorphous (Fig. 2b) and very frequent, whereas in CVMV-infected tissues they were fibrous (Fig. 1b) and rarely found. PeMV induced large tubular/amorphous cytoplasmic inclusions not associated with the other four viruses tested.

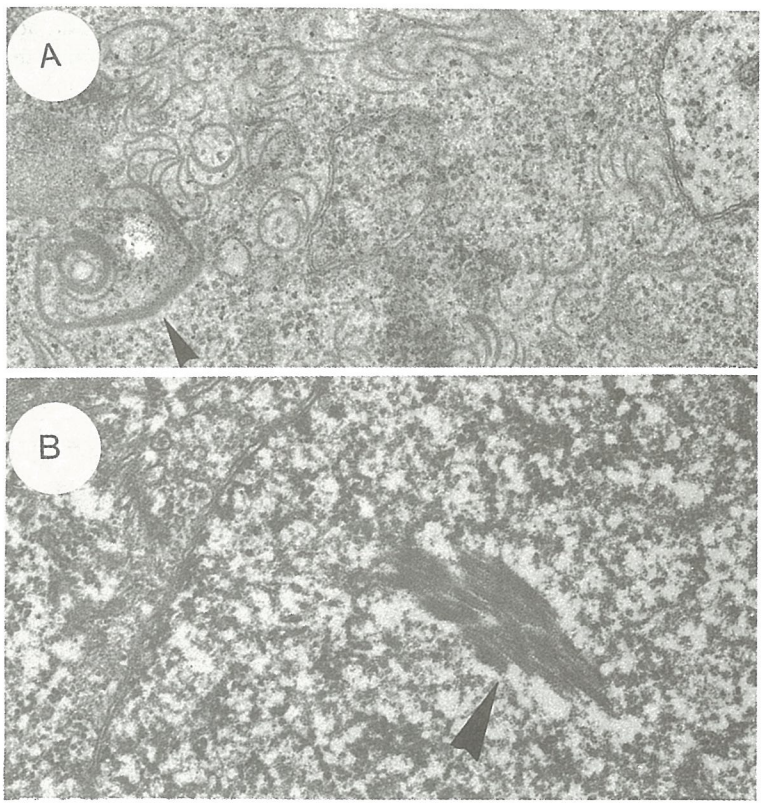

Fig. 1
Ultrathin section of leaf parenchyma cells of *N. glutinosa* (a) and *N. benthamiana* (b) infected with CVMV. (a) Pinwheels,scrolls and curved laminated aggregates (arrow) in the cytoplasm. (b) Nuclear inclusion composed of fibrous material (arrow). Magnification bars equal 500 nm (21 mm = 500 nm).

Light microscopy. PVMV and CVMV induced the same type of granular cytoplasmic inclusions with no clearly recognizable cylindrical elements. These inclusions could be clearly distinguished

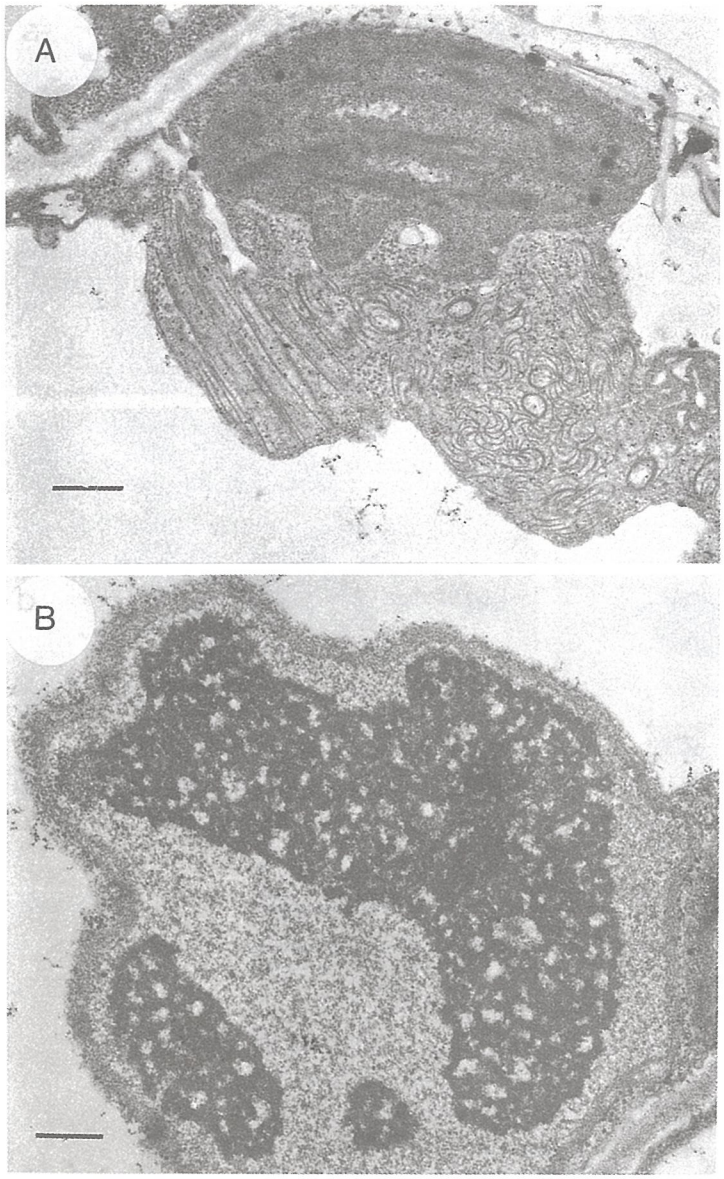

Fig. 2.
Ultrathin section of leaf parenchyma cells of *N. glutinosa* infected with PVMV. a) pinwheel and scroll inclusions in cytoplasm. b) Nuclear inclusion composed of amorphous material. Magnification bar equals 500 nm (12 mm).

from those of PeMV and PVY. PeMV and PVY induced much larger inclusions than those of PVMV and CVMV. PeMV-induced inclusions contained extremely long cylindrical elements, whereas those inclusions induced by PVY were much shorter (Fig. 3).

Serological tests

ELISA. Both CVMV and PVMV immunoglobulins reacted with the homologous but not the heterologous viruses down to a concentration of 4 ng virus/ml. Although the absorbance values were low, they were more than twice the values of the heterologous viruses.

At higher concentrations of 20, 100 and 500 ng virus/ml, absorbance values of CVMV immunoglobulins with the homologous virus were more than 10-, 15- and 20-fold higher respectively than those of the heterologous viruses. It was, however, noted that the absorbance values obtained

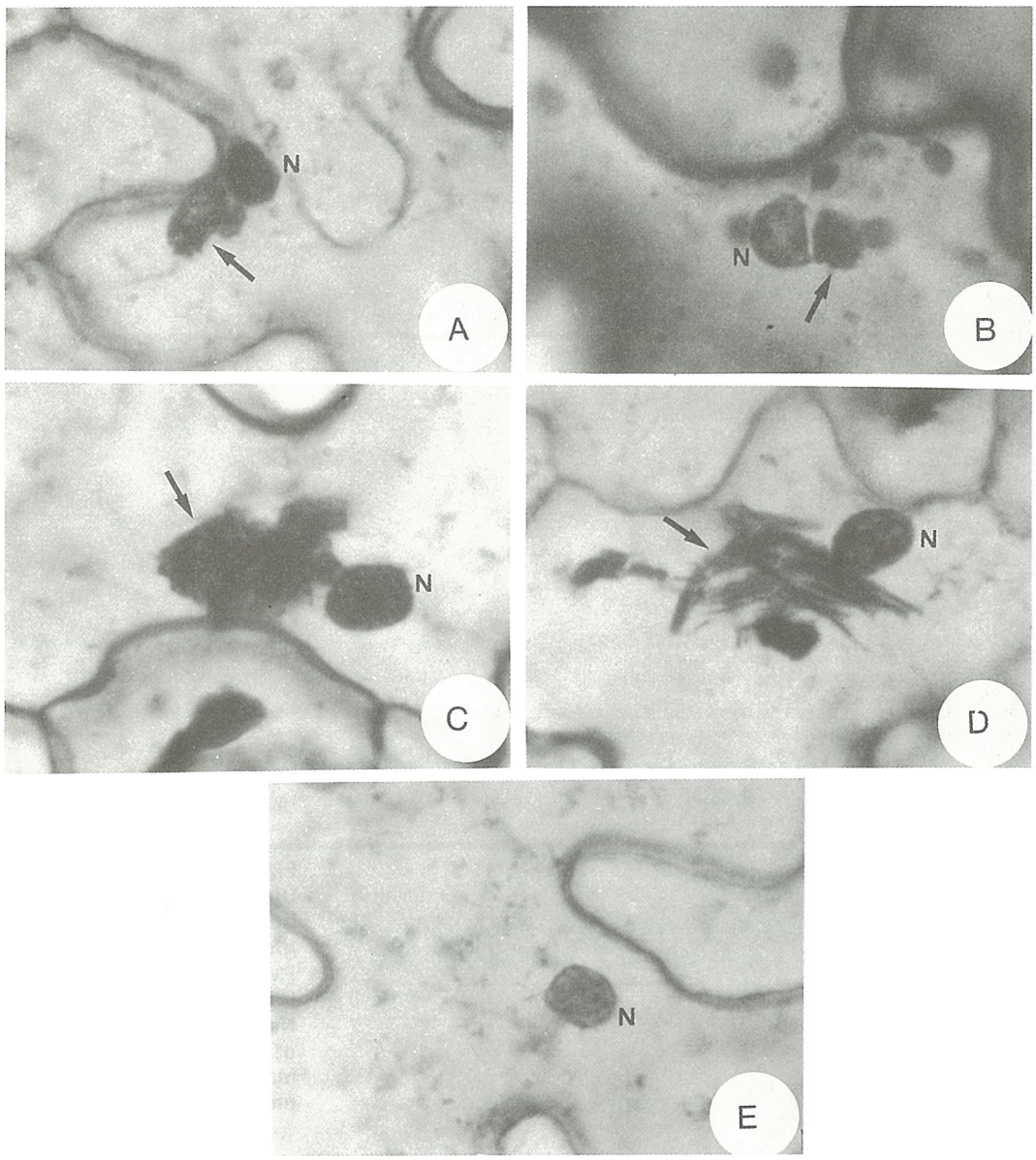

Fig. 3. Light micrographs of Azure A-stained cytoplasmic inclusion bodies of four potyviruses, A = PVMV, B = CVMV, C = PVY, D = PeMV, H = healthy plant tissue.

with PVMV were always higher than those obtained with the two other heterologous viruses, PVY and PeMV.

The reactions with PVMV immunoglobulins were similar in that high absorbance values were obtained only with the homologous virus and down to 4 ng/ml, but not with the heterologous viruses. However, here too it was noticed that at high virus concentrations the A_{405} values obtained with CVMV were higher than those with PeMV and PVY.

When the DAS ELISA test was conducted with different dilutions of the immunoglobulins, the homologous absorbance values were always more than 15-fold higher than those obtained with the heterologous viruses. However at high dilutions of the IgG (2000 and 3000X), only the homologous

viruses gave positive absorbance values. These results indicated that the four viruses are serologically not, or only very distantly related.

Agar gel immunodiffusion. A precipitin line was formed only with the homologous combinations. CVMV antiserum reacted only with CVMV antigen but not with PVMV, PVY and PeMV antigens. Similarly PVMV antiserum only formed a precipitin line with PVMV antigen. The results obtained by the agar gel test confirm those of the ELISA test, in that CVMV is serologically not related to the other three potyviruses (PVY, PVMV and PeMV).

Immunoelectron microscopy-decoration test

High decoration titers were obtained only for homologous combinations. CVMV particles from infected plant sap were decorated with homologous antiserum up to a dilution of 1:12,800. PeMV and PVMV particles were decorated with AS to CVMV only up to 10- and 40-fold dilutions, respectively.

Similarly, PVMV antiserum could decorate PVMV particles up to a dilution of 3200X, whereas PeMV and CVMV were decorated only up to 10- and 20-fold dilutions, respectively.

The low decoration titers of the heterologous virus/AS combinations indicate that CVMV and PVMV are serologically so weakly related that they should be considered as separate viruses.

Investigation of necrotic symptoms

A certain percentage but not all the plants of the five accessions tested reacted with necrosis after having been inoculated with only CVMV. In such necrotic plants there was no indication of the presence of any tobamovirus as evidenced by negative ELISA tests for ToMV and TMV and the absence of local lesions after inoculation of two leaves of such plants to *N. tabacum* 'Xanthi'. A similar percentage of plants inoculated with both ToMV and CVMV also reacted with the same type of necrosis.

Search for CVMV strains

CVMV could not be detected by ELISA, nor recovered from any of the 307 CVMV resistant ''bait'' plants, planted at AVRDC and at various other locations in Taiwan. This suggested that strains of the virus which may overcome the resistance previously found may be rare or absent in Taiwan.

Identification of Tobamoviruses

Summary

Tobamovirus isolates previously collected were classified as tomato mosaic (ToMV strain 0 and 1), tobacco mosaic virus (TMV) and pepper mild mottle virus. In this year's survey a fourth tobamovirus was isolated and characterized as tobacco mild green mosaic virus (TMGMV) by differential host range, agar gel immunodiffusion and an immunoelectron microscopic decoration test. The isolate corresponded to the pathotype P0 of the 'pepper strain' of TMV. The PMMV isolate recovered last year was found to correspond to pathotype 1.2 of the pepper strain of TMV. The four tobamoviruses so far isolated from peppers in Taiwan (TMV, ToMV, PMMV, and TMGMV) are now being used for resistance screening.

Introduction

Six tobamoviruses tobacco mosaic virus (TMV), tomato mosaic virus (ToMV), pepper mild mottle virus (PMMV), tobacco mild green mosaic virus (TMGMV), bell pepper mottle virus (BePMV) and dulcamara yellow fleck virus (DYFV) are known to infect *Capsicum* spp. (Wetter et al. 1987[14], Salamon et al. 1987[15]).

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[14]Wetter, C.I., Dore and M. Bernard, 1987, Bell pepper mttle virus, a distinct tobamovirus infecting pepper, H. Phytopath. 119 (4)333-344.

[15]Salamon, P.L. Beczner and R.I. Hamilton. 1987. Dulcamara yellow fleck virus (DYFV) a new member of the tobamovirus group isolated in Hungary. P. 44-48

By the end of 1989 three tobamoviruses had been detected and isolated from hot and sweet peppers in Taiwan. In this year's survey, additional samples were collected and tested for the presence of tobamoviruses.

Materials and Methods

Leaf samples were collected from peppers grown in various locations in Taiwan. Samples which produced local lesions on *N. tabaccum* 'Xanthi' were considered to be tobamoviruses. Following four single local lesion transfers on *N. tabacum* 'Xanthi' the isolates were transferred to *N. tabacum* 'Samsun'. The isolates were then inoculated to a set of 12 differential host plants, as proposed by Wetter et al. (1987) for the differentiation of tobamoviruses. To correlate the tobamoviruses with the pathotypes of the pepper TMV [as proposed by Boukema (1984) and Rast (1988)[16]] a second set of six differential host plants was inoculated, namely, *C. annuum*, Early Calwonder, *C. annuum* Tisana, *C. frutescens* Tobasco, *C. baccatum* (PI 260549) *C. chinense* (PI 159236) and *C. chacoense* (PI 260429).

For all host plant tests, soil was autoclaved at 120°C for 4 hours to eliminate any soil-contaminating tobamoviruses. Similarly, all seeds used were treated with trisodium phosphate (12.5% for 20 min) to eliminate tobamoviruses contaminating the seed surfaces.

The isolates were further tested by agar gel immunodiffusion tests using antisera to ToMV, PMMV, TMV, BPeMV and TMGMV. The tests were done in medium containing 0.8% Noble agar, 0.02 M Na-azide in 0.01 M phosphate buffer pH 7.5. Immunoelectron microscopic decoration tests were performed as described previously, using antiserum dilution of 50X and 800X, 1600X and 3200X.

Results and Discussion

Of 33 isolates collected, 32 were characterized as ToMV and two as PMMV. One isolate (3M) did not infect *L. esculentum* but infected *Eryngium planum*, a host which can only be infected by BPeMV and TMGMV. To obtain a pure isolate without contamination by other tobamoviruses, the virus was transferred from *N. tabacum* Samsun to *Petunia hybrida*, which reacts with local lesions with ToMV, BePMV and TMGMV. After three local lesion transfers on *Petunia hybrida*, one single lesion was inoculated to *Eryngium planum*. The virus was then recovered from *E. planum* and transferred to *N. sylvestris*. Following three single local lesion transfers on *N. sylvestris*, the virus was back-inoculated to *E. planum* from where it was transferred to *N. tabacun* Samsun for maintenance and propagation.

The reactions produced by isolate 3M produced on the differential hosts recommended for distinguishing tobamoviruses are shown in Table 4. The reactions, particularly the systemic infection of *E. planum* suggested that the isolate was either TMGMV or BPeMV. The exact identity of isolate 3M was determined by agar gel double diffusion tests. In agar gel double diffusion tests a continuous line without spur was formed only with TMGMV. In heterologous combinations spur formation was observed. Using crude plant sap, a high decoration titer of 1:1600 was obtained with TMGMV antiserum. PMMV, TMV and ToMV antisera gave decoration titers of 1:200, 1:400 and 1:200. On the basis of this host range and serological tests it was concluded that the isolate 3M was TMGMV.

Pepper breeders worldwide usually refer to different pathotypes of pepper strains as TMV, when dealing with tobamoviruses which only infect peppers but not tomato, such as PMMV, BPeMV or TMGMV. Therefore the pathotypes of the so-called pepper strains of TMV to which the isolates 3M and 1504 (= PMMV) corresponded were also tested. Table 5 shows that isolate 3M (= TMGMV) corresponds to pathotype P0 of the pepper strain of TMV, whereas isolate 1504 (= PMMV) corresponds to pathotype P1,2 of the so-called pepper strains of TMV. The four tobamoviruses recovered so far from peppers in Taiwan are maintained and propagated for use in resistance screening and for the production of antiserum. The production of monoclonal antibodies is being pursued in an attempt to prevent buildup of tobamovirus contamination in AVRDC soil and greenhouses and to produce large amounts of antisera which can readily and reliably distinguish these four tobamoviruses. When

[15] Boukema, I.W., K. Hansen and K. Hofman 1980. Strains of ToMV and genes for resistance in *Capsicum*. Proc. of Fourth *Capsicum* Eucarpia Meeting, Wageningen, the Nethe rlands. p. 44-48.

[16] Rast, A. Th. B. 1988. Tobacco mosaic virus in sweet pepper. p. 92-93. In: Annual Report 1980. Glasshouse Crops Research and Experiment Station, Naaldwijk, the Netherlands. 115 p.

polyclonal antisera are used, cross reaction is observed among the different tobamoviruses in both ELISA and agar gel immunodiffusion tests.

Table 4. Symptoms of isolate 3M and 1504 on a set of differential hosts used to distinguish tobamoviruses.

Host	Virus isolate	
	3M	1504
C. frutescens	NLLa	M
Chenopodium quinoa	NLL	NLL
Datura stramonium	NLL	NLL
Eryngium planum	SL	
L. esculentum	–	–
N. tabacum		
'White Burley'	NLL	
'Samsun'	M	SL
N. clevelandii	M	M
N. glutinosa	NLL	NLL
N. debneyii	CLL/M	M
N. sylvestris	NLL	NLL
Petunia hybrida	NLL	SL

[a]NLL = necrotic local lesions; CLL = chlorotic local lesions; SL = systemic, latent; M = Mosaic.

Table 5. Differentiation of pathotypes of the pepper strain of TMV.

Host	Proposed Genotype	TMV and ToMV	Pepper strain of TMV Pathotype			
			P0	P1	P1.2	P1.2.3
L. esculentum Bonnie Best	+ / +	M[a]	–	–	–	–
C. annuum Westlandia	L + /L +	SN	M	M	M	M
C. annuum Early Calwonder	L + /L +	M or SN	M	M	M	M
C. annuum Tisana	L1/L1	LL	LL	M	M	M
C. frutescens Tabasco	L2/L2	LL	LL	LL	M	M
C. baccatum PI 260549	L2/L2	LL	LL	LL	M	M
C. chinense PI 159236	L3/L3	LL	LL	LL	LL	M
C. chacoense PI 260429	L4/L4	LL	LL	LL	LL	LL

[a]M = mosaic, LL = local lesions, SN = systemic necrosis; – = no symptoms, no infection (Boukema, I.W., Jansen K. and Hofman K. 1980. Strains of ToMV and genes for resistance in *Capsicum*. Proc. Fourth *Capsicum* Eucarpia Meeting, Wageningen, the Netherlands. p. 44-48.; Boukema 1984; Rast 1988)

Pepper Physiology

Root Morphological Development of Peppers and Tomatoes Grown in Tissue Cultures at Various Temperatures

Summary

Root morphological development of two entries each of hot pepper, sweet pepper and tomato seedlings were examined at 19°, 24°, 29° and 34°C under in vitro conditions. None of the seeds, except hot pepper cultivar Szechuan, germinated at 34°C. Incubation at 29°C limited basal root development in most entries, except hot pepper cultivar, Passion. Hot pepper cultivar Szechuan, and sweet pepper cultivar Key Largo, produced no adventitious roots within 20 days under in vitro culturing.

Lateral root development of Szechuan and sweet pepper cultivars, Blue Star and Key Largo, was limited at or above 29°C. Seedlings of both tomato breeding lines, FMTT 3 and FMTT 22, produced lateral and adventitious roots readily. However, incubation at 29°C limited adventitious root formation in FMTT 22. Incubation at 29°C also tended to increase heat injury at 50°C of root tissue of all entries. Taproot length of all entries was also reduced by incubation at 29°C. Incubation at 29°C increased hypocotyl length in Passion, Blue Star, and FMTT 3, but decreased it in Key Largo and FMTT 22.

With shoot and root fresh weights as indicators of overall temperature response, 24°C appeared to be the optimum for all entries. These results raise the question as to the maximum duration that root temperatures can be elevated over the long-term optimum without harmful effects on root growth of hot and sweet peppers and tomato.

Introduction

High temperature and flooding of the root zone in pepper and tomato can reduce plant growth and yield. These two factors inhibit water and nutrient absorption by modifying the root morphology, or altering root sink strength. Root sink strength affects availability of CO_2 and H_2O, two essential reactants for photosynthesis, and also influences the RuBP carboxylase activation process. The characteristics of the root system of pepper and tomato plants differ. Lateral and adventitious roots are easily produced from the upper section of the taproot basal stem in tomatoes but not in pepper. Since roots of pepper are highly sensitive to high soil temperature and available soil moisture, these may be highly considered in stand establishment. This study determined the effect of temperature on the morphological development of pepper and tomato roots at seedling stage under in vitro conditions.

Materials and Methods

Seeds of hot pepper (Passion and Szechuan), sweet pepper (Blue Star and Key Largo), and tomato (FMTT 3 and FMTT 22) were first surface-sterilized for 20 min in 2% NaOCl solution, and then rinsed three times in sterilized water before sowing in test tubes (25 × 200 mm) at one seed per test tube. Each test tube contained 30 ml of Linsmaier and Skoog's (1965) basal nutrients appended with 100 mg/l myo-inositol, 0.4 mg/l thiamine HCl, 30 g/l sucrose, and 8 g/l agar. The pH of the medium had been adjusted to 6.5 before autoclaving, 600 mg/tube of activated charcoal was added

to darken the medium. Test tubes with seeds were placed in racks, covered with black polyethylene film, and incubated at 19°, 24°, 29° and 34°C, under light for 20 days. An RCB design with three replications was employed. The experiment was conducted four times from March to July 1990.

Number of days to germination (radicle protrusion) and full expansion of cotyledon were recorded. After germination, seedlings were sampled every 5 days for four times, and examined for hypocotyl length, number of basal and lateral roots, taproot length, and fresh weights of shoots and roots. The root tissue was investigated for heat injury at 50°C for 30 min by measuring conductivity of electrolyte leakage. Heat injury (%) was expressed in terms of electrolyte leakage after 50°C incubation for 30 min over the total tissue electrolyte.

Results and Discussion

Table 1 summarizes the effects of temperature on seedling growth and root heat injury of pepper and tomato seedlings after 20 days of in vitro culture. These results support the previous observation that hot peppers are sensitive to soil temperature exceeding 30°C.

Seedlings of Blue Star and Key Largo (sweet peppers) tended to have better shoot and root growth when incubated at 19° and 24°C than at 29°C. Incubation at 29°C also tended to increase heat injury of root tissue of both peppers at 50°C.

Seeds of both tomato varieties FMTT 3 and FMTT 22 also did not germinate at 34°C. Root tissues of FMTT 3 seedlings incubated at 29°C and obtained from later stages were sensitive to heat injury at 50°C. However, root tissues of FMTT 22 seedlings incubated at both 19° and 29°C were sensitive to heat injury. Incubation at 24°C was the optimum for growth of both FMTT 3 and FMTT 22.

In conclusion, the number of basal, lateral and adventitious roots, and the sequence of their development in peppers and tomato appeared to be under genetic control. The early emergence and high number of basal roots, and casual formation of adventitious roots in tomatoes may have been partially responsible for the high shoot and root fresh weight of both FMTT 22 and FMTT 3. However, further investigation is needed to determine if the sequence of root development and number of basal, lateral and adventitious roots are related to flooding response.

Table 1. Effects of temperatures on seedling growth and root heat injury of pepper and tomato seedling after 20 days of in vitro culture.

Entry	°C	Advent. root (no.)	Taproot length (cm)	Hypocotyl length (cm)	Shoot FW (g)	Root FW (g)	Heat Injury %
	19	0.4	7.3 b[a]	5.7 b	0.5	0.2 b	40 b
Passion	24	0.9	8.9 ab	6.2 b	0.6	0.3 a	54 a
	29	0.0	10.0 a	7.5 a	0.5	0.2 b	55 a
	19	0	10.6 a	4.9 a	0.5 a	0.2 a	45 c
Szechuan	24	0	10.9 a	6.5 a	0.5 a	0.2 a	61 b
	29	0	8.2 b	4.2 a	0.2 b	0.1 b	65 ab
	34	0	1.8 c	0.0 b	0.0 c	0.1 b	74 a
	19	1.7 b	8.2 a	2.9 c	0.8 b	0.4 a	33 c
Blue Star	24	4.0 a	8.6 a	4.9 b	1.2 a	0.4 a	38 b
	29	0.0 b	6.7 b	6.3 a	0.5 c	0.2 b	62 a
	19	0	6.8 a	4.2 a	0.3 a	0.1	46 b
Key Largo	24	0	6.2 a	5.3 a	0.3 a	0.1	71 a
	29	0	3.9 b	2.0 b	0.2 b	0.1	60 ab
	19	7.3 ab	6.4 a	7.6 c	1.6 a	0.5 b	47 b
FMTT 3	24	8.7 a	5.8 b	8.8 b	1.7 a	0.7 a	41 c
	29	4.3 b	5.0 c	13.0 a	0.8 b	0.1 c	56 a
	19	2.1 b	4.4 b	8.4 b	1.1 b	0.1	83 a
FMTT 22	24	3.8 a	5.2 a	9.2 a	2.0 a	0.1	40 c
	29	0.0 c	4.5 b	7.3 c	0.5 c	0.1	64 b

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

Responses of Sweet Pepper and Tomato Plants to Different Solution Temperatures

Summary

Functions of aerial and aqueous roots of sweet pepper (Blue Star) and tomato (FMTT 22) plants were studied using different solution temperatures in the aerated hydroponic system. The aqueous root system of tomato plants cultured at 32°C tended to acclimatize and had less heat injury at 50°C, whereas that of sweet pepper plants cultured at 18°C was sensitive to heat stress at 50°C. Oxidation activities of the aqueous root system in tomato plants were high at 32°C, but not in sweet pepper plants. Both aerial and aqueous roots of sweet pepper plants also tended to have lower oxidation activities than those of tomato plants. Both aerial and aqueous roots of tomato plants had higher nitrate reductase activities at 32°C than those at 18° and 25°C. Sweet pepper plants after 30 days of solution culture had only one-fifth the nitrate reductase activities of tomato plants.

There were some differences in physiological activities of the root system of both sweet pepper and tomato plants but these variations were not reflected in the overall dry matter accumulation in different plant parts. There was a great difference between sweet pepper and tomato plants in terms of dry matter accumulation in different plant parts; more dry matter was accumulated in the shoot and root of tomato plants regardless of solution temperatures. In terms of dry matter accumulation, tomato plants grew better than sweet pepper plants under hydroponic conditions. Sweet pepper plants generally accumulated less phosphorus than tomato plants under hydroponic conditions.

Introduction

A short period of flooding due to heavy rainfall often causes oxygen deficiency in the root zone, thereby reducing root respiration for root growth and absorption of nutrients and water. Eventually plants are reduced or killed, and yield in a unit land area decreased.

Similarly, high temperatures are also known to reduce root growth. Previous studies showed that tissue membrane of both aerial and solution-immersed roots of solution-cultured tomato plants were readily damaged by high solution temperature, but to a lesser extent in solution-immersed roots. On the other hand, the root system of soil-cultured sweet pepper was more sensitive to heat injury than that of tomato. This study investigated root structure and function of tomato and sweet pepper plants using different solution temperatures throughout the vegetative and reproductive phases in the aerated hydroponic system.

Materials and Methods

Seeds of sweet pepper (Blue Star) and tomato (FMTT 22) were sown in black, perforated plastic pots (ID 9-cm) containing smoldered rice husks on 26 February 1990. Pots were placed in plastic trays. Three weeks after sowing, seedlings with pots were transferred to polystyrene containers filled with aerating nutrient solution. There were two pots per container. The level of nutrient solution was maintained at 1 cm above the bottom of the plastic pots by adding water or nutrient solution until the roots emerged from the pots. Thereafter, the solution level was allowed to subside to 10 cm from the bottom of the pots, and maintained at that level throughout the rest of the experimental period. On 6 April containers were separated into three groups of solution temperatures: 18°, 25° and 32°C, using the solution cooling system. A split-plot design with three replicates and two plants/replicate or two plants/hydroponic box per treatment was employed.

During the course of the experiment, exact consumption of nutrient solution was monitored, and pH, dissolved oxygen level and electrical conductivity in the solution were monitored. At the initial temperature treatment, and 10, 20 and 30 days after the treatment, two plants per replicate were randomly sampled and observed for the following: 1) oxidation activity of the 1-2 cm root segments (2 g) expressed as α-naphthylamine (NA) oxidized/g fresh weight/hour, 2) nitrate reductase activities of the root system expressed as mmole NO_2 formed/mg protein/hour, 3) heat injury of root tissue expressed as tissue electrolytes conductivity at 50°C for 30 min/total tissue electrolytes conductivity $\times$ 100%, and 4) fresh and dry weights of different plant parts, and their N and P contents.

Results and Discussion

Solutions with sweet pepper plants maintained higher levels of dissolved oxygen (7.5%) than those with tomato plants (6.5%) throughout the 35-day treatment period. Within the same crop species, solutions at 32°C depleted more dissolved oxygen than those at 18° and 25°C. In the same period, solutions with tomato plants increased their electrical conductivity from 1.7 to 4.1 mmho/cm, whereas those with sweet pepper plants maintained about 1.6 mmho/cm. Solutions with tomato plants at 32°C had significantly higher electrical conductivity than those at 18° and 25°C. The pH of solutions with tomato plants increased from 6.5 to 8.0, and those with sweet pepper plants from 6.5 to 7.2.

Aerial and aqueous root tissues of sweet pepper and tomato plants maintained in 32°C solution for 30 days were less sensitive to heat injury at 50°C than those from 18° and 25°C. Since heat injury expressed as conductivity of electrolyte leakage could be used as an indicator to evaluate membrane thermostability, the results suggested that aqueous root tissues were acclimatized at high solution temperatures. On the other hand, both aerial and aqueous root tissues of sweet pepper plants cultured at 18°C for 10 days tended to be very sensitive to heat injury, suggesting a narrow range of optimum temperatures for the sweet pepper root system.

Oxidation activities of both aerial and aqueous roots of tomato plants at 32°C were higher than those grown at 18° and 25°C and tended to peak 20 days after hydroponic culturing. Oxidation activities of both aerial and aqueous roots of sweet pepper tended to be high after 30 days of culture in 18°C solution, with aerial roots having higher oxidation activities than aqueous roots.

Activities of nitrate reductase in both aerial and aqueous roots of tomato plants increased with time at 28°C and 32°C, but decreased in sweet pepper plants. Overall activities of nitrate reductase were higher in both aerial and aqueous roots of tomato plants than in those of sweet pepper plants.

After 30 days of culturing in three solution temperatures, there were no significant differences in flower and fruit number, and dry matter accumulation in different plant parts of sweet pepper as well as tomato plants, except dry matter accumulated in the root system of tomato plants cultured in 32°C. Regardless of solution temperatures, more dry matter was accumulated in tomato plants, especially in shoots, than in sweet pepper plants. These results suggested that tomato plants may have had better overall growth than sweet pepper plants under anaerobic conditions.

Solution temperatures did not seem to affect nitrogen content in leaf, petiole, and aerial and aqueous roots of sweet pepper and tomato plants . However, sweet pepper plants tended to have higher nitrogen concentrations in all plant parts than tomato plants.

Phosphorus concentrations in leaf, petiole and aerial and aqueous roots of tomato plants were not affected by solution temperatures, except for 20 days of culturing at 32°C (Table 2). During the first 20 days of culturing at 18°C, sweet pepper plant parts contained low phosphorus in leaf, petiole, and aerial and aqueous roots.

In conclusion, differences in the response of the root system of sweet pepper and tomato plants to solution culture may be attributed to their structure and function. The root of sweet pepper is woody, and therefore the structure facilitates flow of solution culture. Different solution temperatures resulted

Table 2. Phosphorus content of tomato (FMTT 22) and sweet pepper (Blue Star) cultured in three solution temperatures.

DAT	°C	Tomato				Sweet Pepper			
		Leaf	Petiole	Aer Root	Aqu Root	Leaf	Petiole	Aer Root	Aqu Root
10	18	7.1	7.8	10.0	14.8	4.3 b[a]	4.6 b	5.7	9.0 c
10	25	8.0	8.1	13.1	17.6	5.0 ab	6.0 a	6.8	13.2 a
10	32	7.8	7.1	12.3	37.5	5.5 a	6.4 a	5.6	12.1 b
20	18	6.6 b[a]	6.9 b	13.9	19.4 ab	4.0	3.2 b	5.9	11.1 c
20	25	8.8 a	8.8 a	16.5	27.1 a	5.1	5.4 a	7.2	12.8 b
20	32	5.9 b	6.3 b	13.0	14.5 b	5.1	5.7 a	8.9	14.5 a
30	18	6.60	7.33	10.6	22.1	4.1	3.2	7.9	14.8
30	25	7.54	7.97	9.7	20.0	3.9	3.9	8.1	12.5
30	32	7.36	6.93	8.6	17.6	4.9	4.8	8.5	12.1

[a]Mean separation within a column of the same stage at 5% level by DMRT.

in some variations in physiological activities of the root system. However, high ambient temperature in the greenhouse could have overridden the difference created by varying solution temperatures, and resulted in the comparable dry matter production within the same species.

Heat Response in Cultured Roots of Peppers and Tomatoes

Summary

Under in vitro conditions, heat-killing conditions for terminal root sections were 46°C, 90 min; 42°C, 90 min; and 42°C, 60 min for tomato (FMTT 3), hot pepper (Passion), and sweet pepper (Blue Star), respectively. The appropriate heat shock for inducing heat tolerance against heat-killing temperature is about 40°C, 2 hours for FMTT 3 tomato.

Introduction

The severity of high temperature stress is primarily determined by the temperature differential and the duration of exposure although other factors, such as rapidity of the change in temperature, previous growth conditions, etc. are also important. Species and genotypes within species differ in intrinsic heat tolerance of some vegetative tissues, especially leaves. To what extent the level of this intrinsic heat tolerance is genetically fixed is not certain however. The cause of the differences in heat tolerance of root systems is even less understood.

Elevated growing (sublethal) temperature induces hardening in many plants. Such thermal desensitization or acquired, temporary heat tolerance has been observed in many plants. Some reviews have therefore suggested that heat shock (i.e., brief exposure to supra-optimal temperature) and longer elevated growth temperatures have comparable effects on heat tolerance. This study examined the effects of brief heat shock (HS) on roots of peppers and tomato in liquid culture, and compared differences in species responses to heat shock.

Materials and Methods

Seeds of hot pepper (Passion), sweet pepper (Blue Star) and tomato (FMTT 3), were sterilized with 75% ethanol and 10% sodium hypochloride, and germinated in the dark for 4-7 days at 23-25°C. When the primary root reached a length of 20-25 mm, terminal 10-mm sections were excised and transferred to a petri dish containing Reinert and Yeomen (1982) medium. Terminal root sections were subjected to different temperatures (40-50°C) for various durations (30-90 min), and then incubated at 25°C for 7 days before measuring root growth. The most appropriate heat-killing temperature was then determined.

Heat shock was administered to seedlings of tomato (FMTT 3) by incubating them in 35°, 40° and 45°C for 0.5-6 hours. After HS treatment, 10-mm root sections were excised and treated with heat-killing temperature. The control was not subjected to any heat-killing temperature. After 7 days of incubation at 25°C, growth of root sections was then measured. Heat injuries were expressed as:

$$\% \text{ Injury} = 1\text{-(Root-tip growth increase after treatment/ Root-tip growth increase of control)} \times 100$$

Heat shock treatment, which rendered maximum heat injury using heat-killing temperature, served as optimum heat shock to induce heat tolerance.

Results and Discussion

Heat-killing temperature conditions were determined to be 46°C, 90 min; 42°C, 90 min; and 42°C, 60 min for tomato, hot pepper and sweet pepper, respectively. Roots of FMTT 3 seemed to be more heat tolerant than peppers. Among HS treatments for tomato, 35°C for 2-6 hours did not

induce root tolerance against heat-killing temperature (46°C, 90 min). However, 40 and 45°C for 2 hours induced a certain degree of root elongation under heat-killing temperature conditions (Table 2). Heat injury caused by heat shock was lowest under 35° and 40°C for 2 hours (Table 3). Therefore, the appropriate heat shock for inducing heat tolerance against heat-killing temperature was 40°C, 2 hours for FMTT 3.

Table 3. Effects of heat shock induced by heat-killing temperature on tomato (FMTT 3) terminal root sections.

	Heat Injury (%)		
	2 hours	4 hours	6 hours
35°C	100	84	100
40°C	51	52	94
45°C	40	70	72
Control	82		

Table 4. Effects of heat shock induced by heat shock on tomato (FMTT 3) terminal root sections.

	Heat Injury (%)		
	2 hours	4 hours	6 hours
35°C	12	5	13
40°C	19	43	42
45°C	46	59	80

Soybean Breeding

Hybridization

Summary

A total of 35 new crosses have been made to incorporate high yield potential and stink bug resistance from new Brazilian introductions to AGS lines. Seventeen crosses were intended to combine high yield and resistance to pests and diseases while 15 crosses were to study the narrowness and broadness of leaflets.

Introduction

AVRDC aimed to develop tropical vegetable soybean (VS) with high quality pod, high seed yield and other desirable horticultural characteristics. Combining multiple disease resistance, high yield and good seed quality were the main goals of the grain soybean crossing program.

Materials and Methods

Brazil sent four selections reported to possess high yield characteristics and pest and disease resistance. They were IAC 78-2318, IAC 80-4228, IAC 80-596-2 and IAC 100 (Rossetto, 1989)[1]. They were used to cross with some of the AGS lines which have been released as improved varieties by the NARS and with some of the national program varieties. Crosses made aimed to further improve the yield potential and to incorporate pest resistance.

Selected crosses were made to introduce downy mildew resistance into promising lines. Other crosses have also been made to improve the seed size and quality of Kaohsiung No. 1 vegetable soybean.

To study the inherited characteristics of extra narrow leaflet crosses and back crosses, 20 F_1s were planted in the field on 4 October 1990 and 15 F_1s in the greenhouse on 19 October 1990, respectively.

Results and Discussion

A total of 35 crosses were made. Seventeen crosses of these were intended primarily to combine high yield characteristics and pest and disease resistance. Two crosses were intended to combine downy mildew resistance and one cross to improve vegetable soybean.

Fifteen crosses in all were made to study the inherited characteristics of extra narrow leaflet, narrow leaflet, and broad leaflet.

Yield Trials

Summary

The results of 1989 yield trials suggested that the variance components for seasons were much larger than interaction or genotypic variance. Since the ranking of some of the genotypes remained

[1]Rosetto. 1989. Breeding for resistance to stinkbugs. In: World Soybean Research Conference V. A. H. Pascale, ed. Buenos Aires, Argentina p. 2046-2060.

unaltered regardless of seasons it should be possible to select multiple-season adapted genotypes. However, there were other genotypes which were highly season-specific. The yield in spring 1990 was affected by flooding during critical periods of growth.

Introduction

Promising breeding lines with high yield potential and multiple disease resistance were evaluated in intermediate yield trial (IYT) and advanced yield trial (AYT). Trials were conducted in spring, summer, and autumn. In this section, IYT in spring, summer, and autumn and AYT in summer alone will be discussed. AYT in spring and autumn will be discussed under soybean rust since they are related to soybean rust-resistance breeding. Vegetable soybean will be discussed separately.

Materials and Methods

Plot size for IYT was 3m × 2m, for AYT it was 6m × 3m. The harvest plot size for each of IYT and AYT was $6m^2$ and $10m^2$, respectively. Data on yield, other agronomic characters, and disease ratings were collected and analyzed. The genotypes and treatments were fixed while replications ran at random. Selection of entries from IYT to AYT was based on multiple criteria. Genotype × Season (G × S) response was evaluated from the combined analysis of the data. AVRDC's suggested cultural practices were used in growing the crops.

Results and Discussion

AYT- spring, summer and autumn 1989. Spring and autumn data will be presented and discussed in the soybean rust resistance breeding.In both AYT-I and AYT-II, highly significant differences were observed among genotypes and among seasons. The G × S was also significant. Significant seasonal, varietal and season × variety interaction effects were observed for AYT-I and AYT-II for spring plus summer, summer plus autumn and spring plus summer, plus autumn combinations. When the components of variance for yield were estimated for AYT-I and AYT-II, the Θ^2S (season) was found considerably higher (Table 1). This suggested that seasonal variation influences the yield response of genotypes much more than other factors. Yield varied depending upon the season.The Θ^2SG was much smaller than Θ^2S and therefore, it should be possible to select multiple season-adapted genotypes.

The ranking of some of these genotypes among two or three seasons remains unaltered, the change being only in terms of magnitude. However, there were other genotypes for which the change in ranking occurred between seasons. Such genotypes were highly season-specific. Their suitability to that specific season needs to be verified by evaluating them in different years in that season.

Table 1. Estimates of the components of variance for yield of AYT-I and AYT-II in 1989.

Component of variance	AYT-I			AYT-II		
	sp + su	su + au	sp + su + au	sp + su	su + au	sp + su + aua
Θ^2G	60675	31950	50375	23813	20675	19650
Θ^2S	949185	115998	488388	1168913	403073	589971
Θ^2SG	119375	136975	109950	80975	59125	66175
2	47700	36100	41000	46000	39200	47000

[a]sp, su, au: spring, summer and autumn.

IYT Spring, summer and autumn 1989. The results of pooled analysis of the data from spring, summer and autumn seasons for yield and 100-seed weight for IYT-I and IYT-II showed that there were highly significant differences among genotypes, seasons and G × S interactions for both yield and 100-seed weight (Tables 2 and 3). As in the past years the estimates of variance component indicated predominant effects of seasons for yield. For 100-seed weight, genotypic effect was large.

IYT-spring 1990. Out of 64 entries evaluated, nine entries yielded over 2.6 t/ha. Only GC 86018-427-3 significantly outyielded the two check cultivars. There were two other selections which

Table 2. Pooled analysis of IYT-I trial data in spring, summer and autumn 1989.

Source of variation	Yield				100-seed weight			
	DF	MS (0.1^6)[a]	F	Pr (F	DF	MS	F	Pr (F
Between genotypes (G)	35	0.357	3.83	0.0001	35	67.9776*	133.01	0.0001
Between seasons (S)	2	142.0875**	135.80	0.0011	2	137.0764**	193.14	0.0007
G x S	70	0.2791**	2.99	0.0001	70	4.3309*	8.47	0.0001
Error	105	0.0933**			105	0.5111		

[a]**, *significant at 0.05 and 0.01 P level, respectively.

Table 3. Pooled analysis of IYT-II trial data in spring, summer and autumn 1989.

Source of variation	Yield				100-seed weight			
	DF	MS (0.1^6)[a]	F	Pr (F	DF	MS	F	Pr (F
Between genotypes (G)	20	0.587**	6.31	0.0001	20	19.3858**	46.69	0.0001
Between seasons (S)	2	58.3502**	359.43	0.0003	2	20.6834**	10.86	0.0423
G x S	40	0.3956**	4.25	0.0001	40	2.665**	6.42	0.0001
Error	60	0.0931			60	0.4152		

[a]**, * significant at 0.05 and 0.01 P level, respectively.

had more than 3 t/ha (the yields were on par with check varieties) but they were resistant or moderately resistant to both bacterial pustule (BP) and downy mildew (DM) unlike the checks which were susceptible to at least one of the diseases.

Breeding Vegetable Soybeans

Summary

A number of lines vegetable soybeans (VS) adapted to the tropics and subtropics continued to emerge. GC 86018-427-3, GC 84058-18-4, GC 84051-9-1 and GC 84058-23-1, were confirmed to have high yield potential.

Trials were also conducted at Kaohsiung District Agricultural Improvement Station (DAIS). The length and width of two-seeded pods had excellent relationship to 100-seed weight in vegetable soybeans. GC 84136-P-4-1-8 continuously performed well both at AVRDC and at Kaohsiung DAIS.

Introduction

Vegetable soybeans (VS) have been used for a long time in the Orient. Japan, China, Indonesia, Korea, Nepal, Philippines, Taiwan, and Thailand produce and use vegetable soybeans. Japan imports vegetable soybean primarily from Taiwan. The domestic use of shelled beans and whole pods in Taiwan increased from 4,700 t in 1984 to 13,000 t in 1987. A great potential to produce and use vegetable soybeans exists in the developing Asian countries to improve the nutritive value of the cereal-based diet. Since vegetable soybean varieties adapted to the tropics were unavailable, AVRDC launched a vegetable soybean breeding program specifically for the tropics and subtropics.

The primary breeding objectives are productivity, adaptability to tropical latitudes, and consumer quality. The quality characteristics included pod and seed color, appearance, flavor, texture, taste, the size of pod and seed and number of seeds per pod.

This report discusses the vegetable soybean breeding activities and their results.These activities included greenhouse and field observation of newly introduced vegetable soybeans, generation advance, selection criteria studies, pedigree evaluation and yield trials at AVRDC and at Kaohsiung District Agricultural Improvement Station. They are reported under separate subheadings.

Materials and Methods

Thirty vegetable soybean varieties from commercial seed companies in Japan were evaluated along with two check varieties in the greenhouse. They were planted in 8 inch pots on June 1, 1990. Each entry was planted in 5 inch pots which served as the replications. Each pot had two plants. Data were collected on most of the vegetable soybean characteristics as described earlier. RCBD was used to analyze the data.

Trials conducted autumn 1989

Three trials were conducted in autumn 1989.

The trials were carried out in 3m × 2m plots. AVRDC's suggested cultural practices were followed. Observations were made on days to R_1 and R_2; 100-seed weight at R_6 growth stage, weight of graded pods (two and three-seed, unblemished pods) and total plant weight were taken for five randomly chosen plants from each variety from each replication. Number and weight of one-, two and three-seed pods and pod length and width of two and three-seed pods were observed. Number and weight of damaged pods were also collected. Harvest index for total pod weight, standard-pod weight, one-, two and three-seed pod weight were computed individually.

Trials from each season were analyzed individually. Spring data were presented in 1989. Autumn data and the combined analyses of spring and autumn data were presented in this report.

Yield trials at Kaohsiung DAIS in autumn 1989

Three yield trials were conducted at Kaohsiung DAIS during autumn season, 1989.Eight Japanese vegetable soybeans were evaluated along with one AVRDC breeding line and three check varieties in one AYT. PYT, IYT, and AYT compared all AVRDC breeding lines with three or four check varieties. The trials were planted following the harvest of the rice crop. Data collection was similar to that of AVRDC.

PYT. Out of 46 entries from five crosses evaluated, seven entries from two crosses appeared to be promising. The 100-seed weight and the length and width of pods were smaller in this trial compared to BC_1F_6 VS trial entries. However, the harvest index was higher than that of the BC_1F_6 VS trial. Therefore, an increase in the number of pods would result in the decrease in size of seeds.

IYT. The largest seed size observed among 46 lines was 85 g (fresh weight) and 41.8 g (dry weight) for GC 84126-7-3-1 and GC 84130-12-2-1, respectively. The highest standard pod yield with more than 70 g 100-seed weight was 262 g for five plants compared to check variety G 9053's yield of 218 g with 65 g 100-seed weight. Nineteen selections were made based on 100-seed weight, standard pod yield and graded pod yield harvest index.

The IYT data from spring and autumn were used to determine the relationship between 100-seed weight (dependent variable) and one of the following as independent variables, number of one-seed pods, number of two-seed pods, length and width of two-seed pods. Among them only length and width of two-seeded pods have significant close relationship to 100-seed weight. The regression equation for each of the above traits are given below:

100-seed weight and length of two-seeded pod
$Y = -0.8568 + 13.6041\ x$
100-seed weight and width of two seeded pods
$Y = 21.1135 + 33.9291\ x.$

In the past the length and width of pods were found to have significant relationship to 100-seed weight.

The regression of 100-seed weight with length and width of two-seeded pod was highly significant (Figures 1 and 2). From PYT, based on 100-seed weight, length and width of pods, and number of

standard-graded pod yield, nine out of 46 entries were selected for inclusion in the advanced yield trial.

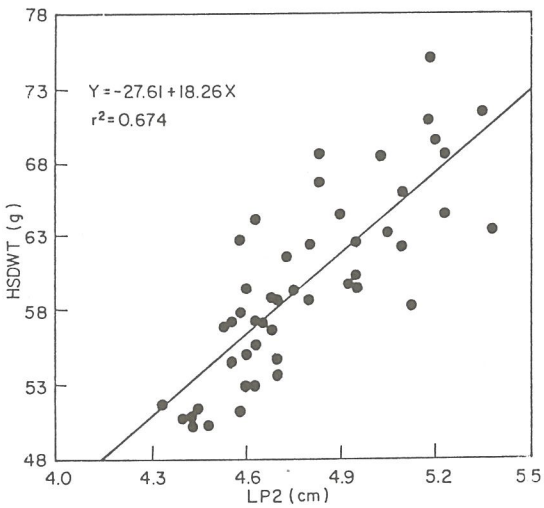


Fig. 1. Regression of HSDWT on LP2.

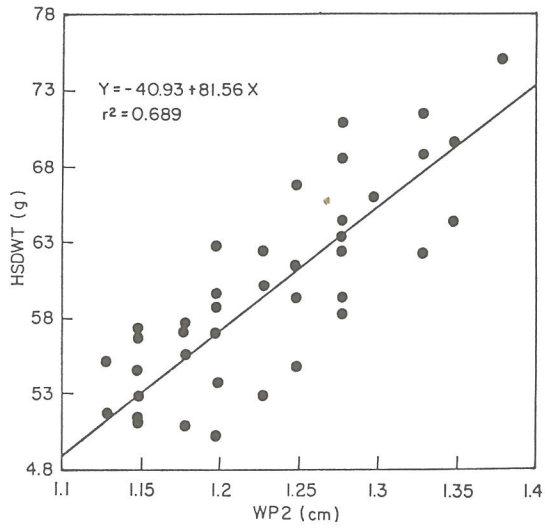


Fig. 2. Regression of HSDWT on WP2.

Yield trials at Kaohsiung DAIS, autumn 1989

PYT. From the 46 entries evaluated 11 entries were selected for further evaluation. Ten entries had significantly higher standard pod yield. The difference in 100-seed weight was, however, not significant.

IYT. Eight out of 46 entries evaluated had a 100-seed weight similar to or higher than that of AGS 292 (check). Among them, five had significantly higher-graded pod number than that of AGS 292.

AYT. Of the eight Japanese vegetable soybeans evaluated, none were higher yielding than any of the check varieties. However, GC 84136-P-4-1-8 significantly outyielded G 9053. Selected entries such as Blue Side and Kahori had fairly large seed size which will be valuable for the breeding program.

Yield trials in 1990 at AVRDC and at Kaohsiung DAIS

Observational trial of introduced vegetable soybeans in the greenhouse. Of the 30 varieties evaluated based on 100-seed weight, standard-graded pod weight and length and width of pod compared to G 10134, 10 entries were selected for further evaluation in the field (Table 4).

AYT at Kaohsiung DAIS. Sixteen entries, out of a total of 27 evaluated, had significantly higher standard-graded pod yield than that of AGS 292 (Kaohsiung No.1). The yield ranged from 3 to 4.9 t/ha (Table 5). There were no significant differences between entries for 100-seed weight. The highest total pod weight was more than 9 t/ha. Compared to AVRDC values, the harvest index using the standard pod was rather low in Kaohsiung. Environmental factors probably played a role in determining the standard pod harvest index. The seed size was fairly large and the number of standard pods for 500 g was well within 180 pods which was acceptable for export. However, at AVRDC the 100-seed weight tended to be smaller and a number of pods for 500 g was higher than those at Kaohsiung DAIS. Such differences between locations merit further investigation.

IYT spring 1990 at AVRDC. Selections GC 87010-2-1-28 and GC 87009-71-1-3 gave significantly higher standard graded yield of 11.4 and 12.1 t/ha compared to the check variety AGS 292

Table 4. Promising selections from Japan observational trial of introduced vegetable soybean in summer 1990.

Entry	Total Pod weight (g)	Days to maturity	Graded pod weight (g)	Graded pod %	Pod length/ 2 seeds (cm)	Pod width/ 2 seeds (cm)	100-seed weight (g)
Kinshu	74.7	74	34.4	70.4	5.1	1.3	68.6
Tsurunoko	68.5	66	25.0	79.9	5.3	1.3	53.6
Yukimusume	98.2	70	34.4	72.9	4.7	1.2	68.8
Fukura	67.7	70	32.9	88.5	4.6	1.1	74.3
Mikawajima	80.5	70	28.4	73.3	4.7	1.3	59.0
Shiratori	67.1	66	33.4	90.7	4.7	1.2	54.3
Shiroke-green 75	74.7	66	39.1	90.8	4.6	1.3	65.6
Karikachi # 3	89.2	74	36.2	73.7	4.7	1.2	75.7
Shironomai	106.0	74	63.8	90.4	5.3	1.3	61.2
Ofurisode	100	66	52.0	89.5	4.6	1.2	59.2
AGS 292	57.8	70	25.1	82.3	5.0	1.2	47.2
G 10134	78.5	79	29.9	72.9	4.9	1.3	64.6
Mean	71.1	69.3	31.7	82.0	4.6	1.2	58.7
CV	21.4	6.3	30.5	12.3	6.5	5.5	17.5
LSD	7.7	2.2	4.9	5.1	0.2	0.0	5.2

Table 5. Promising selections from KS DAIS AYT vegetable soybean, spring 1990.

Entry	Yield (t/ha) standard pod wt.	Yield (t/ha) total pod wt.	Harvest index	Standard pod harvest index	Days to maturity	Pod length/ 2 seeds (cm)	Pod width/ 2 seeds (cm)	100-seed weight (g)	No. of standard pod/ 500 g
GC 84128-9-2-1	4.9	9.3	55.8	29.7	88	5.0	1.3	81.3	173
GC 84130-7-2-1	4.9	7.3	51.5	33.7	84	4.5	1.3	79.8	158
GC 84128-17-2-1	4.2	7.2	46.7	27.3	81	5.3	1.4	81.0	152
GC 86056-35	3.9	7.9	52.1	25.1	88	4.7	1.2	68.8	185
GC 84128-16-3-2	3.7	5.8	48.5	30.7	85	4.8	1.2	91.3	157
GC 84129-6-1-1	3.7	6.1	51.9	30.9	78	5.2	1.4	90.0	142
Mean	2.8	5.5	46.22	23.94	81.5	5.1	1.3	85.7	156.7
CV	25.9	22.5	11.44	14.71	0.2	2.7	3.4	7.3	7.6
LSD (0.05)	1.0	1.7	7.42	4.95	0.2	0.2	0.1	8.8	16.6

(9.1 t/ha). The 100-seed weight was similar to that of the check variety. As stated earlier the number of standard pods per 500 g was slightly higher at AVRDC. However, when compared to the check varieties the higher yielding selections did not differ significantly in their number of standard-graded pods per 500 g sample.

AYT-I spring 1990 at AVRDC. Four selections produced significantly higher-graded pod yield than the check varieties, AGS 292 and G 9053. All the selected entries had a 100-seed weight of more than 60 g and the number of standard pods per 500 g did not differ significantly from those of the check varieties.

AYT-II spring 1990 at AVRDC. Three entries yielded 7.5 to 8.9 t/ha while the two check varieties yielded 6 to 6.2 t/ha for the two check varieties. High yielding selections were 1 week later maturing than AGS 292 and the seed size was slightly smaller than that of the check varieties.

Breeding for Soybean Rust Tolerance

Summary

In autumn 1989 soybean rust intensity was not high. The rust tolerance index (RTI) was high however, suggesting a higher level of tolerance to rust.

A combined analysis of AYT-I and AYT-II for spring and summer seasons indicated that the largest source of genotypic variance was the fungicide treatment (F) and season (S) × fungicide (f) interaction. The response to fungicide was season-dependent. Since the soybean rust incidence varies with season, care should be exercised in selecting for rust tolerance. Multiple season in multiple-years testing was required to select stable rust-tolerant genotypes.

Introduction

Four single genes for resistance to different races of *Phakopsora pachyrhizi*, soybean rust pathogen, had been identified by Hartwig in collaboration with the Frederick, Maryland laboratory. However, new races of the pathogen easily overcame the single-gene resistance. Since the yield loss due to soybean rust could be as high as 90% in the tropics and subtropics, incorporation of soybean rust tolerance was essential to increase yield at reduced cost.

Materials and Methods

In the split plot design, plots with fungicide and without fungicide were designated as the main plots and those with the genotypes were designated as the subplots. Plots with fungicide were not inoculated with soybean rust fungus. Plots without fungicide were inoculated with the inoculum. Data on percent soybean rust infection, yield, and 100-seed weight were collected and were subjected to pooled analysis to determine source of variation for various components. In analyzing the data, the genotypes, treatments and seasons were all assumed as fixed while the replication was considered random.

A pedigree yield trial was also conducted with 40 breeding lines selected in 1988. These entries derived from crosses made during 1986 specifically using PI 459025 as the key resistant source in combination with AGS 129. Data were collected on yield, 100-seed weight and rust-tolerant index (RTI) for yield and 100-seed weight. The trial was conducted in spring and autumn. A combined analysis of spring and autumn was conducted and selections were made based on yield, percent rust infection and 100-seed weight.

Results and Discussions

Yield trials in autumn 1989. In autumn for AYT-I, GC 81118-8-4 was the highest yielder both with and without fungicide treatment. The intensity of rust infection was not very severe in this trial as can be seen in percent rust lesion. As a result the RTI was quite high.

In AYT-II, the RTI and percent rust infection were similar to AYT-I.

The data from spring and autumn were pooled and analyzed. Variance components were calculated by equating appropriate mean squares to their expectations and solving for the respective variance components.

The variance due to season (S) × fungicide (F) interaction and the variance due to fungicide treatments were the largest source of phenotypic variance for yield in both AYT-I and AYT-II (Table 6). The magnitude of genotypic variance, variance due to seasons and other interactions differed in the two yield trials. Therefore, the phenotypic response due to fungicide treatment varied more with S × F interaction than with either genotype or with other factors or their interactions.

Table 6. Estimates of the components of variance for yield in spring and autumn 1989.

Component of variance	AYT I	AYT II
θG^2	50844	29875
θS^2	60410	10008
θF^2	232957	212279
θGS^2	61750	69638
θGF^2	53138	23488
θSF^2	298281	232877
θSFG^2	59450	24050
2	32100	78800

As discussed earlier, the incidence of soybean rust was different between spring and autumn. Therefore, the response to fungicide was also different. The ranking of the entries in spring and autumn according to RTI varied. Care should be exercised in selecting for soybean rust tolerance. If the rust infection is similar in both spring and autumn then it is likely that the variance component for S × F may not be as high as was noted in this trial.

AYT-spring 1990. The mean yield of 18 entries in fungicide treated and untreated plots were 2.21 and 0.76 t/ha, respectively. The differences in yield between the two treatments (with and without fungicide) were very sharp in almost all the test entries. The RTI was quite low for yield as well as for 100-seed weight suggesting that the tolerance to rust was low as well (Table 7).

It is important to mention that the rainfall during spring, particularly at R4 stage onwards was very heavy and there was excess moisture stress due to flooding. At harvest time there was also heavy continuous rain which resulted in poor quality seeds. The yield loss also was possibly caused by the combined stress of excessive moisture and soybean rust.

The combined analysis of spring and autumn 1990 will be presented in the 1991 report.

Table 7. Differences in yield, percent rust infection, and 100-seed weight of selected entries from AYT in spring 1990.

Entry	Yield (t/ha)		100-seed wt.		Rust lesion %		RTI	
	with	without	with	without	with	without	Yield	100 seed wt.
	-----fungicide-----		fungicide ----------(g)----------		-----fungicide-----			
GC 86025-10	2.7	0.8	14.9	10.0	29	57	29	67
GC 84036-22-5-1	2.6	1.0	16.6	10.0	14	42	38	60
GC 87009-71-1-28	2.5	1.3	30.8	19.8	11	41	53	64
GC 86056-11	2.5	0.6	19.9	11.7	27	47	23	59
GC 82334-7-8	2.4	0.6	13.1	9.1	30	67	24	69
GC 81027-6-15-1	2.4	0.7	13.6	7.7	48	55	29	57
GC 86056-40	2.3	1.2	26.7	17.7	4	38	51	66
GC 81027-6-10	2.3	0.9	13.4	8.3	35	51	38	62
AGS 129 (ck)	2.7	0.8	14.9	8.3	26	47	31	56
AGS 302 (ck)	2.6	1.3	21.0	14.7	10	48	48	70
AGS 181 (ck)	2.0	0.8	16.1	10.8	17	50	39	67
Mean of 18 entries	2.2	0.8	17.6	11.8	25.3	51.8	34	67
CV	8.0	13.7	5.1	7.2	36.8	15.4		
LSD (0.05)	0.3	0.2	1.3	1.2	13.2	11.3		

Yield trial of selected breeding lines, spring 1990

From the evaluation of 268 breeding lines in 1989, forty-four promising selections were screened in yield trial during spring 1990 in a split plot design using the treatment with and without fungicide. The top ten entries with high RTI for yield and 100-seed weight and with high yield potential are given in Table 8. Compared to rust tolerant AGS 181 the RTI for yield and 100-seed weight were fairly high indicating better level of tolerance in those lines.

Selection of Bacterial Pustule Resistant Lines

Summary

A total of 135 breeding lines from grain and vegetable soybean yield trials were screened for bacterial pustule resistance by artificially inoculating the plants in the field. Nine check varieties were used for relative comparison. About 31% of the test lines were either moderately or highly resistant to bacterial pustule.

Table 8. High yielding and rust tolerant lines selected from rust trial during spring 1990.

Entry	Yield (t/ha)		Days to maturity		100-seed weight		RTI	
	with	without	with	without	with	without	yield	100
	------fungicide------		------fungicide------		------fungicide------		seed wt.	
					----------(g)----------			
GC 86059-6	4.3	1.6	102	94	20.2	12.5	38.0	61.9
GC 86004-727	4.2	1.8	103	96	18.5	13.8	42.9	74.6
GC 86004-189	4.1	2.1	99	94	18.4	13.6	50.6	73.9
GC 86004-249	4.0	2.2	102	98	21.2	15.4	54.1	72.6
GC 86004-721	3.8	1.7	98	90	18.4	13.5	43.9	73.4
GC 86004-422	3.8	2.4	101	89	20.2	15.6	61.8	77.2
GC 86004-745	3.8	1.9	102	96	20.5	15.6	49.3	76.1
GC 86004-128	3.7	1.8	100	94	18.4	13.5	49.7	73.4
GC 86004-756	3.7	2.8	101	94	18.5	15.7	76.5	84.9
GC 86004-735	3.7	2.5	100	95	19.4	15.9	68.9	82.0
AGS 129 (ck)	3.9	1.3	98	91	15.6	9.6	33.0	61.5
AGS 181 (ck)	2.3	0.8	86	83	15.3	10.3	35.7	67.3
AGS 302 (ck)	2.1	1.2	96	85	18.8	15.3	55.2	81.4
TK 5 (ck)	2.1	0.2	94	89	13.7	10.0	8.5	73.0
Mean of 44 entries	3.3	1.6	97.6	90.5	18.8	13.9		
CV	14.3	16.8	2.3	3.0	5.0	5.1		
LSD (0.05)	0.9	0.6	4.53	5.4	1.9	1.4		

Introduction

Bacterial pustule caused by *Xanthomonas phaseoli* var. *sojensis* is a serious disease during the hot, wet season. The disease causes premature defoliation in infected plants and the yield loss could be up to 50 %. Resistance to bacterial pustule is governed by a recessive gene 'rxp'. To select only the resistant lines for distribution to cooperators, all the breeding lines are routinely screened separately for bacterial pustule in summer.

Materials and Methods

A total of 135 breeding lines and nine check varieties from AYT, IYT, AYT VS I, AYT VS II, and IYT VS were planted in July 1990 in a 2m × 1m plot. There were two replications. The experiment was conducted using a randomized complete block design (RCBD). The plants were inoculated with a bacterial suspension. At the time of inoculation the plants were in R1 to R2 growth stages. Relative to the check varieties used, the test entries were rated as highly resistant, moderately resistant, moderately susceptible and highly susceptible.

Results and Discussion

Out of 135 entries evaluated 14 were rated as highly resistant, 28 were moderately resistant and the rest were either moderately or highly susceptible.

Cooperation with National Agricultural Research Systems (NARS)

Summary

Twenty-four scientists from 19 countries received 143 vegetable soybean lines from AVRDC for their evaluation. Similarly, from 39 countries 60 cooperators received seven ASETS and 506 enhanced germplasm for their trial and use. In the Philippines, a soybean line LGSY 01-24 (Clark 63 × AGS 129) was released as PSBSY-1 or La Carlota Soy 1 by a former trainee, Remedios B. Almodiente at the La Granja National Crop Research and Development Center. At the BPI Economic Gardens in Los Baños, Rosita R. Matias, B.M. Legaspi and G.P. Lanting released AGS 19 as BPI-Sy 6 or Saguisag.

Introduction

The National Agricultural Research System (NARS) from different countries request germplasm and improved enhanced genetic materials for their evaluation and utilization either for use in their research program or for direct use by their farmers. The NARS scientists provide feedback to AVRDC identifying superior or weak AVRDC materials in relation to their native materials. They also inform AVRDC of the problems that need to be resolved. Such valuable information helps AVRDC to refine its research program so that it can complement and supplement the efforts of the NARS scientists to hasten solutions to the problems of soybean production.

New Variety Release

In the Philippines, a former AVRDC trainee, Remedios B. Almodiente helped to develop and release a new variety called PSBSY-1 or La Carlota Soy-1. It was officially approved by the Philippines Seed Board for commercial planting in June, 1990. Nestle, Philippines, the primary buyer of soybean, accepts the quality of the new soybean for their use.

As of December, 1990, 10 countries have officially released to farmers 18 varieties of AVRDC soybeans. R.R. Matias, B.M. Legaspi and G.P. Lanting from BPI Economic Gardens in Los Baños have released AGS 19 as BPI-Sy 6 or Saguisag. It is a narrow leaflet variety.

Distribution of Germplasm, Elite Lines, and AVRDC Soybean Evaluation Trial (ASET)

Twenty nine scientists from 20 countries requested and received from AVRDC 52 AGS lines, 106 Glycine cross (GC) pedigrees, and 77 accessions of vegetable soybeans. Sixty-nine cooperators from 40 countries received from AVRDC 7 ASETs, 234 AGS lines, 316 GC pedigrees, and 141 accessions.

Two cooperators, one from the Philippines and another from Thailand have returned the data for ASET. Among the 12 entries evaluated in the October 1989 planting (dry season) at Los Baños in the Philippines, AGS 268 significantly yielded higher (1.90 t/ha) than those of the two local check varieties, BPI Sy4 and UPL Sy4 (Table 9).

Table 9. Summary of international cooperation results.

Country Entry Location Cooperator	Yield (t/ha)	Days to maturity	100-seed weight	Seed quality (g)	No. of plants	Harvested
Philippines						
Lat. 10°5'N	AGS 268	1.90 a	94 a-e	21.2 b	3 a	159 a
427 FT.AGS 85	1.80 ab	93 c-f	15.5 e	3 ab	159 a	
Ms. Rosita R.	AGS 208	1.78 abc	93 b-f	24.1 a	2 abc	118 a
Matias AGS 299	1.69 a-d	92 def	16.5 de	3 ab	117 a	
Date planted:	AGS 304	1.65 a-d	96 a	7.1 g	1 d	117 a
Oct. 20, 1989	BPI Sy4 (ck)	1.60 bcd	95 abc	16.3 e	1 d	138 a
T: 12, R: 4,	UPL Sy4 (ck)	1.56 b-e	95 a-d	17.9 cd	2 cd	117 a
Dry season						

Twenty-four entries were evaluated in Khon Kaen, Thailand. The trial was planted on June 21, 1989. A local dressing of N, P, K at the rate of 18, 56, 75 kg/ha was used. Experiment was conducted using RCBD with two replications. Two varieties from AVRDC, GC 82341-14-2 and GC 82341-7-2 gave significantly higher yield than the local check SJ 5 (Table 10). Cooperator was Dr. Sadao Hatta.

Vegetable Soybean AYT in Thailand

Two AVRDC vegetable soybean breeding lines, six Japanese varieties and three check cultivars were planted in January, 1990 at the Chiang Mai Field Crops Center. The plot size was 3 m × 6 m.

Table 10. High yielding lines selected from a yield trial in Khon Kaen, Thailand, 1989.

Entry	Yield (t/ha)	Days to flowering	Seed maturity	100-seed quality	Weight (g)
GC 82341-14-2	2.5	69	106	1	10.7
GC 82341-7-2	2.5	67	108	2	14.9
GC 86033-27	2.0	64	107	2	14.8
GC 86033-12	2.0	68	105	2	16.5
GC 86035-28	2.0	70	106	2	16.8
GC 86022-28	2.0	62	105	2	18.6
GC 86033-22	1.9	66	108	2	17.3
GC 86033-17	1.9	64	107	2	14.9
GC 82341-6-8-1	1.6	57	89	3	14.2
GC 86039-26	1.6	62	107	3	16.5
SJ #5 (ck)	1.5	61	107	2	12.7
Mean	1.6	60.8	101.2	1.9	14.2
CV	19.7	3.6	2.5	28.6	8.3
LSD (0.05)	0.6	4.6	5.2	1.1	2.5

Before planting a mixed fertilizer containing N, P_2O_5, K_2O at 15-15-15 was applied at the rate of 625 kg/ha. Ten and 20 days after planting, an additional 310 kg/ha was applied as side dressing. Four replications in an RCB design were used.

GC 84136-P-4-1-8 gave a standard pod yield of 6.85 t/ha and its 100-seed weight was 54 g. The biological yield of the above selection was 22.8 t/ha. In comparison to the above,NS #1 gave a yield of 4.78 t/ha with a total biological yield of 12.6 t/ha and the 100-seed weight was only 36 g. The check variety G 10134 and Blue Side had the largest seed size of 73 and 64 g, respectively (Table 11).

Vegetable Soybean IYT in Thailand

Thirty-eight AVRDC vegetable soybean breeding lines and four varieties were evaluated in an intermediate yield trial at the Chiang Mai Field Crop Center on 18 January.

Eight entries had a standard graded pod yield of ≥ 6 t/ha. Eleven entries had a 100-seed weight of 66 g or more. The total highest biological yield of GC 84128-9-2-1 was 24.65 t/ha. These results suggested the potential to develop high yielding, good seed size vegetable soybeans in Thailand. Cooperator for the vegetable soybean trials was Anek Chotiyarnwong.

Pakistan

Seeds of the following promising selections were sent to M/S Commpex Hatchery and Breeding Farms, for multiplication and large-scale planting by farmers: AGS 129 (100 kg), OCB (275 kg) and GC 60058-12-6-6-1-55 (25 kg).

Taiwan

AGS 292, vegetable soybean released as Kaohsiung No. 1 in 1987 occupied 83% of the total vegetable soybean area in spring 1990.

Table 11. Promising selections from Thailand AYT vegetable soybean, spring 1990.

Entry	Yield (t/ha)			Harvest index	Standard pod harvest index	Days to maturity	Pod length/ 2 seeds (cm)	Pod width/ 2 seeds (cm)	100-seed weight (g)	No. of standard pod/ 500 g
	standard pod wt.	total								
		pod wt.	plant wt.							
GC 84136-P-4-1-8	6.9	8.8	22.8	38.6	30.2	68	5.4	1.4	54.0	202
Shironomai	4.6	6.1	13.3	46.9	34.6	61	5.1	1.4	50.0	238
Oofurisode	4.6	6.1	11.4	53.8	40.0	61	4.7	1.3	47.5	243
GC 83008-16	3.9	4.5	15.5	28.7	25.0	68	4.9	1.4	51.0	235
Blue Side 196	3.7	6.6	12.5	12.5	29.9	29.9	69	5.6	1.5	64.0
Kahori	3.5	5.7	14.5	39.7	24.2	68	5.2	1.5	65.0	194
AGS 292 (ck)	5.3	6.7	12.7	52.9	41.4	61	5.3	1.4	51.0	183
NS # 1 (ck)	4.8	5.7	12.6	45.3	38.1	63	5.2	1.3	35.5	326
G 9053 (ck)	3.8	4.7	12.9	36.9	29.6	63	4.9	1.5	56.5	193
G 10134 (ck)	3.1	4.8	14.6	32.6	21.3	67	5.6	1.5	73.0	161
Means	4.3	5.7	13.9	42.2	31.2	64.6	5.1	1.4	54.6	219.1
CV	16.5	13.6	7.9	15.4	15.8	1.3	3.2	4.2	5.5	10.5
LSD (0.05)	1.6	1.7	2.4	14.4	11.0	1.9	0.4	0.1	6.7	51.1

Soybean Entomology

Mechanism of *Ophiomyia phaseoli* Resistance in Soybean

Summary

Two soybean accessions, PI 171444 and PI 227687 have shown levels of resistance to a biotype of a beanfly species, *Ophiomyia phaseoli*, that lays eggs in cotyledons and kills soybean plants in the seedling stage, especially in Indonesia and parts of Vietnam. This biotype occurs in Taiwan but its population is very low and rarely poses a threat to soybean cultivation in Taiwan. In this preliminary study the oviposition and larval feeding behavior in the cotyledons of two resistant accessions was investigated and compared with that of one susceptible accession. *Ophiomyia phaseoli* laid significantly fewer eggs in PI 171444 than in susceptible AGS 66, but it laid significantly more eggs in PI 227687 than in the susceptible check. Oviposition, therefore, does not seem to be involved in the resistance of PI 227687 but may be responsible for the resistance in PI 171444. There was no difference in egg hatching but larval mortality was significantly higher in PI 171444 and PI 227687 than in the susceptible check. Other potential characters are being studied to find out factors responsible for resistance.

Introduction

Three species of agromyzid flies: *Ophiomyia phaseoli*, *O. centrosematis* and *Melanagromyza sojae*, are major pests of soybean in Asia. In most of Asia, including Taiwan, *M. sojae* is a major species. In Indonesia and the southern part of Vietnam, a biotype of *Ophiomyia phaseoli* is a major pest of soybean. This biotype lays eggs in cotyledons and feeds on the second and third instar larvae in the stem, killing the plant. This biotype is rare in Taiwan, hence not much research has been done to find a soybean accession resistant to it. However, after the development of a mass-rearing technique to rear *O. phaseoli* which uses soybean cotyledons, it has been possible to isolate this biotype from the native population of *O. phaseoli* by growing soybean in the field and harvesting cotyledons after a week and rearing the *O. phaseoli* found in the cotyledon further in the laboratory.

The selected soybean germplasm were screened for resistance to *O. phaseoli* in the greenhouse using the above procedure. We found PI 227687 and PI 171444 to be moderately resistant. In this series of laboratory experiments the mechanism of their resistance to *O. phaseoli* was investigated.

Material and Methods

Oviposition study. Seeds of PI 171444, PI 227687 and AGS 66 were planted in plastic cups containing vermiculite. The vermiculite was kept moist. Six to eight days after germination when cotyledons were about to open, one cup of seeds of each accession was placed in each of four nylon-net cages and an equal number of laboratory-reared *O. phaseoli* adults were released inside each cage. After 24 hours the number of punctures in each cotyledon and number of eggs in each puncture were recorded. Surface area of cotyledons was measured by Licor area meter and volume, by water displacement method. Cotyledons were dried at 100°C for several hours until constant weight was reached. Moisture content was taken by calculating the difference between fresh and dry weights.

Larval stage study. Soybean cotyledons were cut open every day and the number of eggs that hatched into larvae were recorded for 5 days. Ten days after oviposition, cotyledons were opened to record the number of living and dead larvae.

Pupal stage study. When pupae were visible from underneath the epidermis of the cotyledons, all cotyledons were opened to record the number of larvae and pupae and calculate the percentage larvae becoming pupae. The pupae were then removed and the weight of each pupa recorded.

Results

The results of the *O. phaseoli* oviposition in soybean cotyledons are presented in Table 1. *Ophiomyia phaseoli* laid significantly fewer eggs in the cotyledons of the resistant accession PI 171444 but more in PI 227687 than in those of susceptible AGS 66. The oviposition was therefore not related to the volume of cotyledon which represented the available food for the larvae. Oviposition did not seem to be involved in the resistance of PI accessions, at least for that of PI 227687, although it may be involved in the resistance of PI 171444.

The results of egg hatching and larval mortality in the cotyledons of beanfly-resistant PI accessions and susceptible AGS 66 are summarized in Table 2. No significant differences in hatching of *O. phaseoli* eggs were observed. However, larvae in cotyledons of PI 171444 and PI 227687 suffered significantly higher mortality. This high larval mortality was probably partly responsible for resistance of PI accessions to *O. phaseoli.*

No significant differences were noted in percentage larvae pupating or in pupal weight when the larvae were raised on cotyledons of resistant PI accessions or susceptible check. Higher larval mortality in cotyledons of PI accessions seemed to be responsible for resistance of PI accessions to *O. phaseoli*. Further tests are in progress.

Table 1. Oviposition of *Ophiomyia phaseoli* in soybean cotyledons.

Accession No.	Number punctures/ cotyledon	Number eggs/ cotyledon	Volume (cm^3)/ cotyledon	Moisture content (%)
PI 171444	10.09 c	2.25 c	0.16	84.2
PI 227687	41.45 a	5.45 a	0.12	85.2
AGS 66	37.43 b	3.36 b	0.23	85.0

The data for number of punctures and number of eggs/cotyledon are means of four replicates. Means in vertical column followed by same letter are not significantly different at 5% level according to DMRT. Data for cotyledon volume and moisture content are means of 10 cotyledons.

Table 2. Hatching and mortality of *O. phaseoli* larvae in cotyledons of soybean accessions.

Accession	Egg hatching (%)	Larval mortality (%)
PI 171444	95 a	20.3 ab
PI 227687	74 a	33.3 a
AGS 66	73 a	5.5 b

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.

Characterization of Limabean Podborer Resistance Mechanism in PI 227687

Summary

In all tests PI 227687 was always least damaged by limabean podborer. Like other apparently resistant accessions, PI 227687 also had small seeds. However, since this accession had shown resistance to a wide range of insect pests, AVRDC studied the mechanism of its resistance to limabean podborer in a series of laboratory and greenhouse tests. Limabean podborer laid significantly fewer eggs on

the pods of PI 227687 than on those of a susceptible entry, KS9. Significantly fewer first instar larvae penetrated the pods of PI 227687 than those of KS9 to feed on developing seeds. Both male and female pupae developed from larval feeding on the seeds of PI 227687 were significantly lighter than those developed from KS9. The emergence of adults from the pupae was significantly less when pupae were developed from PI 227687 than from KS9. Further tests are underway to characterize the resistance mechanism before using this accession in AVRDC's breeding program.

Introduction

Limabean podborer, *Etiella zinckenella* (Trietsche), attacks soybean and several other legumes. The insect lays eggs on immature pods and larvae bore inside the pod and feed on developing seeds. Fully mature larvae leave the pod and pupate in the soil. Podborer damage results in reduction of seed yield. The pest is especially serious on soybean in Southeast Asia. AVRDC has been screening soybean germplasm for resistance to this pest for the past several years. Several accessions showed less damage by this pest, but all these accessions are small-seeded; the lesser damage to these accessions was due more to small-seededness rather than to true genetic resistance. In 1988-89 PI 2276 87 was found to be consistently least damaged by *E. zinckenella*. This accession also has small seeds but its foliage has shown resistance to a wide variety of insect pests in Taiwan and elsewhere. The small podborer damage inflicted on this accession may be due to true resistance rather than due to the smallness of the seeds. In 1990, studies to confirm whether the little insect damage observed on this accession was due to true resistance were conducted.

Material and Methods

All experiments were conducted with potted soybean plants in the greenhouse. An apparently podborer-resistant accession, PI 227687, and susceptible cultivar KS9 were used.

In the first experiment, starting with plants at the R_2 stage, one plant of PI 227687 and one of KS9 were placed in each of six nylon net cages. Each cage represented one replicate. Three newly emerged pairs of *Etiella zinckenella* were released. After four days the number of eggs laid on each plant, mainly on pods and adjacent plant parts, was recorded. Simultaneously, the larvae were observed daily as to whether they successfully penetrated through the pod cover to feed on developing seeds and the number that pupated was recorded. Those which failed to pupate died.

The pupae of each replicate were maintained at 28°C until emergence of the adults. During this period each pupa in each replicate was weighed. At the end of the pupal period, the number of pupae that emerged into adults was recorded and the percentage of adult emergence was compared.

Results and Discussion

Results of various tests on oviposition, larval feeding and pupation of *E. zinckenella* when raised on apparently resistant and susceptible soybean accessions are summarized in Table 3. Insects laid fewer eggs on PI 227687 than on KS9. This could be attributed not only to resistance, but also to the larger plants and pods of KS9. Host plant had no significant effect on hatching of larvae. Significantly more larvae in search of food penetrated the pod pericarp in KS9 than in PI 227687. This could very well be due to the availability of a greater amount of food in KS9 than in PI 227687. The extent of pupation of the larvae that fed on PI 227687 or KS9 green seed did not differ but the pupae that developed from larvae fed on PI 227687 were significantly lighter than those which developed from KS9. This was true for both males and females. Subsequently the emergence of adults from these pupae was significantly less on PI 227687 than those on KS9. The differences in oviposition, larval penetration in pods, pupal weight and adult emergence indicated that PI 227687 may be a truly resistant accession with a potential antibiotic as the source of resistance. Further tests are planned to investigate the resistance of PI 227687 before its inclusion in the AVRDC resistance breeding program.

Table 3. Oviposition and subsequent development of *Etiella zinckenella* on insect-resistant PI 227687 and susceptible KS9.

Characteristics	PI 227687	KS9	t value
No. eggs/plant	19.7 ± 6.9	45.6 ± 9.9	4.96**
Egg hatching (%)	82.4 ± 2.2	83.9 ± 2.2	1.11NS
Larvae penetrated in pods (%)	73.9 ± 4.9	81.3 ± 4.7	2.43*
Pupation (%)	78.9 ± 2.0	80.4 ± 1.8	1.28NS
Pupal weights			
Male (mg)	30.4 ± 4.8	33.5 ± 4.3	2.58*
Female (mg)	24.4 ± 5.7	31.7 ± 4.1	5.58**
Adult emergence	50.4 ± 5.2	89.6 ± 4.6	12.64**

Data are means of six replicates. Degrees of freedom 10.

Soybean Pathology

Soybean Rust Development and Yield Losses Associated with Lines Selected for High Yields and Rust Tolerance

Summary

Soybean rust, caused by *Phakopsora pachyrhizi*, occurs throughout most of the eastern hemisphere. The disease causes yield reductions that result in economic losses. In this experiment, rust-tolerant lines were compared to those developed for high yields. Rust severities increased from early to later assessments for all lines. The SRE lines (those previously developed for rust tolerance) had the lowest levels of infected leaf area and are considered partially resistant based on pustule counts per leaf node. Yield losses ranged from 29 to 85%. The lines developed for rust tolerance had less yield loss than the other high-yielding lines. A similar trend occurred in 100-seed weight losses. These SRE lines have two valuable traits: one is partial resistance, and the other is tolerance to leaf rust.

Introduction

Phakopsora pachyrhizi, the causal agent of soybean rust, occurs throughout most of the eastern hemisphere. Yield losses of up to 90% have been reported on plants severely infected with the pathogen. Disease resistance in soybean (*Glycine max*) is generally low, or if resistance is conferred by a single gene, then it has only limited resistance to certain strains. Both types of resistance have been a deterrent in breeding lines with specific or general resistance to rust. In the past, AVRDC has crossed and selected lines that have tolerance to rust. Lines selected based on relative yields under severe rust epidemics do not necessarily have less disease. As a result, lines with relatively low yield losses compared to rust intolerant lines have been developed.

This experiment compared the yield and rust levels of lines that had been previously selected for tolerance with lines that had been selected for high yield.

Materials and Methods

Soybean seeds were planted in 3 × 6 m plots on 10 March 1990. There were four rows per plot with 50 cm between rows and 10 cm between plants within a row. The experiment was a split plot in a randomized complete block design with four replications. The main plot treatment was sprayed with Bayleton at 2.4 kg a.i./ha (fungicide-protected). Subplots were 12 soybean lines. Lines GC 82345-20-2, GC 81118-8-4, GC 823449-6-1 and AGS 302 were selected because of their high yields as reported in the 1989 AVRDC Progress Report. Lines SRE B 15A, SRE C-56A, SRE C-56E, SRE D-14C and SRE D-14D were selected from tests conducted at AVRDC under the soybean rust tolerant program in 1980-88. Commercially available cultivars AGS 129 and KS 8 were used because of their high-yielding characteristics. Cultivar AGS 181 was used because it is high-yielding, and was previously shown to be somewhat tolerant to rust. Inoculated plants were sprayed with a uredospore suspension several times before the growth stage (GS) of R_1.

Disease severity was assessed by estimating the percent leaf area infected on a per plot basis and by recording the percent defoliation from five plants within each plot every seven days from 2 May until 21 June. At GS R_5 (+/−0.5 GS) the number of rust pustules were counted from each node

on five plants per plot. Pustule numbers were converted to $\log_{10}$ and regressed to leaf node. The total number of pustules per plant was calculated by adding all the pustule counts made on leaves at individual nodes. The number of pustules per leaf was calculated as follows: (total number of pustules per plant/total number of leaves per plant). These data were analyzed by ANOVA, and means were compared by Fischer's Least Significant Difference (FLSD) ($P>0.05$).

At harvest maturity, plant height, nodes, branches, pods and seeds of five plants per plot were recorded. The yield from the two center rows were harvested, and 100-seed weight and total yield were adjusted to 13.0% moisture. Seed weight and yield loss were calculated as follows: loss (%) = [(weight in protected plots weight in inoculated plots)/weight in protected plots]. Data were analyzed by ANOVA and means separated by FLSD. Correlations of yield and seed weight were compared to disease severity parameters.

Results and Discussion

No rust developed on plants in the fungicide-protected plots. Rust increased in all of the lines from early to later assessments (Fig. 1). The percent leaf area infected was greatest for AGS 181, followed by GC 82345-20-2, KS 8 and GC 8111-8 -8-4 (Table 1). The lines with the lowest percent leaf area infected were SRE C-56A, followed by SRE C-56E, SRE D-14D and SRE D-14C. The five lines that had the lowest percent leaf area infected were those identified in previous experiments as having rust tolerance. The other seven lines had more infection, indicating that they were more susceptible to rust than the SRE lines. The SRE lines, besides having tolerance to rust, can also be classified as having partial resistance to rust since they had less infection.

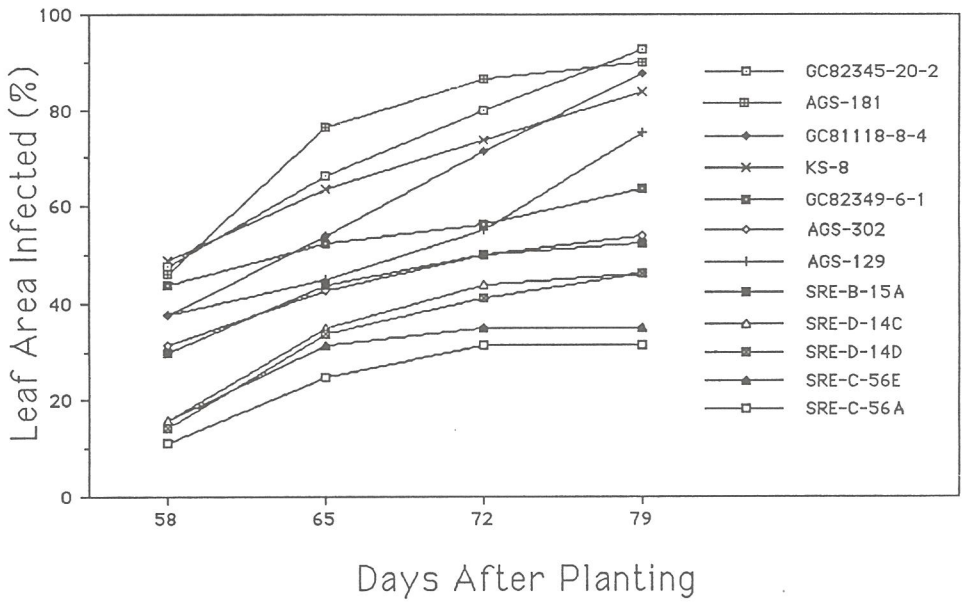


Fig. 1. Percent leaf area infected with 12 soybean lines inoculated with *Phakopsora pachyrhizi* over four assessment periods.

The range of defoliation at 65 days after planting was 16-41% (Table 1). The same SRE lines that showed partial resistance to rust also tended to have less defoliation. The differences in defoliation between the lines were not as great as the differences that occurred in the percent leaf area infected between the lines.

The number of pustules per plant was significantly lower for SRE C-56A and SRE C-56E (Table 1). SRE C-56E had the lowest number of pustules per leaf while GC 82345-20-2 had the highest. The number of pustules at node 7 ranged from 17 to 176. In general, those lines that had lower percent

infected leaf area also had fewer pustules. Regression of pustule number by leaf node demonstrated that the SRE lines had fewer pustules at each node than the high-yielding lines.

Yields ranged from 2.3 to 3.5 t/ha in fungicide-protected plots (Table 2). Yields of GS 82349-6-1 and KS 8 were significantly higher than the other lines in fungicide-protected plots. The SRE lines, except SRE B-15A, had yields that were not significantly lower than most of the other high-yielding lines. In rust-inoculated plots, yields of SRE C-56A, SRE C-56E, SRE D-14C, and SRE D-14D were all significantly higher than the yields of the other lines (Table 2). The average yield loss for all lines was 59% (range 31-85%). Seed weights differed significantly by line within fungicide-protected and in inoculated plots. Seed weight losses ranged from 29 to 63% and were significantly lower in most of the SRE lines compared to the other lines (Table 2).

Table 1. Leaf area infected, defoliation and total number of pustules per plant, per leaf, and at node 7 on 12 soybean lines inoculated with *Phakopsora pachyrhizi*.

Line	Leaf area infected (%)	Defoliation (%)	Total number of pustules	Pustule per leaf	Number of pustules at node 7
AGS 129	45	28	1,776	41	104
AGS 181	76	41	3,849	130	87
AGS 302	43	20	2,209	66	53
GC 81118-8-4	54	29	2,541	61	80
GC 82345-20-2	66	34	5,934	168	176
GC 82349-6-1	53	41	2,108	49	150
KS 8	64	36	2,715	76	107
SRE B-15A	44	29	2,272	70	83
SRE C-56A	25	24	803	23	25
SRE C-56E	31	24	709	19	29
SRE D-14C	35	16	2,159	58	17
SRE D-14D	34	16	2,100	54	51
Average	47	28	2,473	68	78
FLSD ($P \leq 0.05$)[a]	**6**	**13**	**973**	**28**	**44**

Table 2. Yield and 100-seed weight in fungicide-protected plots and in rust-inoculated plots, and their losses on 12 soybean lines inoculated with *Phakopsora pachyrhizi*.

Line	Yield (t/ha)			100-seed weight (g)		
	Fungicide-protected	Rust-inoculated	Loss (%)	Fungicide-protected	Rust-inoculated	Loss (%)
AGS 129	2.8	0.8	70	16.1	7.5	53
AGS 181	2.3	0.8	66	17.1	10.0	42
AGS 302	2.4	1.0	57	21.2	12.5	41
GC 81118-8-4	2.8	0.5	83	17.3	6.2	64
GC 82345-20-2	2.9	0.7	75	19.5	7.8	59
GC 82349-6-1	3.4	0.8	76	22.5	14.3	36
KS 8	3.5	0.5	85	29.8	11.1	63
SRE B-15A	2.4	1.1	54	17.4	10.4	40
SRE C-56A	2.6	1.8	29	25.5	18.0	29
SRE C-56E	2.6	1.8	31	20.7	13.6	34
SRE D-14C	2.8	1.5	46	23.5	16.6	29
SRE D-14D	2.6	1.5	41	25.0	16.4	34
FLSD ($P \leq 0.05$)[a]			9			8
FLSD ($P \leq 0.05$)[b]		214			2.0	
FLSD ($P \leq 0.05$)[c]		263			2.3	

[a]Differences between main plot means. [b]Differences between subplots within the same main plot. [c]Differences between subplots with different main plots.

Percent leaf area infected and defoliation to yield and 100-seed weight were significantly correlated. The correlation coefficient for defoliation from the third assessment to yield and 100-seed weight was r = -0.5 and r = -0.6. The correlation of percent leaf area infected to yield and 100-seed weight was r = -0.84 and r = -0.71.

Results from this experiment indicated that high-yielding lines with partial resistance and tolerance to rust have been successfully developed. Although the mechanism involved in partial resistance or tolerance was not determined in this experiment, the data indicated that partially resistant lines had fewer pustule numbers. Further analysis of this and other data from field trials on soybean rust should clarify whether a single count of pustules on leaf node 7, for example, could be used to assess partial resistance.

Soybean Physiology

Effects of Abiotic Factors and Growth Regulators on Shell Quality of Detached Vegetable Soybean Pods

Summary

Immature vegetable soybean pods were excised and grown in vitro in a defined medium, and studied for pod shell quality. Humidity and glutamine in the medium were found conducive to black spot development on the pod shell. Both temperature and light treatments, and incorporation of growth regulators did not show any deterring or accelerating effects. $CaCl_2$ was found effective in offsetting the degradation of pod shell quality. The technique developed could be useful in studying the influence of a single chemical or environmental parameter or combination of the same on regulation of seed growth without the confounding interactions with the mother plant.

Introduction

Determining the appropriate stage for harvesting immature pods as vegetable soybeans has always been a problem for growers. Furthermore, harvested vegetable soybeans are susceptible to yellow coloration and brown spot. The latter substantially reduces the shelf life and commercial value of the produce. Yellowing of pod shells depends on the degradation of chlorophyll, the presence of carotene and xanthophyll pigments, or the presence or absence of anthocyanin pigments. This study examined the effect of temperature, light, hormone and calcium on detached developing soybean pods intended as vegetable soybeans. The results of this study may be used in future studies on in situ developing pods of vegetable soybeans to overcome pod shell quality problems.

Materials and Methods

G 9053 (Tzurunoko, Tainung No. 205), AGS 292 (Kaohsiung Selection No. 1) and G 10134 (Tainung 305, Ryokkoh) were planted every two weeks in the field to provide a continuous supply of immature pods. Immature pods which reached full size with developing seeds were harvested, and sterilized in 1% NaOCl solution containing 0.2% Tween 20 as a surfactant for 10 min. The pods were then transferred to test tubes containing MS culture medium with 10% sucrose. The test tubes were then subjected to the following culture conditions: 1) two levels of light intensity at 150 and 320 $\mu M/sec/m^2$, 2) three temperatures at 24°, 28°, and 32°C, 3) aqueous or solidified MS medium, or 4) additions of growth regulators and calcium in the medium. These selected growth regulators were based on their reported involvement in senescence. Chemicals used included: BA at 0.10, 1.00 and 10.00 mg/l, kinetin at 0.10, 1.00 and 10.00 mg/l, IAA at 0.10, 1.00 and 10.00 mg/l, GA_3 at 0.10, 1.00 and 10.00 mg/l, silver nitrate at 1.0, 10.0 and 100.0 mg/l, epi-brassinolide at 0.01, 0.1 and 1.0 mg/l, cytex at 0.10, 1.00 and 10.00 mg/l, $CaCl_2 \times 7H_2O$ of MS medium at 0.0, 30.0 and 300.0 mM, and control with MS culture medium ($CaCl_2 \times 7H_2O$ at 3.0 mM) only. There were four replicates for each treatment, and 12 pods for each replicate. Pods were observed for black spot development, and rated using the following scale: 0 = no spot and 3 = many spots.

Results and Discussion

Light and temperature are known to alter the rate of formation and degradation of pigments. All three incubation temperatures used in this experiment resulted in black spots on the cultured pods; AGS 292 developed fewer spots than the other two entries.

No apparent difference in the level of black spot development on the pod shell was observed among the two levels of light intensity used. On the other hand, the underside of the pod shell, regardless of temperature or light treatments, had significantly more black spots than the upper side. The result suggested that high humidity may be responsible for the black spot development on the pod shell. When solidified MS medium (with 1% agar) and liquid MS media (with or without glutamine) were compared, pods cultured in the liquid medium with glutamine showed more black spots than those cultured in solid medium with glutamine or liquid medium without glutamine for one day. Glutamine may have over-activated the metabolic process, causing shell disorder. After 6 days of culture, all developing pods in liquid media produced more black spots than those in solid media. Again the result suggested that high humidity is detrimental to pod shell quality.

Cytokinins are known to be very effective in deterring, and ethylene, in accelerating senescence. None of the three cytokinin-related growth regulators used, BA, cytex and kinetin, and GA_3 and IAA incorporated into the MS medium, showed any deterring or accelerating effect on black spot development on the pod shell. On the contrary, $AgNO_3$, an inhibitor of ethylene action, at 50 ppm and epi-brassinolide, a steroidal growth substance, at 1 ppm, slightly reduced black spot development on the pod shell during the first 2 days of incubation, but this beneficial effect did not last.

The incorporation of $CaCl_2$ at 300 mM in the MS medium significantly decreased the development of black spots on the pod shell after 5 days of incubation (Fig. 1). Calcium has been reported to decrease the rate of chlorophyll and protein degradation. It may have delayed the development of black spots on the pod shell of vegetable soybean.

In conclusion, humidity and glutamine appear to contribute to black spot development on the pod shell of vegetable soybean cultured in vitro. However, $CaCl_2$ is effective in offsetting the degradation of pod quality.

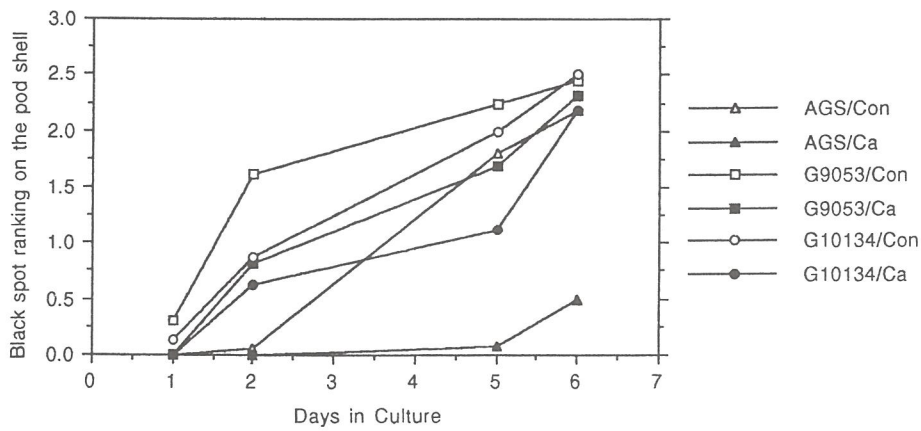


Fig. 1. Effects of incorporating 300 mM $CaCl_2 7 \times H_2O$ in the MS agar medium on black spot development in the underside of shells of detached soybean pods cultured under light at 24°C.

Effects of Controlled Water Supply on Vegetable Soybeans

Summary

Yield of vegetable soybeans was reduced by drought and flooded soil conditions during 54 days of growing. Drought reduced pod number and seed size, which may be due to premature loss of

leaf area and a shortening of the pod filling period. On the contrary, moist and flooded soil conditions were favorable for overall vegetative growth. Yield and reproductive growth of vegetable soybeans, however, were reduced by flooded soil condition. Poor seed quality was also observed in soybeans subjected to flooding; drought tended to increase seed protein content, whereas flooded soil tended to increase seed oil content. Soil moisture maintained around 12% was favorable for vegetable soybean yield; under this soil moisture condition, about 3 l of water/plant was consumed in 54 days during the cool season.

Introduction

Drought stress is detrimental to both yield and quality of vegetable soybeans. The relationship of compositional and physiological changes in the developing pod of vegetable soybeans and soil moisture, however, is not fully understood. This experiment evaluated the water requirement of vegetable soybeans, and the overall effect of soil moisture content, including both drought and excess soil moisture conditions, on growth and production of vegetable soybean to determine if specific changes in soil moisture correlate to the growth and quality of developing pods of vegetable soybeans.

Materials and Methods

Growing medium of 65% sandy loam, 20% sand and 15% compost at 2880 kg were incorporated with 214 g $(NH_4)_2SO_4$, 130 g $Ca(H_2PO_4)_2$ and 206 g KCl before transferring to the PE box (80 × 45 × 25 cm^3). Three irrigation pipes were embedded in the growing medium at two-thirds height of the box. Seeds of AGS 292 (Kaohsiung Selection No. 1) were sown on 19 October 1989 using 15 cm spacing, after soil moisture in the PE box had been equilibrated. There were 30 plants per box. Three weeks after sowing (about 1 week before flowering), PE boxes were supplied with different amounts of water through the embedded pipes to create four levels of mean soil moisture contents (5.2% = drought, 7.1% = dry, 11.5% = moist and 29.8% = flooded). The amount of water supplied to each box and soil moisture contents were measured. At flowering stage, liquid Hyponex No. 2 was applied. Mean maximum and minimum temperature during the growth period were 29.1°C and 17.2°C, respectively.

Developing pods were sampled when they reached full length with seeds occupying about one-half of the pod lumen. Sampled pods were examined for relative water, cell wall and chlorophyll contents, firmness and fresh weight. On 12 December 1989, immature pods (vegetable soybeans) and other plant parts were harvested. Parameters related to yield, yield components and quality, and plant growth were investigated and recorded.

Results and Discussion

During the pod filling stage, drought decreased hardness, relative water contents, fresh weight of both pod shell and seed, and wall content of pod shell, but increased chlorophyll content in the pod shell (Table 1). Drought seemed to affect mechanical properties of the cell wall. During 54 days of growing, both drought and dry soil condition decreased leaf area, total dry matter production and height (Table 2). Soybean plants in both moist and flooded soil conditions had comparable leaf area, dry matter production and plant height; each plant consumed about 3-4 l of water in 54 days of growth. Despite comparable vegetative growth of soybean plants grown in moist and flooded soil conditions, flooding tended to reduce leaf chlorophyll content, total pod number and number of fully developed pods (Table 3). The reduced pod number seemed to be a major factor in the yield reduction caused by flooded soil. It is possible that flooding stress slows the greening process by blocking synthesis or enhancing degradation, which may have an effect on seed development.

Lack of soil moisture significantly retarded both pod and seed development, resulting in reduced pod number and high number of seedless pods (Table 3). Among four levels of soil moisture, soybean plants grown under drought conditions had the least pod yield. Both drought and flooded soil conditions reduced seed size. Flooded soil condition tended to increase oil, sugar, starch and crude fiber contents of the seed, but decreased its hardness. On the other hand, drought tended to increase dry matter, protein and free amino acid contents.

Table 1. Relative water contents (RWC), hardness, chlorophyll content and pod shell wall content of developing pods of AGS 292 at four soil moisture levels.

Treatment	RWC		Hardness		Chlorophyll		Pod-shell cell wall content (%)
	Shell	Seed	Shell	Seed	Shell	Seed	
	(%)		(dyn/cm^2)		(mg/cm^2)	(mg/g)	
Drought	63 b[a]	79 b	780 b	354	15 a	120	10.0 b
Dry	78 a	82 a	1104 a	408	13 b	124	13.0 a
Moist	86 a	83 a	1199 a	450	13 b	111	14.9 a
Flooded	85 a	81 a	1257 a	459	12 b	116	14.7 a

[a]Mean separation within columns at 5% level by DMRT.

Table 2. Growth of AGS 292 at four soil moisture levels for 54 days.

Treatment	Plant height (cm)	Leaf area (cm^2/plant)	Chlorophyll ($\mu g/cm^2$ leaf)	Pod DM (g/plant)	Total DM (g/plant)	Top/root ratio (%)
Drought	62 b[a]	233 c	30 b	1.1 d	2.93 c	17 b
Dry	63 ab	340 b	32 b	2.5 c	4.77 b	27 ab
Moist	72 a	487 a	43 a	4.1 a	6.80 a	33 a
Flooded	69 a	505 a	22 c	3.5 b	7.11 a	24 ab

[a]Mean separation within columns at 5% level by DMRT.

Table 3. Pod yield of AGS 292 at four soil moisture levels for 54 days.

Treatment	Pod yield (g/plant)	Pod no. (/box)	Seedless pods (%)	Unfilled pods (%)	Filled pods (%)	Seed FW (mg/seed)
Drought	3.8 d[a]	155 c	42 a	12 ab	46 d	383 c
Dry	9.8 c	228 b	35 a	6 c	59 bc	535 a
Moist	17.1 a	283 a	5 b	9 bc	87 a	501 ab
Flooded	14.3 b	244 b	11 b	18 a	71 b	486 b

[a]Mean separation within columns at 5% level by DMRT.

Sweet Potato Breeding

Development of Breeding Populations

Summary

Four polycross populations were developed in 1989-90 cool season to enhance the following traits: dry matter of orange-fleshed clones, eating quality, dry matter and yield of yellow-fleshed clones, dry matter content and dry matter yield, and scab resistance. Two special populations for scab resistance and high dry matter content were developed in 1990. True seeds from these populations, together with a brief leaflet on handling the seeds and resulting clones, will be distributed to all interested cooperators in the national programs and other research institutions in 1991.

Introduction

In 1989-90 cool season, four populations were developed through the polycross method and one by hand-crossing. In 1990, two special polycross nurseries were set up.

The 1989 polycross nurseries were established to develop special populations with the following desired characteristics: improved dry matter content of orange-fleshed clones; improved eating quality, dry matter, and yield of yellow-fleshed clones; high dry matter content and high dry matter yield; and high scab resistance.

Materials and Methods

Olsen's Latin Square design was used to establish the first two polycross populations with 16 and 12 replicates, and eight and six parents, respectively. The last two populations were each laid out on a randomized complete block design with seven replicates. Twelve parents each were used in these polycross nurseries.

Hand-crossing was carried out to obtain hybrid progenies for the special project on genetics of scab resistance. Forty-seven cross combinations among 10 clones with varying reactions to scab were made. Progenies of these crosses were jointly screened for scab resistance with the plant pathologists (see Pathology report).

The 1990 polycross nurseries were set up to produce two kinds of breeding populations for use by the sweet potato breeders in the national programs. The first set (Polycross I) was intended to produce a population with a high level of scab resistance. For this polycross set, 16 parental clones were selected from the following sources: six from Papua New Guinea, four from Taiwan, two from the Philippines, and one each from Indonesia, Nigeria, Thailand and Tonga. The range of scab resistance of the parental clones in this polycross set ranged from 1.0 to 1.67, based on a rating scale of 0 = highly resistant to 6 = highly susceptible.

The other 1990 polycross population (Polycross II) began as an attempt to produce a genetically diverse population which can be maintained via true seeds to represent a subset of the Center's germplasm collection. However, this was later considered to be a time-consuming activity; moreover, it became clear later that more than 80% of the original set of clones for inclusion as polycross parents originated from Papua New Guinea and Taiwan. Therefore, the polycross set was reduced to one aimed at developing a population in which both high dry matter and high scab resistance segregate

simultaneously. True seeds from this gene pool could then be provided later to interested national programs. The total parental clones being used for this population was 28, of which 22 originated from Papua New Guinea, two from Taiwan and four from other sources. These parental clones were selected from a group of 300 clones which performed relatively well in the 1989 fall season evaluational yield trial. Scab resistance of parental clones ranged from 1.0 to 1.83 on the rating scale. Dry matter content of parental clones ranged from 30 to 33.9%.

Results

A total of 77,113 seeds was produced in the 1989-90 crossing program. Some of these seeds have already been distributed to cooperators in the national programs. Others are in storage for safekeeping and future sharing with international cooperators and with the International Potato Center which had expressed interest in utilizing botanical seeds developed in AVRDC's hybridization program.

Performance of Selected Clones in the Advanced Yield Trials

Summary

Six clones were selected from the 1989 fall AYTs. These selections generally showed comparable yielding ability as the best yielding check cultivars and had dry matter contents and dry matter yields similar to, if not better than, the high dry matter check clone CN 1489-89. On the other hand, 11 new clones were outstanding in the 1990 AYTs in spring and summer. Invariably, the new clones yielded consistently well in both seasons, combined with other desirable traits such as high dry matter content and/or high dry matter yield. Some of the best selections are currently being virus-indexed for eventual distribution to interested cooperators.

Introduction

Following the 2-year, four-season evaluation in the preliminary yield trial stage, the best clones were entered in the advanced yield trial (AYT). The AYTs were carried out in three different seasons spring, summer and fall. Based on their combined performance in the AYT series, clones were selected for multilocational trials in Taiwan and for distribution to international cooperators after virus-indexing and multiplication.

In 1989-90, a number of advanced trials were conducted to evaluate selections from previous preliminary yield tests.

Materials and Methods

Detailed information on the AYT trials conducted in 1989-90 season are given in Table 1.

Three groups of selections were evaluated in the 1989 fall AYT. These groups included the following materials: 14 most advanced clones,14 orange-fleshed clones and 18 yellow-fleshed clones.

In 1990, four groups of AYT materials were evaluated during the spring season. These consisted of the following: 14 processing/supplementary food type, 10 orange-fleshed clones, 11 yellow-fleshed clones and 16 feed-type clones. Four checks, CN 1489-89, CN 1510-25, Tainung 57 and Tainung 66, were used for the first and third group. Tainung 57 was replaced by CN 1108-13 in the second group. Common checks for the fourth group were CN 1489-89, CN 1510-25, CN 1232-9 and Tainung 66. A fifth check, Tainung 67 was also added.

The same set of AYT entries was compared to the same check cultivars during summer 1990. In addition, Group 1 clones were also planted in Chin-Shan, an additional trial site. However, combined data analysis to evaluate the stability of clonal performance has been deferred pending availability of more data from repeated trials.

Table 1. Comparative yield and other traits of selected clones vs. best checks; PYT II-Group 2 (high dry matter clones); 1990 spring and summer.

Entry	Marketable yield (t/ha)		Total yield (t/ha)		DM	DMY	Starch	Starch	Skin	Flesh
	90SP	90SU	90SP	90SU	(%)	(t/ha)	%DWB	%FWB	color	color
TN 66 (CK)	24.1 ab[z]	13.6 ab	30.9 a	20.0 ab	23.6 g	5.7 bcde	57.6 g	13.6 g	R5	O3
CN 1899-33	22.5 abc	13.7 ab	27.4 ab	20.6 ab	38.0 ab	8.5 a	72.1 ab	27.4 ab	Y1	Y1
CN1899-59	20.6 abcd	12.0 ab	31.5 a	23.9 a	35.3 cd	7.3 abc	72.6 ab	25.6 bc	P3	Y1
CN1489-89(CK)	18.6 bcde	14.5 ab	22.1 bc	18.0 ab	33.7 d	6.3 bcd	65.6 ef	22.1 de	Y1	Y1
CN1899-38	17.8 cdef	14.4 ab	21.3 bc	18.6 ab	40.0 a	7.1 abc	67.9 bcdef	27.1 ab	R1	Y1
CN1903-32	16.7 cdef	12.3 ab	21.7 bc	17.8 ab	38.6 ab	6.4 bcd	73.3 a	28.3 a	P3	Y1

[a]Mean separation within columns by DMRT at 5% probability level. [b]Skin and flesh colors are given in a 1-5 scale (1 = light to 5 = intense or deep); P = purple, R = red, Y = yellow, W = white and O = orange.

Results and Discussion

Only one most advanced clone, CN 1688-116, showed an overall performance (especially yielding ability, dry matter content and dry matter yield) that was comparable to the checks in the 1989 AYT of Group 1 materials.

No selection was taken from Group 2 (orange-fleshed types). The best yielding clone, CN 1821-130, had an undesirably low dry matter content of only 22.7%. Low dry matter content is a well-known unfavorable trait of orange-fleshed clones which the AVRDC sweet potato breeders have been trying to resolve.

Five new clones which had comparative yields as the best yielding check, CN 1489-89, were selected from Group 3 (yellow-fleshed clones). The selected clones had comparable dry matter content and dry matter yield as CN 1489-89, except for the highest yielding clone, CN 1821-39 (Table 2).

Table 2. Comparative yield and other traits of best clones vs. best check cultivars, AYT-Group 3; 1989 fall season.

Entry	Marketable weight (t/ha)	Marketable root no.	Total yield (t/ha)	Cull root no.	Cull weight (t/ha)	Top yield (t/ha)	Dry matter (%)	Dry matter yield (t/ha)
CN1821-39	18.5 a	106 a	21.5 a	89 defg	3.0 cdef	6.0 bcd	28.0 ef	5.1 a
CN1823-77	14.8 b	105 a	18.7 b	110 bcde	4.0 abc	6.6 abc	29.7 cd	4.4 b
CN1821-8	13.2 bc	74 bc	16.1 c	89 defg	2.9 cdef	5.6 cde	30.3 bcd	4.0 bc
CN1756-163	12.4 cd	80 b	15.4 cd	86 defg	3.0 cdef	3.5 fg	27.3 fg	3.4 cd
CN1489-89(CK)	12.4 cd	69 bc	16.3 c	98 cdef	3.9 abcd	7.9 a	31.4 bc	3.9 bc
CN1757-30	11.3 cd	74 bc	14.9 cd	99 cdef	3.6 abcde	5.9 bcd	31.3 bc	3.5 c

Mean separation within columns by DMRT at 5% probability level.

At least two clones yielded consistently well in the 1990 AYT of Group 1 and may be considered tentatively to have equally stable performance as the best check, CN 1489-89. Both selected clones were orange-fleshed, supplementary food types with slightly lower β-carotene but slightly higher dry matter contents than the orange-fleshed check cultivar, Tainung 66. The advantages of the new clones over Tainung 66 in stability of yield were very apparent.

Among the Group 2 entries, two orange-fleshed clones with consistently high yields in spring and summer were selected. Apart from their stable high yields, these clones also had higher dry matter contents and dry matter yields than the best orange-fleshed check cultivars, TN 66 and CN 1108-13. However, they had only moderate amounts of β-carotene. If these clones had acceptable eating quality, however, they would have a better potential of being accepted in the tropics than AVRDC's previous deep orange-fleshed clones, e.g. AIS 35-2, which had generally wet textures.

Three new clones from Group 3 (supplementary food type /yellow-fleshed clones) had comparable yields and dry matter contents as the best yellow-fleshed check cultivars. Clone 1757-30 had the highest dry matter content and dry matter yield in the trial, outperforming even the high dry matter check cultivar, CN 1489-89.

In the AYT of Group 4 clones (feed type), four were considered to have comparable yielding ability as the best yielding check cultivars. However, only clone 1833-27 had dry matter content, dry matter yield and starch production potential comparable to those of the feed-type check cultivar, Tainung 67; it also outyielded the latter.

Utilization of Interspecific Hybrids

Summary

Six clones were selected from the 1989 fall AYTs. These selections generally showed comparable yielding ability as the best yielding check cultivars and had dry matter contents and dry matter yields similar to, if not better than, the high dry matter check clone, CN 1489-89. On the other hand, 11 new clones were outstanding in the 1990 AYTs in spring and summer. Invariably, the new clones

yielded consistently well in both seasons, combined with other desirable traits such as high dry matter content and/or high dry matter yield. Some of the best selections were currently being virus-indexed for eventual distribution to interested cooperators.

Introduction

The AVRDC sweet potato program initiated in 1985 the evaluation of 5x-hybrids from crosses between *Ipomoea trifida* and Japanese sweet potato cultivars. Preliminary evaluation of the interspecific hybrid progenies showed that some were relatively less infested with sweet potato weevil. Moreover, there was a tendency for the hybrid progenies to have high dry matter contents. Thus, the sweet potato breeders continued to study the potential of these hybrids, especially the progenies from one backcross to the sweet potato parent stocks designed to improve their yielding ability.

Materials and Methods

One final preliminary trial of interspecific hybrid progenies selected in previous PYTs was conducted in fall 1989 season to determine which of the progenies should be maintained for further breeding and other related studies. Twenty clones were entered in PYT-II in fall1989-90, of which 11 were selections from the BC_1F_1 generation of the interspecific hybrid with *Ipomoea trifida*. The two parental sweet potato lines, CN 1345-8 and CN 1405-14, along with check clones, CN 1108-13, CN 1232-9, CN 1489-89, Tainung 57, Tainung 66 and Kinmen were also entered in the trial. The design used was group balanced block split plot with two replications. The blocks were allocated to two fertilizer treatments. This experiment was later converted to randomized complete block design with the fertilizer treatment effects confounded with the replication effects.

Results and Discussion

Yields of the six selected derivatives from the first backcross generation were comparable to those of the best yielding check cultivar, CN 1489-89. The best yielding backcross derivatives were CN 1872-8 and CN 1867-5, both yielding about 23 t/ha compared to 21 t/ha for CN 1489-89.

As observed in the 1989 trials, the dry matter content and dry matter yield of the interspecific backcross progenies were generally low. In this trial, the dry matter content of the progenies ranged from 23 to 29%. All these were significantly lower compared with those of CN 1489-89 and one of their high dry matter parents, CN 1345-8, which showed dry matter contents of 31.8 and 32%, respectively. It appears that the high dry matter trait of the immediate hybrid progenies with *I. trifida* was quickly lost after a single backcross to the sweet potato parents.

Based on average root size, it was clear that the hybrid progenies have already inherited the root bulking capacity and thus, the yielding ability of their sweet potato parents. Most of the selected clones had yellow skin with the exception of three which had some orange tinge. In general, the roots of the interspecific hybrid derivatives have a fairly good general appearance comparable to the sweet potato checks. A number of selected clones are currently being maintained as special parental stocks for future distribution.

Summary

Six backcross derivatives from interspecific hybridization with *Ipomoea trifida* yielded as well as the best yielding check cultivars, with yields as high as 23 t/ha in the 1989 fall PYT-II trial. As previously observed, the backcross progenies tended to have lower dry matter content than their high dry matter parent, CN 1345-8. Generally, the backcross progenies have already inherited the root bulking capacity and thus, the yield potential of their sweet potato parents. A number of selected clones are being maintained as special stocks for future distribution.

International Cooperation

AVRDC has been distributing virus-indexed elite cultivars and breeding clones to its cooperators in the national programs since 1988. In addition, AVRDC has also provided botanical seeds from crosses to interested collaborators.

In 1990, AVRDC distributed a total of 204 tissue culture tubes of virus-indexed clones to nine countries: Australia, Bahamas, Congo, Haiti, Korea, Madagascar, Thailand, Zambia and Zimbabwe. In addition, a total of 6,300 botanical seeds from crosses was distributed to five countries: China, Indonesia, Philippines, USA and Vietnam. No feedback has been received yet from cooperators who received virus-indexed tissue culture plantlets of AVRDC advanced germplasm during the last 2 years.

Sweet Potato Entomology

Screening of Interspecific Backcross Progeny for Resistance to Sweetpotato Weevil

Summary

Seven clones from a backcross between (*Ipomoea batatas* × *I. trifida*) × *I. batatas*, which were selected for low sweetpotato weevil (SPW) *Cylas formicarius* (F.) damage in 1988, were screened for resistance to weevil in a field test. The test entries with three susceptible checks were planted in 5 m × 1 m single row plots bordered on one side by weevil-infested sweet potato crop. Roots were harvested and evaluated for damage by weevil. Two entries, CN 1869-13 and CN 1872-9, were significantly less damaged than the susceptible checks and most other test entries. CN 1872-9 had higher yield (30.8 t/ha) than CN 1869-13 (15.6 t/ha). These clones which appeared promising for weevil resistance, will be screened further and if found resistant, the mechanism of resistance will be studied in 1990-91.

Introduction

Sweetpotato weevil, *Cylas formicarius* (F.) (Coleoptera: Curculionidae) is the most destructive pest of sweet potato in the tropics and subtropics. Because of its concealed feeding habit, this insect is difficult to control economically by conventional insecticide use. AVRDC, therefore, had aimed to develop integrated pest management (IPM) practices based on the development of SPW-resistant cultivars. However, no resistant clones were found among AVRDC's 1,200 sweet potato germplasm accessions. In 1985 AVRDC plant breeders crossed *Ipomoea trifida* with *I. batatas* to incorporate desirable agronomic characteristics, including possibly SPW resistance in sweet potato. Selected progeny were backcrossed to sweet potato to improve yield and quality. In 1988, 76 entries were screened and seven promising ones were selected for confirmation of resistance.

Materials and Methods

Each of the seven selected entries and three susceptible checks were planted in 10 randomly selected 5 m × 1 m plots in an SPW nursery. Each plot was bordered on one side by a weevil-infested row of sweet potato, which was planted two months earlier and inoculated with laboratory-reared weevils. The crop was raised using standard cultural practices except that no insecticide was applied. At harvest, the roots were evaluated for SPW infestation. Each root was cut open to count the number of SPW larvae, pupae and adults inside. The weevil-damaged and healthy portions of the roots were weighed and the percentage of damaged roots was calculated. The insect count data were converted to number of weevils (larvae + pupae + adults) per kilogram roots. All data were analyzed using analysis of variance and differences in means were compared by Duncan's multiple range test.

Results and Discussion

Among the seven apparently resistant lines of sweet potato found in 1988 tests only two, CN1869-13 and CN1872-9, were significantly less damaged than the susceptible checks and most other entries (Table 1). CN 1872-9 had a relatively high yield of 31 t/ha. This clone should be investigated further for yield, agronomic characteristics and mechanism of SPW resistance.

Table 1. Performance of selected backcross progeny for resistance to SPW.

Entry	No. of weevils per kg roots	Damaged roots (%)	Yield (t/ha)
CN 1861-2	45.6 b	29.4 bc	12.7 de
CN 1864-56	86.0 b	42.2 a	12.0 de
CN 1867-15	29.4 bc	19.1 cde	11.8 e
CN 1869-6	29.5 bc	17.8 cde	17.9 cd
CN 1869-13	12.6 c	8.9 e	15.6 cde
CN 1872-6	35.6 bc	26.4 bc	25.7 b
CN 1872-8	53.7 b	37.6 ab	38.9 a
CN 1872-9	12.8 c	12.1 de	30.8 b
CN 1510-25	28.5 bc	23.3 cd	19.8 c
Tainung 66	86.0 a	29.0 bc	16.3 cde

Planting date : 1 September 1989. Harvest date: 12 February 1990. Data are means of 10 replicates. Means in each vertical column followed by the same letter are not significantly different at 5% level according to DMRT. Plot size: 5 m × 1 m.

Screening of Selected Sweet Potato Germplasm for Resistance to Sweetpotato Weevil in Vine

Summary

Thirty-six germplasm accessions and progeny from a cross between *I. batatas* and *I. trifida* were screened for resistance to sweetpotato weevil in crowns. The crown served as an important source of weevil for infestation of sweet potato roots. Each entry was planted in four randomly selected plots; one month after planting, a large number of laboratory-bred weevils were released on the plants to assure uniformly high weevil infestation. Three months after planting, crowns were cut open and evaluated for weevil damage. One germplasm accession, I 959 and three *I. batatas* × *I. trifida* progeny, WT 81, WT 352, and WT 578 were the least damaged. There was a significant positive correlation between crown diameter and weevil infestation. Most *I. batatas* × *I. trifida* progeny had thin crowns. A significant negative correlation was found between length of internodes of vines (planting material) and weevil infestation of crown.

Introduction

Among over 300 species of insects that damage sweet potato, the sweetpotato weevil (SPW), mainly *Cylas formicarius* (F.) (Coleoptera: Curculionidae), is the most destructive both in the field and in storage. The insect causes the greatest damage to the roots, but when plants are young or when roots are inaccessible, SPW adults lay eggs in vines; later, larvae feed inside. Control of SPW in vines would thus remove the initial infestation source and reduce damage to the roots considerably. Breeding of sweet potato cultivars with genetic resistance to weevil in vines will help reduce SPW infestation. In 1988-89, therefore, AVRDC screened the entire sweet potato germplasm for resistance to SPW in vines and selected 36 apparently resistant entries, including several progenies from crosses between *I. batatas* and *I. trifida*. These entries were screened in replicated tests in spring 1990.

Materials and Methods

A parcel of land was worked into 1-m wide beds which were further divided into 5 m × 1 m plots. Vine cuttings of each of the 36 apparently resistant and three susceptible entries were planted individually in each plot. Each entry was planted in four randomly selected plots, each plot representing one replicate. The crop was raised using standard cultural practices except that no insecticide was applied. One month after planting a large number of laboratory-reared SPW adults were released uniformly over the entire planted area. Two months after weevil release, 10 plants in each plot were observed to measure the diameter of the crown at three points in three different internodes and the diameter of the terminal vine (usually used for planting) at three internodes. The lengths of three internodes in the terminal vine cutting were also measured. All plants were uprooted and

the 50 cm crown cut open to count the number of SPW larvae, pupae and adults inside. The number of insects (larvae + pupae + adults) per crown and percentage of crown damage were correlated to the diameter of vine and crown as well as internode length.

Results and Discussion

One germplasm accession, I 959 and three *I. batatas* × *I. trifida* cross progeny WT 81, WT 352 and WT 578 were the least damaged when screened for resistance to SPW through assessment of damage to crown and number of weevils found inside the crown.

There was a significant positive correlation between crown diameter and SPW infestation. All three WT entries had much narrower crowns than the rest. However I 959 had a much bigger stem than most other accessions. Resistance in this accession may be due to other factors. The color of the pigment in the epidermis of the crowns had no significant bearing on SPW infestation. Three of the four apparently resistant accessions had green crowns; the remaining had purple.

The entries with thinner vine also had significantly thinner crowns. However, there was no significant correlation between vine diameter and weevil infestation of crown. In general, the thinner the vines the longer were the internodes. There was a significant negative correlation between internode length and crown diameter. A significant negative correlation was observed between internode length of vines (planting material) and number of weevils in the crown or percentage crowns damaged.

Internode length and, to some extent, diameter of the cuttings can be used as criteria to select plant materials to reduce SPW damage. Plants derived from vine cuttings with thinner diameters and longer internodes are likely to be less damaged in the crown by SPW. The effect of this type of vine on sweet potato root yield needs to be clarified.

Advanced Screening of Sweet Potato Germplasm for Resistance to Sweetpotato Weevil

Summary

Two sweet potato germplasm accessions and four *I. batatas* × *I. trifida* cross progeny which were least damaged by sweetpotato weevil in a previous test, were screened with four susceptible checks for resistance to weevil in crowns. Each entry was planted in three adjacent 5 m × 1 m beds, four such randomly selected plots constituting four replicates. One month after planting, laboratory-bred weevils were uniformly released over the entire planted area to initiate infestation and avoid escape. Each entry was evaluated at 3, 5 and 7 weeks after weevil inoculation. Two sweet potato germplasm accessions I 123 and I 959 and four *I. batatas* × *I. trifida* progeny WT 81, WT 230, WT 352 and WT 578 were consistently least damaged in all three observations. These materials represented an important source of resistance to breed weevil-resistant sweet potato cultivars.

Introduction

Sweetpotato weevil (SPW), *Cylas formicarius* (F.) (Coleoptera: Curculionidae), in its larval stage, feeds inside sweet potato roots as well as stems. When tuberous roots are not yet developed or they are inaccessible, the weevil lays eggs in sweet potato vines and the larvae later feed inside. These larvae normally develop into pupae and adults. The adults act as an inoculum source for SPW infestation of roots. Since it is difficult to find sweet potato accessions with genetic resistance to weevil in tuberous roots, AVRDC initiated screening to evaluate sweet potato germplasm for resistance to SPW in vines. Resistance in the vine will reduce SPW populations before root formation and thus reduce root damage by removing the source of weevil infestation. The preliminary and second screening of sweet potato germplasm identified two sweet potato accessions and four *I. batatas* × *I. trifida* progenies as highly resistant to SPW. In this experiment their resistance was confirmed by sampling plants at various intervals during the season to judge the stability of resistance.

Material and Methods

A parcel of land was worked into 1 m wide raised beds. These beds were further divided into 40 plots, each consisting of three adjacent 5 m beds. Vine cuttings of each of the six promising and four susceptible entries were planted individually (one accession/plot) in three rows in each of four randomly selected plots; each plot was considered as one replicate. The crop was raised according to standard cultural practices, except that no insecticide was applied. One month after planting, a large number of laboratory-bred SPW adults were released uniformly over the planted area to initiate weevil infestation. At 3, 5 and 7 weeks after weevil release, all plants were uprooted in the first, second and third row, respectively, from each plot. A 30 cm portion of crown was cut open and SPW larvae, pupae and adults found inside were counted. The number of plants showing visible weevil damage in the crown was recorded. Insect count and percentage plants damaged were analyzed by analysis of variance and means were compared by Duncan's multiple range test.

Results and Discussion

Two sweet potato accessions, I 123 and I 959, and four progenies from *I. batatas* × *I. trifida* crosses WT 81, WT 230, WT 352 and WT 578 were consistently less damaged than three sweet potatoes and one *I. batatas* × *I. trifida* cross susceptible checks (Fig. 1). All four wide cross progenies had thin stems. The two sweet potato accessions, I 123 and I 959, however, had relatively thicker stems compared with WT progeny. Accession I 123 had shown varying levels of resistance to SPW in roots in past studies. It is possible that due to its resistance to SPW in vine, its roots, especially when they were either inaccessible or only partly accessible, had less. When this accession proved to be susceptible in other seasons, it was probably due to exposure of the roots to weevil from neighboring plots. If an entire field is planted to this accession, it will reduce weevil inoculum and thus minimize damage to sweet potato roots. Further studies are necessary to explore the mechanism of resistance.

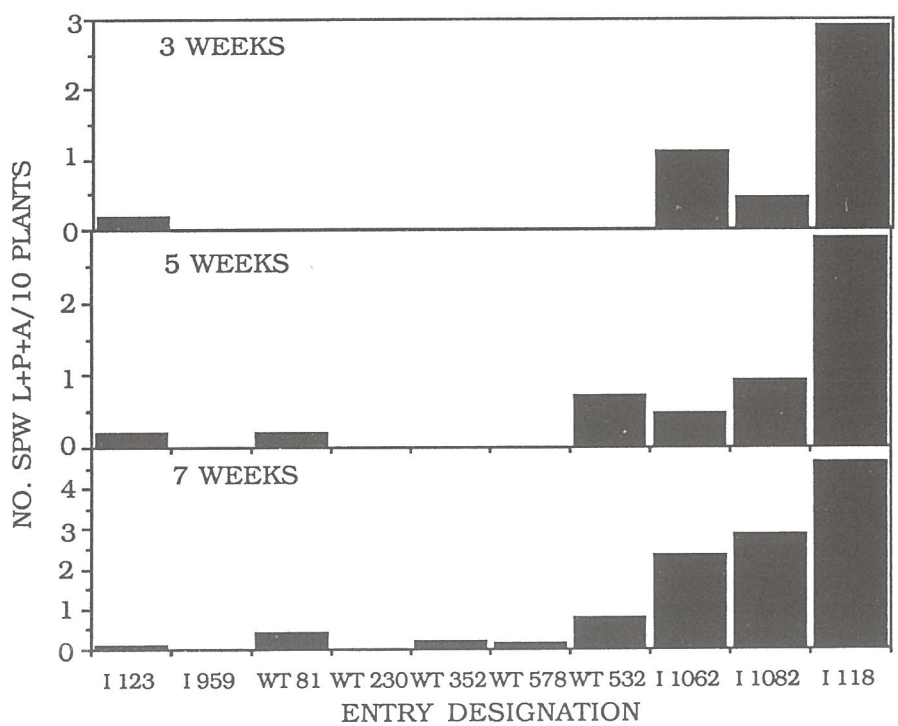


Fig. 1. Number of weevils found in the crowns of various entries at 3, 5, and 7 weeks after weevil release.

Effect of Sweetpotato Weevil Infestation of Crowns on the Yield of Sweet Potato

Summary

A two-season experiment was conducted in autumn 1989 and spring 1990 to find out whether sweetpotato weevil infestation of crowns reduced sweet potato root yield. In both experiments sweet potato (cultivar Tainung 57) was planted in the vicinity of a weevil-infested crop. Various levels of weevil infestation in the crown were achieved by spraying crowns only with carbofuran at 5, 10, 15, 20, 25, 30 or 35 day intervals throughout the season. Weevil infestation in the crown was monitored once every month (autumn 1989 experiment) or once every 2 weeks (spring 1990 experiment) and roots were harvested 135 days after planting. In the autumn 1990 experiment, there was a significant negative correlation between crown infestation and root yield. In the autumn test, greater weevil infestation occurred and showed greater impact on root yield. In the spring 1990 experiment, however, no such correlation was found. The effect of weevil infestation of crown on yield seemed to be influenced by environmental factors, especially the season of growth.

Introduction

Sweetpotato weevil (SPW), *Cylas formicarius* (F) (Coleoptera: Curculionidae) lay eggs in crowns and in exposed tuberous roots. Larvae hatched from eggs feed on the plant parts where the eggs are laid. There is no movement of larvae from the crown into the tuberous roots. Larval feeding in root destroys the root quality and makes them unfit for human consumption. The significance of larval feeding in the crown has not yet been clearly established. A survey of weevil infestation at harvest at AVRDC and in the U.S. showed no correlation between the number of weevils in the crown or damaged crowns and root yield. However, reports from Papua New Guinea, U.S. and elsewhere indicated that weevil damage in crowns reduces root yield. A two-season experiment was conducted to clarify the relation between SPW damage in the crown and the yield.

Materials and Methods

This experiment was conducted in autumn 1989 and spring 1990.

Autumn 1989. Land was rototilled and worked into 12 40 m^2 (8 m × 5 m) plots. In six randomly selected plots, sweet potato cuttings dipped for 30 min in 0.05% AI carbofuran were planted, and in the remaining six, untreated cuttings were planted. The planted area was located next to a weevil-infested sweet potato planting. In six plots where cuttings were treated before planting, carbofuran 0.04% AI was further applied once a week with a brush to 10-15 cm stems in the crown just above the soil surface. Starting 4 weeks after transplanting and once every month thereafter, 20 plants were uprooted from each plot. Each plant was cut open and the number of larvae, pupae and adults found inside were recorded. Also recorded were the number of plants showing visible damage by SPW. Five months after planting, the crop was harvested and root yield was computed. Five kilograms of roots were sliced and the number of SPW larvae, pupae and adults found in them were recorded. Weevil-damaged root slices were weighed and the percentage root damage by the weevil recorded.

Spring 1990. In this experiment, the land was rototilled and worked into eight 10 m × 5 m plots. Each plot was planted with sweet potato cuttings from weevil-free planting. This planting was located next to a sweet potato field heavily damaged by the weevil. Starting 1 week after planting, 0.04% AI carbofuran was applied to 10-15 cm stem just aboveground in the crown. Insecticide was applied once every 5, 10, 15, 20, 25, 30 or 35 days. Once every 2 weeks, 15 plants were uprooted and the number of weevil larvae, pupae and adults found were recorded. Also recorded were plants showing weevil damage in crown. At harvest root yield was recorded. Five kilograms of roots from each plot were sampled and the number of SPW larvae, pupae and adults recorded. Roots were thinly sliced, the damaged and healthy ones were weighed and the percentage damaged roots computed.

Results and Discussion

In all past studies, no correlation was observed between weevil infestation and root yield when the observations were made at harvest. In this study, instead of observing weevil damage of crown at harvest, weevil infestation was observed at 1, 2, 3 and 4 months after planting. At 1, 2, and 3 months after planting, there was a significant negative correlation between the number of weevils in the crown and root yield. No significant correlation was found at 4 months after planting. This indicated that weevil feeding in young vines may have reduced the yield. As plants mature, they become more tolerant. A significant positive correlation was found between number of weevils in crown found 1, 2 and 3 months after planting and number of weevils in roots at harvest. No such correlation was found when sampling was done 1 month before harvest.

In insecticide-treated plots, the number of weevils found in roots at harvest was significantly less ($t = 3.637^{**}$, $df = 10$) than those found in untreated plots. Treating of crown with insecticide seemed to reduce weevil inoculum and thus helped to reduce weevil infestation of sweet potato roots.

Spring 1990. There was no significant correlation between the number of weevils in the crown and root yield in any of the 10 observations taken every fortnight from planting to harvest. No significant correlation was found between number of weevils in the vine at any observation interval and in the roots at harvest.

Role of Types of Cuttings and Weevil Source on Sweetpotato Weevil Infestation

Summary

In one field experiment, normal terminal vine cuttings (30 cm length) and cuttings from older vine growth (second cutting after removal of distal 30 cm growth) were planted in open plots or plots surrounded by 5-m wide standing water to prevent weevil migration from the surrounding area. Infestation of crown and roots was monitored at a fortnightly interval throughout the season. In the open field, plants derived from both types of cuttings were eventually equally damaged. However, in water-surrounded plots, the number of weevils in crowns of plants derived from the terminal vine cutting was far less than in plants derived from old growth cuttings. This could be due to the presence of weevils in older cuttings. The use of fresh growth cuttings could prevent weevil infestation from the surroundings and result in weevil-free harvests.

Introduction

Sweetpotato weevil (SPW), *Cylas formicarius* (F.) (Coleoptera: Curculionidae), feeds inside tuberous roots and vines of sweet potato, although it prefers roots over vines. However, when roots are not developed or are inaccessible, the weevil lays eggs in vines where larvae feed inside. Planting of stem cuttings infested with the insect spreads weevil infestation from field to field. To minimize the spread of SPW by this mode, the types of cuttings that were prone to weevil infestation were investigated. AVRDC studied the role of these cuttings and the migration of the weevil from the surroundings on the infestation of sweet potato plantings.

Material and Methods

A parcel of land was worked into 1-m wide beds. These beds were further divided into 16 10 m × 10 m plots arranged in a square. A distance of 7 m was maintained between any two adjacent plots. Each of the eight plots in one half of the parcel was confined on all sides by a 5-m wide trench which was kept flooded with water throughout the season. This arrangement isolated individual plots from surrounding weevil source. For the other half of the parcel with eight plots, a 7 m space between plots was kept uncultivated. This area was occasionally rototilled to keep it relatively weed-free.

Sweet potato vines from weevil-infested fields were used as planting materials. The distal 30-cm shoots or fresh (growth) cuttings were planted in four plots surrounded by water and in four open plots. From the same shoot, starting with the decapitated distal end, a further 30 cm piece of vine (second cutting) was cut. These old growth cuttings were planted in the remaining eight plots: four water-surrounded plots and four open plots. In water-surrounded plots, a 1 m distance was maintained between water and sweet potato planting. All standard cultural practices were adopted except that no insecticide was used to grow the crop. Once every 2 weeks 15 plants were uprooted from each plot, the crowns cut open and the number of SPW larvae, pupae and adults found inside recorded. The number of plants with visible weevil damage in the crown was also recorded. At harvest 5 kg roots from each plot were obtained and cut open to record the number of SPW larvae, pupae and adults found inside.

Results and Discussion

In an open field, the type of cuttings used for planting did not influence the percent weevil-damaged plants, except that plants derived from old (growth) cuttings were damaged sooner than those derived from fresh (growth) cuttings. In the end, plants in all plots were equally damaged. In the case of water-surrounded plots, the plants derived from old cuttings showed a moderate level of damage practically from planting to harvest. There was, however, much less damage in plants derived from fresh (growth) cuttings. This difference could be due to relatively greater infestation of old portions of vines by SPW for laying eggs in, as was observed in the 1989 study. The faster rate and greater percentage of plants damaged in the open field appeared to be due to the migration of weevils from surroundings and insulation of water-surrounded plots from such migration.

The number of weevils found in the crowns was proportionate to the percentage of plants damaged by the weevil. Old cuttings planted in both open and water-surrounded plots had weevils from planting to harvest. Weevil infestation of old cuttings followed by migration of SPW from the surroundings to the open field could have caused this. Plants from new cuttings also had SPW inside the crowns. Plots surrounded by water had far fewer weevils because they were protected from the continuous migration of weevils from the surroundings. However, plants from open plots were not as protected, allowing the weevils to cause considerable damage to the plants.

New growth cuttings are relatively free of weevils and if plants derived from them are maintained free of weevils from surroundings, it is possible to get a weevil-free sweet potato crop without using any purchased inputs.

Preference of Sweetpotato Weevil to Roots and Vines of Sweet Potato

Summary

Preference of sweetpotato adult weevils to lay eggs either in tender vines or sweet potato roots and initiate infestation was studied in two modes in a greenhouse experiment. In one mode roots and vines of same plant were exposed to weevils; in the second, roots of one plant and vines of another were used. Exposure of roots and shoots of two different plants simulated field conditions wherein harvested roots or fully developed roots and newly planted sweet potato crops are accessible to weevil. Under such circumstances, the weevil was found to prefer storage roots. When roots and shoots of the same plant were exposed to weevils, weevil still preferred the storage roots over the shoots. This left vines free of weevil; thus, these vines can be safely used for planting a new sweet potato crop.

Introduction

Sweetpotato weevil (SPW), *Cylas formicarius* (F.) (Coleoptera: Curculionidae), feeds on both tuberous roots and in vines. Although the vines are not economically important, they are a source of infestation of the roots, the economically important parts of the plant. It is believed that SPW overwhelmingly prefers to oviposit and feed on sweet potato roots than in the vines. It is also believed

that when the sweet potato plant has developed roots, all weevils feeding on the vines will move to the roots when the roots become accessible through land cracks. It was already established that SPW prefers sweet potato roots over morning glory vines. But there are no data suggesting that SPW preferred roots over vines when both plant parts are available. Information on this aspect will help clarify the interaction between the weevil and its host.

Material and Methods

Two different approaches were used to study the preferences of weevils to root and shoot: preference for shoots and roots of two different plants and preference for shoots and roots of the same plant.

Preference for roots and shoots of two different plants. Sixty stem cuttings of cultivar Tainung 57 were planted in six plastic flats (containing soil), with 10 cuttings per flat (60 cm x 30 cm). The plants were placed in a greenhouse away from a potential weevil source and allowed to grow for 6 weeks. At this stage 60 healthy roots of the same sweet potato cultivar were planted in six similar flats. The roots were kept partially exposed (20-25% surface area). The six flats with cuttings and those with roots were placed randomly in a greenhouse room. A large number of laboratory-reared SPW adults were placed in the center of the flats, giving the insect equal access to roots or shoots. Six weeks later all roots or shoots in each flat were cut open to count the SPW larvae, pupae and adults found inside. Shoots or roots showing visible SPW damage were also counted.

Preference for roots and shoots of same plant. One hundred medium sized weevil-free roots of Tainung 57 were planted in six 60 cm x 30 cm flats containing sand. The roots were allowed to germinate. Two weeks after germination only 10 plants were maintained in each flat. Each root was allowed to have only one shoot; new shoots coming out were cut off. Six weeks after germination, the sprouting roots were exposed (20-25% of its surface). A large number of laboratory-bred SPW adults were placed in the center of the six flats allowing the insects equal access to roots and shoots in all flats. Six weeks after release of weevils, all plants were harvested, roots and shoots were cut open to record the number of larvae, pupae and adults inside. Roots and shoots showing visible weevil were also counted.

The insect count and percent plant damage data from both experiments were analyzed by t-test to compare the preferences of SPW to roots and shoots of sweet potato plants.

Results and Discussion

Under conditions where roots and shoots of two different plants were exposed to weevils, SPW preferred the roots over the shoots. Roots and shoots of the same plant under this simulated field condition developed roots, some of which became accessible to SPW, usually through land cracks. Under this condition, SPW also preferred to feed on roots. Only when the roots were not developed or when they were inaccessible was the weevil forced to oviposit and feed inside the sweet potato shoots. Sweet potato vines were not their naturally preferred food.

Sweet Potato Pathology

Evaluation of Selected Germplasm for Resistance to *Sphaceloma batatas*

Summary

Scab of sweet potato is an important disease in the Asia and Pacific regions. Sources of resistance to this disease have been previously reported in AVRDC Progress Reports. In this study, germplasm was inoculated to evaluate potentially useful clones for sources of resistance to scab. From initial tests of 322 accessions, 43 were retested. Ten of these retested clones had equal or lower levels of infection than lines I 949 and I 1189.

Introduction

Scab of sweet potato is caused by the fungus *Sphaceloma batatas*. It is a major disease in some production areas in Asian and Pacific countries. There is a dearth of information published about this disease. The disease cycle, epidemiology and control of scab is not well understood. AVRDC initiated a program on scab primarily to find host sources of resistance, and also to understand more about culturing the pathogen. Efforts have resulted in the development of host resistance screening procedures, along with the identification of resistant sources. This study screened germplasm selected by the breeding program for resistance to scab.

Materials and Methods

In an initial screening of 322 accessions, 47 and two checks were selected for further scab evaluations. Of the 47 accessions, 32 were initially rated as resistant and the other 15 were rated as susceptible. Twenty-four cuttings from each entry were started in 7.5 cm diameter pots. These accessions were selected as promising germplasm for use in further evaluations.

The cuttings were inoculated with *S. batatas*, incubated, and rated for scab using the following rating scale based on percent infection of new growth: 1 = × 3%, 2 = 3-10%, 3 = 10-25%, 4 = 25-50%, 5 = 50-95%, 6 = 95-100%.

Results and Discussion

The average infected tissue was 9.3%. Most of the lines tested had fairly good levels of resistance. I 949 and I 1189 each had 4% infected tissue. Lines I 336, I 4, I 731, I 766, I 835, I 921 and I 932 had equal or lower levels of infected leaf area compared to I 949 and I 1189.

Virus Elimination and Virus Indexing

Summary

The virus elimination and virus indexing method developed in 1986 was applied to 135 additional lines, comprised of the elite AVRDC breeding lines and collections from Southeast Asia and

the Pacific that could be lost or neglected. Meristem survival in these lines ranged from 40 to 85%. An average of 11% virus-infected plants could be detected in young plantlets in the first ELISA test, conducted for feathery mottle virus (SPFMV), yellow dwarf virus (SPYDV), latent virus (SPLV), sweet potato virus II (SPVII) and mild mottle virus (SPMMV). However, in the first graft indexing conducted on grown out plantlets, 27% of the plants still carried virus. In most cases, unknown virus(es) which could not be detected by ELISA seemed to be involved. However, only an average of 3.5% virus-infected plants were detected in the second graft indexing, conducted after the graft I negative plants were cut back and allowed to mature again.

Eighty-four virus-free lines were obtained this year, bringing the total of meristemmed and virus-tested sweet potato germplasm to 322.

Introduction

Sweet potato clones are usually heavily contaminated with viruses because they have been vegetatively propagated for many years. For international movement of sweet potato germplasm, it is important that materials are virus-free.

As of last year more than 200 clones had gone through the virus indexing scheme initiated in 1986. Priority is presently given to elite breeding materials and to those collections that are threatened by neglect or abandonment.

Materials and Methods

The procedure described in last year's Progress Report was followed. The AVRDC elite breeding lines, elite lines from China, Japan, Malaysia and Nigeria and collections from Thailand, the Solomon Islands, Papua New Guinea, the Cook Islands and Niue Islands were subjected to the scheme in 1989-90.

Results and Discussion

Of the 135 lines that underwent the virus elimination and virus indexing scheme in 1989-90, 84 virus-free lines were obtained (Table 1). Meristem survival ranged from 40% (Papua New Guinea lines) to 85% (China II lines). The average meristem survival value was 54.4%. In the ELISA 1 test conducted with FMV, SPLV, SPYDV, SPVII and SPMMV antisera, an average of 11.2% virus-infected plants were detected. In the graft-indexing I step which followed ELISA 1, 26.9% of the

Table 1. Sweetpotato virus indexing 1990

Country	Description	Received	No. of lines received	No. of lines rooted	No. of virus-free lines before 1990	No. of virus-free lines 1990
Thailand	Germplasm collection	Nov. 86	100	91	69	12
Solomon Islands	Collection	Dec. 87	102	56	20	15
Papua New Guinea	Elite lines	Sept. 87	17	16	12	1
Nigeria	IITA lines	Oct. 87	10	10	8	2
Taiwan	AVRDC Breeding lines (3rd batch)	Dec. 87	10	10	7	3
Taiwan	AVRDC Breeding lines (4th batch)	June 89	16	16	0	15
China II	Elite lines	Mar. 88	2	2	0	2
China III	Elite lines	Dec. 88	11	11	0	9
Cook Island	Germplasm collection	Apr. 89	11	5	0	4
Niue Island	Germplasm collection	Sept. 89	6	6	0	3
Japan I	Elite lines	Sept. 89	8	8	0	4
Japan II	Elite lines	Oct. 89	1	1	0	1
Malaysia	Elite lines	May 89	20	20	0	9

plants were still virus-infected. All *Ipomoea nil and I. setosa* plants which showed virus-like symptoms after grafting were checked by DAS-ELISA for these five viruses. Many of these were negative, indicating that a high percentage of these virus-infected plants contained unknown virus(es). However, in the second graft indexing, only an average of 3.5% of the plants were found to be virus-infected. This shows that the ELISA test alone is not sufficient in detecting virus infection in the meristem-derived plantlets because virus concentration in these young plantlets is not high enough to allow detection by ELISA and because of the possible presence of unknown viruses for which antisera are presently not yet available. Detectable levels of virus seem to be reached mainly after the plantlets have grown out and allowed to reach maturity.

Two viruses, SPYDV and SPLV which have been originally described only in Taiwan, were also detected in lines originating from other geographic areas. Sweetpotato yellow dwarf was found in lines from Japan, Malaysia, Nigeria, Cook Island, Niue and Solomon Islands. Latent virus was found in lines from the Solomon Islands and Thailand. Viruses which could not be characterized, and which may be new viruses, were present in all lines except the ones from Nigeria.

Effect of Meristemming on Yield and Quality of Sweet Potato Grown for Various Lengths of Time

Summary

Virus infection in vegetatively propagated plants is usually high. Virus elimination can be achieved through meristem tip culture. However virus reinfection usually occurs when such plants are planted to the field again. A replicated field trial was therefore conducted to investigate yield, quality parameters and virus reinfection in six meristem-derived lines, planted from one to four growing periods in the field. Virus infection took place within the first growing season in all six meristem-derived lines. Significantly higher yields could be obtained in meristem-derived plants grown up to four growing periods (from September 1988 to July 1990) in the field than in field-propagated plants. However, at the end of the fourth growing season, virus reinfection of meristem-derived plants had reached that of the field-propagated plants. Meristemming had no apparent effect on the quality of the crop. Starch, sugar, protein, carotene and fiber content were the same in meristemmed and nonmeristemmed plants.

Introduction

In vegetatively propagated crops the carryover of viruses from one generation to another leads to a gradual crop decline. Most of the AVRDC sweet potato germplasm collection were previously found to be virus-infected through visual observation and/or ELISA test. In 1976, a virus elimination and virus indexing system was initiated to 1) ensure that all incoming and outgoing materials are free of virus; and 2) to enable breeders to determine the true yield potential of promising lines. In 1989, it was found that the yield of five meristem-derived plants was significantly higher in the first growing season than that of field-propagated plants. Furthermore, in terms of yield, different cultivars were shown to be affected differently by virus infection. This study aimed to determine how long meristemming can be effectively used.

Materials and Methods

Experiment 1. 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 field-grown plants (F), and one set from mature meristem-derived and virus-indexed plants (M). Two other sets were derived from originally meristemmed plants which had been grown in the field for one growing season (M_1) (20 January-4 October 1989), and two growing seasons (M_2) (20 September 1988-4 October 1989).

Cuttings of set M were multiplied in an insect-proof screenhouse. All other sets were multiplied in the field. Tip cuttings, 20 cm long, were used as planting material. A randomized complete block design with six replications was used.

Plot size was 4 × 5 m and consisted of four rows of 20 plants per plot. Plant to plant distance within rows was 25 cm, and distance between plots was 2 m. The cuttings received a 30 min preplant drench in Furadan (0.04%). A pheromone trap was placed every 20 m to control weevils.

The experiment was planted 4 October 1989 and harvested 20 February 1990. Data collected included total and marketable yield, dry matter, starch, sugar, protein and fiber. Quality measurements were taken by the Chemistry Department.

Virus incidence was recorded in 10 randomly chosen plants per plot. Three leaves each were collected from the top, middle and bottom of each plant and pooled and tested by DAS-ELISA for SPFMV, SPYDV and SPLV.

Experiment 2. The same five improved sweet potato lines were used as in Experiment 1. There were five sets: set 1 (F) derived from field-grown plants; set 2 (M) derived from mature meristem-derived and virus-indexed plants, and propagated in an insect-proof screenhouse; set 3 (M_1) derived from originally meristemmed plants which had been grown in the field for one growing season (since October 1989); set 4 (M_2) derived from originally meristemmed plants which had been grown in the field for two growing seasons (since May 1989); and set 5 (M_3) derived from originally meristemmed plants which had been grown in the field for three growing seasons (since September 1988).

The experiment was planted 15 February and harvested 10 July 1990. The experimental design, cultural management practices and data collection were the same as those in Experiment 1 except that only three instead of five replications were made. Quality measurements were not taken. Virus incidence was recorded in all plants of each plot.

Results

Experiment 1. The greatest yield increase due to meristemming in the first growing season was observed in line I 57 with 75% increase, followed by lines CN 1510-25, CN 1108-13, CN 1028-15 and TN 66 with 45, 36, 20 and 18% yield increase, respectively (Table 2). In all lines the positive effect of meristemming in terms of increased yield (marketable and total yield) was still evident in the third season after the growing out of the virus-indexed meristem-derived plants to the field (Table 2). The yields of the meristem-derived plants grown in the field for three seasons were still significantly higher than those of nonmeristem-derived field-grown plants. In first season field-grown meristem-derived plants, virus incidence was reduced by 91% in I 57 followed by 87% in CN 1108-13 and 82% in the other lines. With one exception (line CN1028-15) virus incidence in M_1 and M_2 stayed significantly below that of the non-meristemmed field-propagated plants.

Meristemming had no apparent effect on six quality parameters tested in the five sweet potato lines (Table 3).

Experiment 2. The meristem-propagated clones generally showed significantly lower virus incidence than the field-propagated clones (Table 3). However, by the end of the fourth field planting, virus incidence of two clones (TN 66, CN 1028-15) had already reached that of nonmeristem-derived field-propagated clones. In another clone (I 57) virus incidence of M_3 plants was even higher than that of nonmeristemed field-propagated plants. In the two other lines (CN 1510-25, CN 1108-13) virus incidence in meristem-derived plants planted for four growing periods in the field was still lower than in nonmeristemmed field-propagated plants. However, in all five lines, yields of meristem-derived plants which had already been grown in the field up to four growing periods were found to be still significantly higher than those of the nonmeristemmed field-propagated clones (Table 3).

Infection of sweet potato with viruses apparently had no effect on the quality of the crop. Starch, sugar, protein, carotene and fiber content were the same in field-propagated and meristem-derived plants. It is not clear which factors contributed to the increase in yield in meristemmed plants, which in all lines lasted until such meristemmed plants were grown in the field for up to four growing periods, despite their being reinfected by viruses at a level similar to that of field-propagated plants.

Meristemming followed by virus indexing has thus proved useful as an economical approach to increase yields in farmers' fields in the absence of virus-resistant cultivars. However, further tests are needed to determine whether this yield increase in meristem-derived lines can also be maintained under different agroclimatic and epiphytotic conditions.

Table 2. Effect of meristemming on yield and quality of five sweet potato lines (Experiment 1)[a].

Variety	Treatment[b]	Market. Yield/ Plot (t)	Total Yield/ Plot (t)	Dry Matter (%)	Starch (%)	Sugar (%)	Protein (%)	Carotene (%)	Fiber (%)
TN 66	F	0.5[c]	0.6	31.5	61.4	15.3	7.1	8.1	3.8
	M	0.6	0.7	30.8	61.2	15.5	7.1	8.2	3.9
	M1	0.6	0.6	31.1	61.7	15.5	7.1	7.9	4.0
	M2	0.6	0.7	30.9	61.6	14.7	7.4	8.4	3.9
CN 1108-13	F	0.5	0.6	30.2	65.6	14.4	7.6	1.7	3.8
	M	0.7	0.7	29.8	66.4	14.1	7.7	2.0	3.9
	M1	0.7	0.8	29.8	66.5	14.2	7.4	1.5	3.9
	M2	0.7	0.7	30.4	66.4	14.1	7.4	1.5	3.9
CN 1510-25	F	0.4	0.5	34.4	65.3	17.0	6.5	2.2	4.1
	M	0.6	0.7	34.4	65.1	16.9	6.8	1.5	4.0
	M1	0.6	0.6	34.6	65.9	16.7	6.5	2.3	4.0
	M2	0.6	0.6	34.4	65.1	16.4	6.9	1.7	4.2
I 57	F	0.4	0.5	31.1	62.9	16.0	6.4	1.1	4.6
	M	0.7	0.8	29.2	63.1	17.5	6.0	0.5	4.4
	M1	0.7	0.8	30.0	64.6	16.0	5.6	0.8	4.2
	M2	0.7	0.7	29.8	63.2	17.2	6.0	0.7	4.3
CN 1028-15	F	0.8	0.8	28.5	61.0	18.9	6.4	0.5	4.6
	M	0.9	0.9	27.3	60.8	19.5	5.9	0.3	4.6
	M1	1.0	1.0	27.1	60.8	19.5	5.8	0.3	4.6
	M2	0.9	1.0	28.3	62.5	18.4	6.0	0.4	4.6
CV		11.14	10.71	3.9	2.8	4.8	10.0	22.2	4.6
LSD0.05		8.97	9.07	1.5	2.2	1.0	0.8	0.7	0.2
VAR (V)		83.14**	79.52**	97.32**	36.40**	129.62**	21.32**	725.87**	66.40**
TRT (T)		41.57**	39.30**	2.41ns	0.80ns	2.44ns	1.47ns	0.49ns	0.85r
VXT		2.88**	2.57**	0.70ns	0.65ns	2.02*	0.84ns	0.43ns	1.43r

[a]The experiment was planted 4 October 1989 and harvested February 1990. [b]F = field propagated cuttings; M = cuttings derived from meristems; M_1 = meristem-derived cuttings planted in the field for one growing season (since May 1989); M_2 = meristem-derived cuttings, planted in the field for two seasons (since September 1988). [c]Data are means of six replications. [d]f value and significance level.

Table 3. Effect of meristemming on yield and virus infection in five sweet potato lines (Experiment 2).[a]

Variety	Treatment[b]	Market. yield/ plot (t)	% increase in yield	Total yield/ plot (t)	Virus incidence (%)	% reduction in virus incidence
TN 66	F	0.2[b]		0.3	30	
	M	0.3	48	0.4	3	89
	M1	0.4	56	0.4	22	28
	M2	0.4	56	0.4	23	22
	M3	0.3	25	0.3	30	0
CN 1108-13	F	0.1		0.2	67	
	M	0.3	156	0.4	5	92
	M1	0.4	180	0.4	25	63
	M2	0.4	211	0.4	57	14
	M3	0.3	156	0.4	62	7.5
CN 1510-25	F	0.2		0.3	43	
	M	0.3	54	0.4	7	85
	M1	0.3	56	0.4	12	73
	M2	0.3	33	0.4	18	58
	M3	0.3	42	0.4	35	19

Table 3. Continued.

Variety	Treatment[b]	Market. yield/ plot (t)	% increase in yield	Total yield/ plot (t)	Virus incidence (%)	% reduction in virus incidence
I 57	F	0.3		0.3	23.33	
	M	0.4	44	0.4	6.66	72
	M1	0.4	64	0.4	11.67	50
	M2	0.4	52	0.4	18.33	21
	M3	0.3	14	0.3	26.67	14
CN 1028-15	F	0.4		0.4	18.30	
	M	0.6	66	0.6	1.67	91
	M1	0.7	99	0.5	8.33	55
	M2	0.5	33	0.5	13.33	27
	M3	0.5	29.9	0.5	18.33	0.2
CV		10.30		8.64	29.19	
LSD0.05		2.62		2.48	5.01	
VAR(V)		69.81**d		68.87**	44.53**	
TRT (T)		50.94**		56.02**	56.60**	
VXT		3.73**		3.53**	5.09**	

[a]The experiment was planted 15 February and harvested 10 July.1990. [b]F = Field propagated cuttings. M = cuttings derived from meristems; M1 = meristem-derived cuttings planted in the field for one growing season (since October 1989); M2 = meristem derived cuttings, planted in the field for two growing seasons (since May 1989); M3 = meristem-derived cuttings, planted in the field for three growing seasons (since September 1988). [c]Data are means of three replications. [d]f value and significance level

Resistance to Viruses and Mycoplasma-like Organisms

Summary

Resistance to viruses and mycoplasma in cultivated sweet potato and related species is not known. A preliminary investigation was therefore conducted to obtain information on possible resistance/ tolerance to these pathogens. Of the 466 accessions screened for resistance to witches' broom under natural epidemic conditions in Penghu Island, 58 were without witches' broom symptoms up to 5 months after planting. Eighteen of these remained symptomless in a second confirmation field screening. However, when grafted to witches' broom-infected sweet potato, only two lines (I 1 and I 903) were symptomless. Line I 117, reported to be resistant by previous AVRDC virologists was 100% infected 5 months after graft inoculation. Symptoms, however, were mild and began to appear after a long incubation time of 3 months.

Of the total germplasm screened for resistance/tolerance to virus, only three lines (I 427, 545 and 358) were identified symptomless after 5 months in the field in two consecutive plantings. When grafted to SPFMV-infected sweet potato cuttings, the two lines were symptomless and also negative for SPFMV in DAS ELISA. However when highly susceptible healthy *I. nil* and *I. setosa* were grafted on these symptomless and ELISA-negative plants, they showed symptoms, indicating that low amounts of virus which were not detectable by ELISA were present in these three lines. Preliminary screening results indicated that resistance to certain viruses (SPFMV, SPLCV) may be present in related *Ipomoea* sp. such as *I. aquatica*. It may be concluded that resistance to viruses and MLO appears to be rare in the AVRDC germplasm collection. When screening for MLO-resistant plants it is important to observe them for a sufficient length of time because of the long latent period of the MLO in some sweet potato lines.

Introduction

Although virus infection is common in sweet potato and is known to cause significant yield reduction, screening for resistance has not been conducted systematically. Information, therefore, was obtained about virus resistance (tolerance) in the AVRDC germplasm collection. Witches' broom (WB) disease of sweet potato is common throughout the Pacific Islands and in certain regions of Southeast Asia, such as Okinawa (Japan), Penghu Island (Taiwan) and Fujien province of China. About 200

lines were screened at AVRDC prior to 1976, and one line I 117, was identified as resistant (AVRDC 1975, 1976 Progress Reports). Since then screening has been discontinued.

The AVRDC accession I 117 which was reported to be resistant (=no infection) in 3 years of intensive field screenings on Penghu Island (AVRDC 1976 Progress Report) was, however, found to be susceptible under conditions prevailing in Solomon Islands, both when planted in the field and when grafted with plants infected with the local witches' broom agent (Jackson and Zettler 1983 Plant Disease 67: 1141-1144.). This accession was found to develop symptoms as early as 46 days after grafting. The resistance of this line was reinvestigated at AVRDC this year by grafting to determine whether the MLO causing witches' broom in Taiwan and Asia might be different from the one causing witches' broom disease in the Pacific Islands. Six additional lines, observed to be field-tolerant to witches' broom disease, were also screened for resistance by grafting in the screenhouse. Selected accessions of the AVRDC germplasm collection were screened for witches' broom resistance at Penghu Island under natural epidemics to detect potentially resistant/tolerant lines. To obtain more information on virus resistance, the AVRDC field-grown germplasm collection was subjected to a preliminary observational test.

Materials and Methods

Witches' broom (MLO)

Grafting. Witches' broom (WB)-infected sweet potato cuttings were originally collected from a farmer's field in Penghu Island. They were virus-free and maintained in the AVRDC quarantine screenhouse. Twelve 30-cm long stem cuttings of each of seven accessions (I 65, I 100, I 117, I 125, I 279, I 345 and Tsou Twun) to be tested were rooted in soil and wedge grafted with individual 8-10-cm long WB-infected sweet potato shoots. The grafted plants were maintained in an insect-proof screenhouse and observed for six months for symptom development.

Field screening

Screening 1. Two hundred and sixty lines were planted on 23 June 1989 on Penghu Island, where both the leafhopper vector and the mycoplasma are endemic. Cuttings of 40 cm length were taken from the AVRDC field-grown germplasm collection. Plot size was 1 × 2 m, consisting of a single row of nine plants. Every fifth row was a spreader row, planted to nine WB-infected plants. The planting received no insecticide treatment throughout the growing season. The experiment was replicated twice. The trial was done in an area of the island where sweet potato had been planted previously.

The plants were visually assessed four times, on 23 August, 21 September, 23 October and 21 November, for typical witches' broom symptoms, such as stunting, excessive proliferation of stems and buds and reduced leaf size.

Screening 2. Two hundred sixty lines were screened in Penghu in spring/summer 1990: 38 lines from the first field screening which had 0% incidence of visible MLO infection at the last assessment after 5 months; 15 lines had less than 5% final infection from the first field screening; and 206 were additional new lines. A highly susceptible check (I 181) which had shown 100% infection in last year's screening was also included. The experiment was planted on 23 May 1990. The same experimental design and assessment described in screening 1 was used. Visual assessments were done on 24 July, 25 September and 29 October.

The experiment was planted in an area where sweet potato had not been previously grown. Another area, which might have provided more optimum natural screening conditions (MLO-infected weeds, MLO-infected volunteer sweet potato plants, high population of MLO carrying leafhoppers etc.) was not available.

Viruses

Resistance in the AVRDC germplasm collection. The AVRDC germplasm collection, consisting of 1,216 accessions, was planted to the field in the fall / winter 1988-89 season and assessed

for virus infection. Each accession consisted of five plants. Plants of each line were visually inspected throughout the growing season for typical signs of virus infection, such as chlorotic spots, red spots, red rings, red or yellow discoloration, mottle, veinclearing, leaf curling and stunting. Accessions where these symptoms were absent were tested by ELISA for the presence of FMV, the most frequently encountered virus in AVRDC and elsewhere in Taiwan. The ELISA test was conducted for each plant of symptomless accessions, using five randomly collected leaves per plant, which were pooled for the ELISA test.

A total of 96 accessions which showed no symptoms after 5 months in the field and which gave a negative ELISA reaction were planted in spring/summer 1989 in a non-replicated observational trial (planted to the field 24 February) in an area of 30 x 24 m. Plot size was 3 x 1.5 m. Each plot consisted of a single row of five plants with a plant to plant distance of 25 cm. The five plants originated from cuttings taken from five different plants of each accession planted in fall/winter 1988-89. The field was surrounded with a border row of FMV- infected plants. There were no insecticide treatments except for the AVRDC recommended pheromone traps for weevil control. The plants were monitored at 2-week intervals throughout the growing season.

Five cuttings from each line which did not show obvious virus symptoms in spring/summer 1989 were taken to the screenhouse where they were wedge-grafted with a 5-7-cm long FMV-infected sweet potato scion. The cuttings were observed for 5 weeks for symptom appearance. At 6 weeks after grafting, they were tested by ELISA for the presence of FMV. Scions of these plants were also grafted to *I. nil* and *I. setosa*, which are known to produce pronounced symptoms when grafted with virus-infected scions. These indicator plants were observed for 5 weeks for symptom development and then tested by ELISA for FMV.

Resistance in other *Ipomoea* sp. Seven *Ipomoea* species (*I. bona nox, I. yhederacea, I.lacunosa, I. wrightii* and *I. aquatica*) were tested for resistance to FMV, SPYDV, SPLV, SPVII and SPLCV. Plants were either mechanically (SPYDV, LV, SPVII) or graft inoculated (FMV, SPLCV). Fifteen plants from each species were tested. An ELISA test was performed 3 weeks after the inoculation.

Results and Discussion

Witches' broom (MLO)

Grafting. Symptom appearance varied with the cultivar tested. Symptoms observed in I 65, I 100, I 279, I 125 and Tsou Twun were very severe with extensive proliferation of erect axillary shoots and very small leaves (about 0.5-1 cm) . In line I 345, symptoms were milder, i.e. proliferation was not as extensive, and leaves were only about 30-50% the size of normal leaves. In line I 117 only very little proliferation of axillary shoots was observed; leaf size was reduced by less than 20%.

It is apparent that the incubation time of the MLO differs in the cultivars tested (Fig. 1). One group of lines (I 100, I 65, I 279, I 343) had a relatively short incubation time of 1 month before symptoms began to appear. In this group, 50% infection of the plants occurred between 2 and 4 months after grafting. The other group of lines (I 117 and Tsou Twun) had an incubation time of more than 3 months.

In line I 117, 100% infection occurred shortly after the incubation period. The long incubation time in I 117 may be the reason why this line has previously been reported to be field-resistant in Taiwan. It had probably not been observed for a sufficient length of time for symptom development. Furthermore, when infection by leafhoppers occurs in nature, the incubation time may even be longer because of the small amount of MLO introduced into the plant by the insect. Because line I 117 was previously found to be immune to the Taiwan witches' broom disease but not to the Pacific strain, it had been suspected that the two diseases are caused by different strains of MLO. However, the finding that I 117 also was 100% susceptible to the Taiwan strain indicates that the witches' broom disease in the Pacific Islands and in Taiwan may be caused by the same agent.

The study clearly showed that when screening for witches' broom resistance by grafting, the test plants should be observed for a sufficiently long time, at least for 6 months after grafting, because of the long incubation time of the MLO in some sweet potato cultivars.

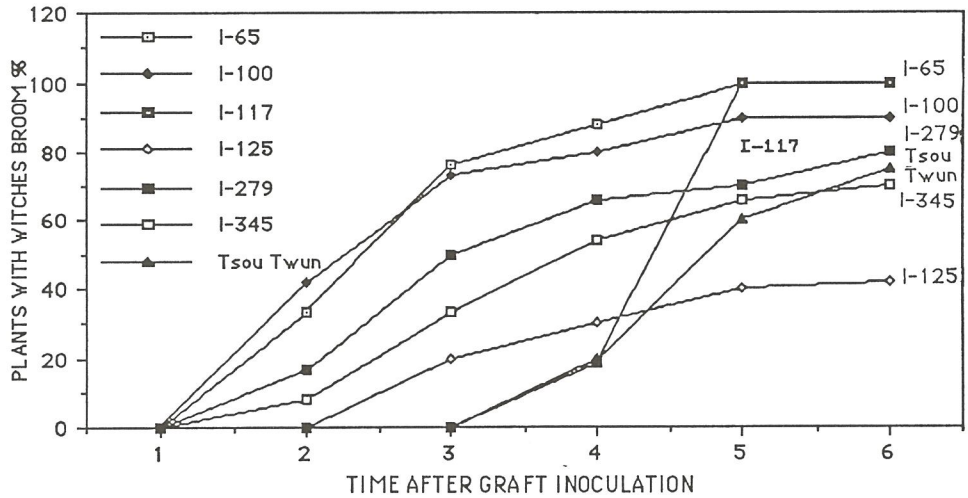


Fig. 1. Witches broom infection in selected lines after grafting.

Field screening

Screening 1. Of the 260 lines screened in the first experiment on Penghu Island, 39 lines did not have infection 5 months after planting. By that time the other lines showed 50% WB infection or more. Several highly susceptible lines were observed with 100% incidence after 5 months in the field: I 181, I 229, I 355, I 411, I 439, I 637, I 928 and I 1056.

Screening 2. Eighteen of the 38 lines, which were without symptoms in the first screening, were also symptomless after 5 months in a second screening test in Penghu fields. At the same time accession I 117, previously reported resistant, showed 11% witches' broom infected plants. Some of the symptomless lines (I 1, I 172, I 288, I 354, I 360, I 365, I 495, I 657, I 679, I 829, I 903) were also subjected to graft indexing (10 cuttings of each line were grafted to 10 MLO-infected sweet potato plants). However, only two lines (I 1 and I 903) were still without symptoms at 4 months after grafting.

Of those lines screened for the first time in Penghu fields, 18 remained symptomless after 5 months in the field. They will be screened again. When screening is conducted under natural epiphytotic conditions, observation should be for at least 5 months because of the long latent period of the MLO in some sweet potato lines.

Virus

Germplasm collection. One hundred and eighty-one lines of AVRDC field-grown germplasm collection of 1,219 accessions were found to be without obvious symptoms after 5 months in the field (October to February 1989). When an ELISA test for FMV was performed on these lines, 85 were found to harbor the virus. Cuttings were taken from each plant of the remaining 96 ELISA negative lines and planted in the field for further observation during spring/summer 1989. After 5 months, eight of the 96 lines were found with no symptoms (I 192, I 196, I 394, I 491, I 545, I 487, I 928, I 1080) and 23 lines with very mild or questionable symptoms.

With the exception of seven lines, plants of these 31 lines were found to produce clear symptoms (chlorotic spots) when grafted with FMV-infected stem cuttings. Lines I 933 and I 358 showed none to very mild symptoms and FMV was detected by ELISA in only two of the five plants after back-grafting to *I. setosa* and *I. nil*. Line I 427 showed no symptoms after grafting with FMV-infected sweet potato although FMV was detected in two of the five plants when back-grafted to *I. setosa* and *I. nil*. Only one plant of I 1080 showed symptoms after grafting to FMV-infected sweet potato.

However, when back-grafted to *I. setosa* and *I. nil*, two plants were positive for FMV. Two lines (I 427, I 358) appear to be highly tolerant to FMV, since they remained symptomless when grafted to FMV-infected cuttings and did not react with FMV in ELISA. The negative ELISA values indicated either absence of virus or presence of an extremely low virus titer of viruses, lying below the detection threshold of ELISA. However, when grafted to the virus-susceptible indicator plants *I nil* and *I. setosa*, virus was detectable by ELISA in some of these plants. It thus appears that the low virus titer in the grafted sweet potato plants was amplified in the virus-susceptible indicator plants after grafting.

Thus, lines with tolerance to virus (none or very mild visible symptom appearance, despite infection with the virus) can be found in the AVRDC germplasm collection.

Other *Ipomoea* species. None of the lines tested appeared to have resistance to all the viruses tested. However, several of the *Ipomoea* species tested showed resistance to some of the viruses, e.g. *I. bonanox* did not become infected with SPLCV, SPLV and SPVII; *I. wrightii* was not affected by SPLCV and SPLV, and *I. aquatica* was not affected by FMV, LV and SPVII.

Sweet Potato Physiology

Evaluation of Flooding Tolerance in Sweet Potato Clones

Summary

Thirty-nine promising sweet potato clones were evaluated in three distinct seasons for flooding tolerance using the leaf cutting method. Disregarding planting season as a variable, flooding imposed 3 or 7 weeks after planting reduced leaf cutting growth and storage root formation. The extent of reduction in storage root enlargement and yield due to high temperatures seemed to be more acute than that by flooding. Flooding imposed 3 weeks after planting was critical in accelerating leaf senescence and inhibiting storage root initiation, but flooding 7 weeks after planting was effective in impeding storage root enlargement and reducing starch content in the storage root.

There were clonal differences in leaf senescence and survival of leaf cuttings after flooding treatments. CN 1489-89 had the slowest rate of leaf chlorosis and the highest survival rate after flooding. I 100 and I 444 also had relatively high survival rates after flooding. In general, I 100, I 444, and CN 1489-89 produced more storage root yield than other clones under flooding conditions in three separate evaluations. However, I 444 appeared to be sensitive to high temperature, whereas both I 100 and CN 1489-89 were more stable under flooding conditions in both cool and hot seasons.

Soil moisture at 100% field capacity decreased oxygen diffusion rates of the medium with leaf cuttings from eight promising clones, but increased the fibrous root oxidation activity of both high and low yielding leaf cuttings. Soil moisture at 100% field capacity also decreased storage root yield. Therefore, increase in fibrous root oxidation activity in sweet potato may not necessarily lead to flooding tolerance in terms of storage root formation.

Introduction

Excess soil moisture, especially at the critical stage of storage root initiation, is one of the major factors that limit the productivity of sweet potato in the hot, humid tropics. To overcome this constraint, identification of clones which are able to produce storage roots under excessive soil moisture conditions is necessary. However, the bulk of sweet potato plants, and great variation in field-grown plants make assessment of clonal tolerance to flooding rather cumbersome . This study identified flooding-tolerant clones among 39 promising clones under three seasonal conditions using leaf cutting method, and looked into the mechanism involved in flooding tolerance.

Materials and Methods

Leaves with petioles were detached from 39 field-grown sweet potato clones and transplanted to PE tubes (ID 17 cm, height 40 cm) with soil-sand-compost mixture on 17 July and 17 October 1989 and 12 March 1990. Leaf cuttings were grown under screenhouse conditions. Three or 7 weeks after transplanting, PE tubes with leaf cuttings were submerged in the water up to 5 cm below the soil surface for 4 days. A split plot design with six replicates and six leaf cuttings per replicate was employed. Flooding treatments were main plots, and clones subplots. Rates of plant survival, and leaf blade chlorosis were recorded during the course of experiment.

Leaf cuttings were sampled 10 or 12 weeks after transplanting (depending upon plant conditions) examined for leaf area, storage root number, fresh and dry weights of leaf blade, petiole, fibrous root, pigmented roots and storage roots. Mean maximum and minimum temperatures during the course of the experiment were 33.8° and 25.3°C for July planting, 26.6° and 16.6°C for October planting, and 29.2° and 20.8°C for March planting.

In another study involving eight promising clones, leaf cuttings were made and transplanted to PVC containers (40 × 15 cm) filled with growing media on 17 July. Soil moisture was maintained at 50-70%, 70-90% and 100% of field capacity with average oxygen diffusion rates of 505, 533 and 323 mg/cm^2/min, respectively, starting 1 week after transplanting. A split plot design with four replicates was employed. Soil moisture treatments were main plots, and clones subplots. Flooding tolerance was based on plant survival, oxidation activity of roots expressed as A-naphthylamine (NA) oxidized/g fresh weight/hour, leaf blade chlorophyll content, storage root number and weight (fresh and dry) and total fresh and dry weights.

Results and Discussion

Flooding imposed 3 weeks after planting, disregarding testing season, significantly reduced storage root yield, average root size and harvest index of leaf cuttings (Table 1). It appeared that flooding was critical in limiting storage root formation, especially at storage root initiation (i.e. about 3 weeks after transplanting regardless of planting season). It is possible that flooding reduced translocation of assimilates to the developing storage root. Due to the limited amount of storage root produced in March and July testings, only carbohydrate contents of storage root of the October testing were analyzed. Flooding decreased starch contents in the storage root, especially when leaf cuttings were flooded 7 weeks after planting, thus confirming that translocation of assimilates to the storage root and conversion of assimilates to starch could be limited by flooding.

Table 1. Effects of flooding 3 or 7 weeks after planting on the growth and root system development of sweet potato leaf cuttings grown in three seasons.

Flooding Treatment	Storage root FW (g/root)	Total DW (g/leaf)	HI (%)	Pencil root (no./leaf)	Storage root (no./leaf)
July planting					
Control	1.2 a[b]	1.23	13 a	0.7	0.4 a
3 WAT[a]	0.6 b	1.17	7 b	0.6	0.2 b
7 WAT	1.1 a	1.11	12 a	0.5	0.4 a
October planting					
Control	3.1 a	1.41 a	46 a	0.05 b	1.3
3 WAT	2.3 c	1.11 c	35 b	0.17 a	1.2
7 WAT	2.9 b	1.28 b	46 a	0.24 a	1.4
March planting					
Control	2.6 a	1.92	17 a	0.56	0.63 a
3 WAT	2.1 b	1.21	9 b	0.51	0.32 b
7 WAT	2.4 ab	1.35	16 a	0.47	0.56 a

[a]Time, weeks after transplanting (WAT), flooding was imposed. [b]Mean separation within a column of the same entry at 5% level by DMRT.

Furthermore, high temperatures in July and March testings, disregarding flooding effects, limited storage root yields and decreased harvest indices (Table 1). Storage root number was reduced, but number of pigmented pencil root increased due to high temperatures in July and March testings. The results suggested that high temperature is detrimental to the enlargement of pigmented pencil roots which develop into storage roots. The extent of reduction in storage root enlargement and yield due to high temperatures seemed to be more acute than that by flooding.

Flooding imposed 3 and 7 weeks after planting was critical in accelerating leaf senescence and cutting mortality, especially in July and March testings. The leaf cuttings tested in July and March aged rapidly; high temperatures in these two testings apparently aggravated the effect of flooding. However, there were clonal differences in leaf senescence and survival of leaf cuttings after flooding.

CN 1489-89 had the slowest rate of leaf chlorosis and the highest survival rate, more than 90%, with flooding 3 or 7 weeks after planting in three testings. Other clones, I 100 and I 444, also had relatively high survival rates and low chlorosis after flooding. Results also reveal that I 100, I 444, and CN 1489-89 produced more storage root yield than the other 36 clones under flooding conditions (Table 2), indicating they were more tolerant to excess soil moisture than other clones. However, I 444 appeared to be sensitive to high temperature, whereas both I 100 and CN 1489-89 were more stable under flooding conditions in both cool and hot seasons.

The fibrous root oxidation activity of eight sweet potato clones was significantly increased in the soil with 100% field capacity, 96.5 α-NA oxidized/g fresh weight/hour at 100% field capacity versus 85.8 and 83.0 at 50-70% and 70-90% of field capacities, respectively. Leaf cuttings of both CN 1448-49 and CN 1489-89 had relatively high storage root yield, dry matter production and chlorophyll content in the leaf blade. Low yielding CN 1232-9 had the lowest root oxidation activity among eight clones. No significant differences in the root oxidation activity were observed in other high and low yielding clones under high and low soil moisture conditions. In contrast to the root system of other vegetables, high soil moisture apparently did not damage the fibrous root system of sweet potato.

Table 2. Effects of flooding 3 or 7 weeks after planting on storage root yield (g/leaf cutting) of sweet potato leaf cuttings grown in three seasons.

	Mean of 39 clones	I 100	I 444	CN 1489-89
July planting				
Control	1.2 a[b]	4.2 a	0.9 ab	2.9
3 WAT[a]	0.6 b	3.1 b	0.4 b	1.6
7 WAT	1.1 c	4.1 b	1.5 a	2.5
October planting				
Control	4.0 a	6.2	5.6	7.8
3 WAT	2.8 b	5.4	4.4	5.4
7 WAT	3.9 a	5.4	6.6	6.4
March planting				
Control	1.6 a	4.2	0.9 ab	2.9
3 WAT	0.7 a	3.1	0.4 b	1.6
7 WAT	1.3 b	4.1	1.5 a	2.5

[a]Time, weeks after transplanting (WAT), flooding was imposed. [b]Mean separation within a column of the same entry at 5% level by DMRT.

Tomato Breeding

Crosses and Segregating Populations

One-hundred ninety-one (191) crosses were made in 1990. Eight combinations aimed to incorporate black leafmold resistance into tropical lines which already possess resistance to other diseases such as bacterial wilt, tomato mosaic and nematode. Nineteen biparental crosses to further improve the large-fruited fresh market lines were also produced.

AVRDC continued to look for processing tomato genotypes which not only carry multiple resistance to diseases, viz. bacterial wilt, tomato mosaic and nematode, but also possess other favorable traits such as jointlessness. A total of 124 new combinations were made for combining ability test. Thirty-two crosses aimed to incorporate the jointless trait to the processing tomatoes. New open-pollinated lines will be bred from these crosses.

Several special crosses were also produced. Two crosses of bacterial wilt-resistant stocks with susceptible stocks were made to develop populations for future RFLP (restricted fragment length polymorphism) analysis of wilt resistance and fruit size. Six crosses were developed to incorporate insect resistance from *Lycopersicon pennellii* to cultivated tomato.

Several segregating populations were planted in 1990 as part of the overall program to select for desirable traits during the appropriate seasons. Segregating families that were planted include the following: 29 backcross families to complement heat tolerance with the parthenocarpic gene; three F_6 families from crosses to improve firmness and compact growth habit in processing tomatoes; and, 5 backcross families to improve the firmness of tropical tomatoes. Eleven doublecross families planted in 1990 hot season to screen for heat tolerance were completely destroyed by typhoon and will be replanted next year. Selection rates in the families successfully evaluated during the year ranged from 1 to 4%.

Screening for Bacterial Wilt Resistance

Summary

Five determinate and three indeterminate tropical lines showed comparatively high bacterial wilt (BW) survival rates of 97% and above in their respective nurseries. Three of these lines were also resistant to nematode, carrying the dominant gene *Mi* in homozygous condition.

Several elite tropical lines had survival rates of 97% and above compared to 29% for susceptible L 390. The best lines were from the CLN 475, 466, 657 and 698 series. In addition to BW resistance, these lines were also resistant to nematode.

Tm-2, a variety which originated from the Philippines, had 100% survival rate in the test of elite BW-resistant stocks.

FMTT 301 was the most resistant fresh market entry in the Puli BW trial with 90% survival rate compared to only 15% for the highly susceptible L 390. It was also nematode-resistant.

Introduction

All new breeding materials and reportedly bacterial wilt-resistant introductions were rigorously screened for BW resistance because this is one of the most important traits required for tropical

adaptation. In 1990, a range of materials was tested using the field screening method developed in 1986. In addition, the large-fruited fresh market materials were brought to the Puli Substation of the Taichung District Agricultural Improvement Station for on-field screening after a strong typhoon destroyed the AVRDC wilt nursery.

Materials and Methods

The breeding materials and accessions screened for bacterial wilt resistance in 1990 are given below.

Type of materials	Total lines	Sown	Transplanted
Determinate tropical lines	42	5/4/90	6/1/90
Indeterminate tropical lines	36	5/4/90	6/1/90
Elite tropical lines	51	5/4/90	6/1/90
Elite BWR stocks	48	5/4/90	6/1/90
Fresh market materials I	15	5/4/90	6/1/90
Fresh market materials II	84	6/29/90	7/27/90

All tests were carried out at the AVRDC BW nursery except the last trial which was evaluated at the Puli Substation of Taichung DAIS.

Results and Discussion

In the BW test of determinate tropical lines, five showed a survival rate of 97% and above. Compared to these lines, susceptible L 390 had a survival rate of 46%. Two of the lines, CLN 475-265-4-19 and CLN 698-358-4-13, also carried the *Mi* in gene for nematode resistance.

Among the indeterminate tropical lines, three had 100% survival rates compared to 53% for L 390. One of the lines, CLN 657-274-15-7, was resistant to nematode.

Several elite tropical lines had a survival rate of 97% and above. In contrast, L 390 had a survival rate of 29%. All lines with high survival rates were already resistant to nematode, carrying the dominant gene *Mi* in homozygous condition. The best lines belong to the CLN 475, 466, 657 and 698 series.

The elite BW-resistant stocks from previous trials, which were screened to compare their reactions in one uniform nursery, showed survival rates of 80% and above. In contrast, no L 390 plants survived in the trial. Tm-2, a variety which originated from the Philippines, showed a 100% survival rate.

Among the large-fruited materials which are often lacking in highly resistant elements, a number had survival rates of 90% and above in the BW trial conducted at AVRDC. However, the disease pressure was not ideally high as indicated by a relatively high (53%) survival rate for L 390. FMTT 312 had the highest survival rate of 95%. This entry was also nematode-resistant.

In the confirmatory test at Puli, the most resistant entry was FMTT 301 with 90% survival rate. This entry was also nematode-resistant. In contrast, only 15% of L 390 survived. L 285 had 80% survival rate, whereas CLN 65-349, a highly resistant breeding line, had 96% survival rate.

The best entries from the different BW screening trials are summarized in Table 1.

Table 1. Entries with the highest BW resistance[a] from different BW nurseries.

Entry	SR (%)	RRL	RRB	ToMV	Nematode
CL 6046-51-1-20-5-15	100	163	100	2a/2a	+ / +
CLN 657-274-15-7	100	163	100	2a/2a	Mi/Mi
CL 5915-206-2-2-4	100	163	100	2a/2a	+ / +
BL 410 (Tm-2)	100	159	246	+ / +	+ / +
FMTT 312	95	154	95	2a/ +	Mi/ +
FMTT 301	90	113	93	2a/ +	Mi/ +

[a]SR = survival rate; RRL = relative resistance vs L 285; RRB = relative resistance vs CLN 65-349.

Evaluation of Fresh Market Breeding Lines

Summary

The best fresh market entries in the 1989-90 fall-spring PYT significantly outyielded KY 301 by at least 50 t/ha but not FMTT 22. However, they were superior to the latter in fruit firmness, fruit size and BW resistance level.

None of the new PYT entries outyielded the heat tolerant checks, FMTT 138 and FMTT 22, in the 1990 hot-wet season but several appeared to be promising in terms of yield, cracking resistance, fruit firmness and resistance to diseases (except bacterial spot) when compared to the commercial check, KY 301.

The new entries in another PYT set tested during the 1990 hot-wet season were superior in fruit firmness, cracking resistance and resistance to diseases compared to KY 301. The BW resistance level among the entries in this trial seemed to be better than among the other PYT sets.

Introduction

AVRDC continued the development of fresh market tomato entries with the following characteristics: heat tolerance; resistance to diseases especially bacterial wilt, tomato mosaic virus and root-knot nematode; and firm fruits with good flavor and improved size. The new materials were evaluated during the 1990 hot wet season after they were initially selected for desirable horticultural traits during fall-spring 1989-90.

Materials and Methods

Five trials were conducted in 1989-90. Information on the kind of materials, type of trials and sowing/planting dates is given below:

Type of trial	No. entries	Sown	Transplanted	Harvested
Observational	28	10/19/89	11/16/89	2/9-3/2/90
Observational	35	4/23/90	5/24/90	7/19-8/8/90
Preliminary	27	10/19/89	11/16/89	2/9-3/2/90
Preliminary I	10	4/17/90	5/15/90	7/10-24/90
Preliminary II	14	4/23/90	5/24/90	7/19-8/8/90

All observational trials (OYT) were invariably unreplicated and had generally more entries. On the other hand, the preliminary trials (PYT) were evaluated in randomized complete block design with two replications. Unit plots of the OYT and PYT consisted of a double-row 4 m long bed, spaced 60 cm apart. Plants within the row were 40 cm apart.

Results and Discussion

The best market entries in the 1989-90 fall-spring season trial are listed in Table 2. These entries significantly outyielded KY 301 by at least 50 t/ha. Although they did not outyield FMTT 22, they were better in fruit firmness, fruit size and in BW resistance level.

The same entries tested in the 1990 hot wet season revealed lines that appear to be promising in terms of yield, cracking resistance, fruit firmness and resistance to diseases (except for bacterial spot) (Table 3). None of the new entries outyielded the heat tolerant checks, FMTT 138 and FMTT 22, however. FMTT 264 which performed well in the fall-spring trial also did well in this trial. It also appeared to have relatively higher BW resistance than the other entries. KY 301 had higher soluble solids than other entries except the other checks but this is very likely because of its very low yield.

In a second set of PYT entries planted a week later, significantly greater differences in yield among entries were apparent (Table 4). KY 301 again had very low yield compared to the test entries and

Table 2. Yield and other horticultural characters of the best fresh market tomato hybrids vs check cultivars in the preliminary yield trial; AVRDC, 1989 fall 1990 spring.

Entry	Marketable yield (t/ha)	Fruit size (g/fruit)	Firmness[a]	Cracking[b]	Disease resistance			
					BLM[c]	ToMV[d]	NEM[e]	BW[f] (%)
FMTT 260	139 a	148 b-d	F-VF	3 R	1	2a/+	+/+	59
FMTT 264	134 ab	141 c-f	F-VF	1 R	1	2a/+	Mi/+	56
FMTT 22 (CK)	119 a-e	128 c-f	MS	1 R	1	2a/+	+/+	37
KY 301 (CK)	85 fg	185 a	MS	4 CR	2	+/+	+/+	7

[a]MS = moderately soft; MF = moderately firm; F = firm; VF = very firm. [b]C = concentric crack; R = radial crack; rating = 0-4 (0 = none; 1 = very slight; 2 = slight; 3 = moderate; and, 4 = severe). [c]Rating scale of 1 = none to 10 = severe. [d]2a/+ = heterozygous resistant for gene Tm-2[a]; +/+ = susceptible. [e]Mi/+ = heterozygous resistant for gene Mi; +/+ = susceptible. [f]BW(%) = survival rate in BW test at natural nursery.

Table 3. Yield and other horticultural characters of the best fresh market tomato hybrids vs check cultivars in the preliminary yield trial I; AVRDC, 1990 summer.

Entry	Marketable yield (t/ha)	Fruit size (g/fruit)	Brix°	Firmness[a]	Cracking[b]	Disease resistance			
						BLS[c]	ToMV[d]	NEM[e]	BW[f] (%)
FMTT 245	21.0 ab	71	5.60 b	F	0	6	2a/+	+/+	37
FMTT 264	20.0 ab	73	5.60 b	MF	0	6	2a/+	Mi/+	56
FMTT 261	19.9 ab	79	5.25 b	F	0	7	2a/+	Mi/+	45
FMTT 255	16.5 ab	69	5.50 b	F	0	7	2a/+	+/+	39
FMTT 138 (CK)	23.9 a	56	5.85 ab	MS	0	6	2a/+	+/+	31
FMTT 22 (CK)	15.0 ab	74	5.85 ab	MF	0	6	2a/+	+/+	37
KY 301 (CK)	6.6 b	82	6.60 a	MS	3R	9	+/+	+/+	7

[a]MS = moderately soft; MF = moderately firm; F = firm. [b]C = concentric crack; R = radial crack; rating = 0-4 (0 = none; 1 = very slight; 2 = slight; 3 = moderate; and, 4 = severe). [c]Rating scale of 1 = none to 10 = severe; BLS = bacterial spot. [d]2a/+ = heterozygous resistant for gene Tm-2[a]; +/+ = susceptible. [e]Mi/+ = heterozygous resistant for gene Mi; +/+ = susceptible. [f]BW (%) = survival rate in BW test at natural nursery (highland)

Table 4. Yield and other horticultural characters of the best fresh market tomato hybrids vs check cultivars in the preliminary yield trial II; AVRDC, 1990 summer.

Entry	Marketable yield (t/ha)	Fruit size (g/fruit)	Brix°	Firmness[a]	Cracking[b]	Disease resistance				
						ToMV[c]	BW[d]	NEM[e]	BLM[f]	BLS
FMTT 276	15.3 a	76	6.1 de	MF	3 R	2a/+	60	+/+	3	4
FMTT 306	14.1 ab	71	5.9 ef	MF	3R	2a/+	42	Mi/+	6	8
FMTT 273	13.6 a-c	65	6.0 e	F	0	2a/+	65	+/+	4	6
FMTT 277	13.6 a-c	72	5.9 ef	MF	2CR	2a/+	80	+/+	4	5
FMTT 274	11.7 a-c	77	5.6 f	F	0	2a/+	40	+/+	3	4
FMTT 138 (CK)	15.4 a	39	6.1 e	MF	0	2a/+	32	+/+	5	6
FMTT 22 (CK)	9.4 cd	64	6.6 bc	MF	2 R	2a/+	37	+/+	5	8
KY 301 (CK)	0.9 f	43	7.3 a	MS	4R	+/+	7	+/+	7	9

[a]MS = moderately soft; MF = moderately firm; F = firm. [b]C = concentric crack; R = radial crack; rating = 0-4 (0 = none; 1 = very slight; 2 = slight; 3 = moderate; and, 4 = severe). [c]2a/+ = heterozygous resistant for gene Tm-2[a]; +/+ = susceptible. [d]BW (%) = survival rate in BW test at natural nursery (highland). [e]Mi/+ = heterozygous resistant for gene Mi; +/+ = susceptible. [f]Rating scale of 1 = none to 10 = severe; BLM = black leaf mold; BLS = bacterial spot.

the heat tolerant checks, FMTT 138 and FMTT 22. The new entries were better in fruit firmness, cracking resistance and resistance to diseases especially when compared to KY 301. The level of BW resistance among the entries in this trial appears to be better compared to the other PYT materials tested previously.

Evaluation of Processing Tomato Lines

Summary

The best entries in the preliminary yield trial had better concentration of maturity, ranging in first harvest yields from 64 to 69 t/ha compared to only 32 to 44 t/ha for the checks. Soluble solids

contents of the test entries were comparable to the best check (TK 70) and definitely better than UC 82. The test entries were also superior in resistance to diseases, particularly tomato mosaic virus and nematode.

In the advanced yield trials, significant differences in concentration of maturity could be detected, with PT 4300 and PT 4225 showing the highest first harvest yields. These two entries performed similarly in previous tests.

Introduction

AVRDC continued to select processing entries that are heat-tolerant, resistant to diseases, particularly bacterial wilt, tomato mosaic virus and nematode, with high concentrated yield of firm fruits, and possessing suitable processing quality such as adequate soluble solids content, good red color, etc. A number of hybrids were evaluated in various trial stages.

Materials and Methods

The types of processing tomato trials conducted, number of entries and dates of sowing and transplanting are given below:

Type of trial	No. entries	Sown	Transplanted	Harvested
Preliminary	14	9/8/89	10/6/89	1/15-2/2/90
Advanced I	10	9/6/89	10/5/89	1/9-2/2/90
Advanced II	10	9/6/89	10/5/89	1/9-2/2/90

The preliminary trial was replicated twice in a randomized complete block design. Unit plot consisted of two 4-m long beds spaced 1.5 m from adjoining beds and with within-row spacing of 40 cm.

The advanced trials were planted in a randomized complete block design consisting of three replications. Each plot was comprised of four 4-m long beds which were spaced 1.5 m apart. Within-row spacing between plants was 40 cm as in the other trials.

Results and Discussion

No significant differences in final marketable yields could be noted between the best entries and the check varieties in the preliminary yield trial (Table 5). However, the test entries had significantly better concentration of maturity as evidenced by their higher first harvest yields (64-69 t/ha vs. 32-44 t/ha for the four checks). Soluble solids contents of the test entries were comparable to the best check (TK 70) and definitely better than UC 82. The test entries produced moderately firm fruits and were thus better than the widely grown TK 70 and TK 18. They were also superior in terms of resistance to diseases, particularly tomato mosaic virus and nematode, which are lacking among the check varieties.

Again, in the advanced yield trial I, no significant differences in final yield were noted; however, significant differences in concentration of maturity could be detected (Table 6). The best entries in terms of first harvest yield were PT 4300 and PT 4225, both of which performed similarly in previous tests. Other important processing traits were comparable between the best entries and the checks. The test entries possessed resistance to tomato mosaic which the check varieties lacked. Severe powdery mildew infection of the trial revealed the relative susceptibility of TK 18. In contrast, varieties such as UC 82, TN-2, PT 4275 and PT 4225 showed relatively better resistance.

Similar results were obtained in advanced yield trial II, i.e. test entries were definitely superior to the checks in concentration of maturity (Table 7). Again, important processing attributes, notably soluble solids content, pH, acidity and color, were comparable between test entries and checks. Other characters such as fruit firmness, vine cover, vine compactness and cracking were also comparable. Advantage of test entries over checks in terms of resistance to tomato mosaic could be noted. However, they were relatively more susceptible to powdery mildew than the check varieties, especially TN-2 and UC 82.

Table 5. Yield and other horticultural characters of the best processing tomato hybrids vs check cultivars in the preliminary yield trial; AVRDC, 1989 fall.

Entry	Marketable yield (t/ha)		Fruit size	pH	Brix°	Acidity	Hunter color	Firm-ness[a]	Vine[b] cover	Vine[c] compact-ness	Crack-ing[d]	Disease resistance		
	final	first	(g/fruit)									PM[e]	ToMV[f]	Mi[g]
PT 4439	109	66 a-c	76 c-f	4.3 a-c	5.0 ab	0.25 a-c	2.05 bc	MF	G-E	G-E	1 C	1	2a/+	Mi/+
PT 4440	108	67 ab	92 b-d	4.4 a	5.0 ab	0.22 c	2.17 ab	MF	G	E	2 C	3	2a/+	Mi/+
PT 4441	101	64 a-c	98 b	4.3 a-c	5.1 a	0.25 a-c	2.05 bc	MF	G-E	G	0	4	2a/+	Mi/+
PT 4454	99	69 ab	83 c-f	4.4 ab	4.7 ab	0.24 bc	2.03 bc	MF	G	F-G	2 R	1	2a/+	Mi/+
TN-2 (CK)	110	37 d	90 b-e	4.3 b-d	4.6 a-c	0.25 a-c	2.25 a	F	G	F-G	1 C	1	+/+	+/+
TK 70 (CK)	97	32 d	92 b-d	4.2 d	5.0 a	0.31 a	2.03 bc	S	E	E	3 C	1	+/+	+/+
TK 18 (CK)	91	44 cd	142 a	4.3 a-c	4.3 bc	0.23 bc	2.25 a	MS	G	G	0	4	+/+	+/+
UC 82 (CK)	89	37 d	82 d-f	4.2 bc	3.9 c	0.24 bc	1.97 c	MF	E	E	3 CR	1	+/+	+/+
Mean of all entries	92	54	90	4.3	4.7	0.25	2.09	–	–	–	–	–	–	–
CV %	13.9	17.5	6.7	1.0	5.9	10.1	3.1	–	–	–	–	–	–	–

[a]S = soft; MS = moderately soft; MF = moderately firm; F = firm. [b,c]F = fair; G = good; E = excellent. [d]C = concentric crack; R = radial crack; rating = 0-4 (0 = none; 1 = very slight; 2 = slight; 3 = moderate; and, 4 = severe). [e]Rating scale of 1 = none to 10 = severe; PM = powdery mildew. [f]2a/+ = heterozygous resistant for gene Tm-2a; +/+ susceptible. [g]Mi/+ = heterozygous resistant for gene Mi; +/+ = susceptible.

Table 6. Yield and other horticultural characters of the best processing tomato hybrids vs check cultivars in the advanced yield trial I; AVRDC, 1989 fall.

Entry	Marketable yield (t/ha)		Fruit size	pH	Brix°	Acidity	Hunter color	Firm-ness[a]	Vine[b] cover	Vince[c] compact-ness	Crack-ing[d]	Disease resistance	
	final	first	(g/fruit)									PM[e]	ToMV[f]
PT 4225	106	49 b	69 e	4.26 b	4.20 bc	0.25 a-d	2.03 cd	MF	G-E	G	2C	2	2a/+
PT 4275	99	31 cd	75 de	4.27 ab	4.53 a-c	0.23 cd	2.03 cd	MF	E	G-E	3 CR	1	2a/+
PT 4300	90	59 a	72 de	4.22 bc	4.60 ab	0.28 a-c	1.98 b-d	MF	G	G	2 CR	4	2a/+
TN-2 (CK)	100	20 e	94 bc	4.22 bc	4.87 a	0.24 b-d	2.19 b	F	G	G	2 R	1	+/+
TK 18 (CK)	91	27 de	139 a	4.33 a	4.83 a	0.24 cd	2.33 a	MS	F	F	0	7	+/+
UC 82 (CK)	91	27 de	88 cd	4.19 bc	4.00 c	0.24 d	1.92 de	MF	E	G	3 CR	1	+/+
Mean of all entries	93	34	86	4.23	4.56	0.254	2.07	–	–	–	–	–	–
CV (%)	14.9	14.1	9.9	0.91	6.8	8.9	3.7	–	–	–	–	–	–

[a]MS = moderately soft; MF = moderately firm. [b,c]TF = fair; G = good; E = excellent. [d]C = concentric crack; R = radial crack; rating = 0-4 (0 = none; 1 = very slight; 2 = slight; 3 = moderate; and, 4 = severe). [e]Rating scale of 1 = none to 10 = severe; PM = powdery mildew. [f]2a/+ = heterozygous resistant for gene Tm-2a; +/+ = susceptible.

Evaluation of Tropical Cherry Tomato Lines

Summary

The best entries selected from four preliminary yield trials conducted during fall-spring 1989-90 were not only high-yielding but also had as high a soluble solid content as the sweet-tasting commercial check variety, Sugar Pearl. Other superior characteristics of the selected entries were: firm fruits, resistance to fruit cracking, resistance to tomato mosaic virus, large number of fruits per cluster with good to excellent uniformity of fruit size in each cluster.

The most promising cherry lines for the hot season yielded 20 t/ha or more in three trials conducted during the 1990 hot season. These entries were also superior to the check varieties, Girl's Sweet and Sugar Pearl, in fruit firmness, resistance to fruit cracking, fruit size (close to the ideal size of 15 g) and resistance to diseases, especially tomato mosaic virus.

Introduction

The development of tropically adapted cherry tomato lines and hybrids was continued by emphasizing the selection for the following characteristics: heat tolerance; resistance to bacterial wilt, tomato mosaic virus and nematode; good fruit traits such as firmness, absence of cracking and high soluble solids content.

Materials and Methods

Four preliminary yield trials (PYT) were conducted in fall-spring 1989 to select for desirable quality traits among cherry materials which were initially selected in summer 1989. Selected lines and hybrids with the best quality were then evaluated for heat tolerance during the 1990 hot wet season.

The four fall-spring PYTs were sown on 13 October and transplanted on 9 November 1989 and consisted of 28, 26, 55 and 15 entries each. The first PYT of the 1990 hot season was sown on 17 April and transplanted on 15 May. The other two were sown on 23 April and transplanted on 24 May. All PYTs were laid out using a randomized complete block design with two replications. Unit plot consisted of two 4-m long rows. Spacing of plants within the row was 40 cm. Rows within each double-row bed were spaced 60 cm apart. Beds were 1.5 m apart, center to center.

Results and Discussion

The combined results of the four PYTs conducted in fall-spring 1989-90 are summarized in Table 8.

Two entries, CHT 262 and CHT 269, performed well, yielding as high as the high yielding check, CHT 105, and also producing as high a soluble solids content as the check variety for good quality, Sugar Pearl. Other superior characteristics of the new entries are: fruit firmness, resistance to fruit cracking, resistance to tomato mosaic virus, large number of fruits per cluster (up to 28 in the case of CHT 269) and good to excellent uniformity of fruit size in each cluster.

In PYT II, CHT 268 and CHT 312 yielded as well as the high yielding cherry check, CHT 105 (Table 8). At the same time, these entries showed comparable soluble solids content as Sugar Pearl and Sweetie, two checks used as reference materials for good cherry tomato quality. Other good traits of the new entries were: firm fruit; only slight fruit cracking tendencies; resistance to tomato mosaic virus; apparent 'resistance' to bacterial spot (especially CHT 312 and a few other entries); many, generally uniformly sized fruits in each cluster.

Two entries in PYT III, CHT 278 and CHT 306, performed well, yielding as high as the high-yielding check, CHT 105, and showed as good a quality (based on high soluble solids content) as the checks, Sugar Pearl and Sweetie. Like the entries selected from the previous PYTs, these entries showed advantages in other traits such as moderate fruit firmness; absence of moderate cracking; resistance to tomato mosaic virus; and many, uniformly sized fruits in the cluster.

Two entries in PYT IV, CHT 411 and CHT 397, performed as well as the selections from previous PYTs, i.e. high yield combined with good quality. CHT 411 even gave higher soluble solids than Sugar Pearl in this trial. Generally, however, yield in this trial was lower than in the other PYTs.

Table 7. Yield and other horticultural characters of the best processing tomato hybrids vs check cultivars in the advanced yield trial II; AVRDC, 1989 fall.

Entry	Marketable yield (t/ha)		Fruit size	pH	Brix°	Acidity	Hunter color	Firm-ness[a]	Vine[b] cover	Vine[c] compact-ness	Crack-ing[d]	Disease resistance	
	final	first	(g)									PM[e]	ToMV[f]
PT 4226	90	55 a	98 b	4.18	4.17 b	0.33 a	1.92 c	MF	F	F	2 R	7	2a/+
PT 4286	80	37 c	96 bc	4.25	4.57 ab	0.24 b	1.97 c	MF	F	F	4 C	5	2a/+
TN-2 (CK)	71	20 fg	92 bc	4.27	4.93 a	0.25 b	2.26 ab	F	F	F	2 C	2	+/+
TK 18 (CK)	75	28 d-f	126 a	4.25	4.73 ab	0.26 b	2.35 a	MS	G	F	0	6	+/+
UC 82 (CK)	93	26 ef	90 bc	4.22	4.37 ab	0.24 b	1.92 c	MF	E	E	4 CR	1	+/+
Mean of all entries	77	33	94	4.22	4.64	0.26	2.05	–	–	–	–	–	–
CV (%)	20	12.8	10.6	1.3	6.5	11.8	5.7	–	–	–	–	–	–

[a]S = soft; MS = moderately soft; MF = moderately firm; F = firm. [b,c]F = fair; G = good; E = excellent. [d]C = concentric crack; R = radial crack; rating = 0-4 (0 = none; 1 = very slight; 2 = slight; 3 = moderate; and, 4 = severe). [e]Rating scale of 1 = none to 10 = severe; PM = powdery mildew. [f]2a/+ = heterozygous resistant for gene Tm-2[a]; +/+ = susceptible.

Table 8. Summary of yield and other horticultural characters of the best cherry tomato entries vs check cultivars in the preliminary yield trial (I-IV); AVRDC, fall spring 1989/90.

Entry	Source	Marketable yield (t/ha)	Fruit size (g/fruit)	Brix°	Firm-ness[a]	Crack-ing[b]	Other disease resistance				
							BLSc	PMc	ToMVd	NFCe	NFSf
CHT 306	PYT III	69.0	17	7.20	MF	3 R	1.0	5.0	2a/+	16-28	E
CHT 278	PYT III	67.0	13	7.50	MF	0	3.0	9.0	2a/+	16-22	G
CHT 268	PYT II	66.0	13	7.65	MF	2 R	4.0	6.0	2a/+	14-16	G
CHT 312	PYT II	65.0	15	7.20	F	2 R	1.0	4.0	2a/+	10-20	G
CHT 269	PYT I	64.4	14	7.00	F	0	3.0	3.0	2a/+	12-28	G
CHT 262	PYT I	64.2	13	7.35	F	0	4.0	6.0	2a/+	12-22	E
CHT 397	PYT IV	47.0	12	6.85	MF	4 R	–	–	2a/+	12	G
CHT 411	PYT IV	38.0	13	7.15	MF	3 R	–	–	2a/+	18	G
Girl's Sweet (ck)		53.0	25	6.45	MF	4 R	4.0	8.5	+/+	6-10	G
Sugar Pearl (ck)		42.0	18	7.25	MS	4 R	5.5	7.5	+/+	6-12	G
Sweetie (ck)		36.0	9	8.20	VS	4 R	4.5	8.0	+/+	15-30	F
CHT 105 (ck)		78.0	24	6.15	MF	2 R	2.5	8.5	2a/+	6-10	G

Note: Data of check cultivars are means of several trials. [a]VS = very soft; MF = moderately firm; F = firm. [b]C = concentric crack; R = radial crack; rating = 0-4 (0 = none; 1 = very slight; 2 = slight; 3 = moderate; and, 4 = severe). [c]Rating scale of 1 = none to 10 = severe; BLS = bacterial spot; PM = powdery mildew. [d]2a/+ = heterozygous resistant for gene Tm-2[a]; +/+ = susceptible. [e]No. of fruit per cluster. [f]F = fair; G = good; E = excellent; UFS = uniform fruit size within cluster.

Results of the three PYTs conducted in the 1990 hot wet season are summarized in Table 9. In general, the most promising cherry entries for the hot season yielded 20 t/ha or more.

Two entries, CHT 173, and CHT 175, yielded as well as the high-yielding check, CHT 105, in PYT I of 1990 summer albeit their soluble solids contents were slightly lower than those of the checks, especially Sugar Pearl. The new entries were superior, however, in fruit firmness, crack resistance, fruit size (ideal of about 15 g per fruit) and resistance to tomato mosaic virus.

CHT 221 and CHT 217 were the most promising new entries in PYT II, yielding significantly higher than the commercial varieties, Sugar Pearl and Girl Sweet, and having comparable soluble solids contents. Other superior traits of the new entries included: moderately firm to firm fruits, absence of fruit cracking tendencies, and resistance to tomato mosaic virus.

All check cultivars generally yielded well in PYT III. CHT 302 and CHT 349 gave statistically comparable yields as the checks. However, they are better in fruit firmness, absence of fruit cracking and resistance to tomato mosaic virus than the checks.

Table 9. Summary of yield and other horticultural characters of the best cherry tomato entries vs check cultivars in the preliminary yield trial (I-III); AVRDC, summer 1990.

Entry	Source	Marketable yield (t/ha)	Fruit size (g/fruit)	Brix°	Firm-ness[a]	Crack-ing[b]	ToMV[c]
CHT 302	PYT III	26.1	13	5.90	F	0	2a/+
CHT 349	PYT III	25.7	13	5.85	VF	0	2a/+
CHT 217	PYT II	25.0	12	6.55	F	0	2a/+
CHT 173	PYT I	24.5	15	5.05	F	0	2a/2a
CHT 221	PYT II	22.0	14	6.65	MF	0	2a/+
CHT 175	PYT I	20.2	18	5.10	F	0	2a/+
CHT 105 (ck)		25.6	20	5.95	MF	0	2a/+
Girl's Sweet (ck)		18.0	19	5.76	F	4 R	+/+
Sugar Pearl (ck)		14.9	16	6.60	MF	4 R	+/+

Note: Data of check cultivars are means of several trials. [a]MF = moderate firm; F = firm. [b]C = concentric crack; R = radial crack; rating = 0-4 (0 = none; 1 = very slight; 2 = slight; 3 = moderate; and, 4 = severe). [c]2a/+ = heterozygous resistant for gene Tm-2[a]; +/+ = susceptible.

International Cooperation

Seed Distribution

AVRDC distributed 2,089 seed packets to 153 cooperators in 62 countries. Feedback on trials conducted by some cooperators has been received. AVRDC lines continued to show outstanding performance in a number of countries. These trials are discussed below.

Official Cultivar Releases

Six fresh market tomato varieties derived from the AVRDC germplasm were recorded as officially released: two were previously released in India but information was not provided earlier, one in Taiwan, one named 'Manik' and previously released in Bangladesh but for which AVRDC did not have any record, and two released recently for the Amazon region of Brazil.

The above releases bring the total number of tomato lines released worldwide to 67 breeding lines in 28 countries since 1978.

Trial Feedbacks

American Samoa. Ms. W. H. Kuo, University of South Pacific in Apia, Western Samoa, compared a set of three indeterminate AVRDC fresh market lines against hybrids Kingkong and Vanguard from Known You Seed Company and another set of four determinate fresh market lines against the check, Season Red. Among the indeterminate entries, FMTT 138 outyielded the high yielding check, Kingkong, at least four times although it produced slightly smaller fruit. This hybrid was also

the earliest maturing and had comparable bacterial wilt resistance as the other entries. In the trial of determinate lines, CLN 65-349 had the highest yield, although practically all AVRDC entries did very well. Three of the AVRDC entries showed no bacterial wilt infection, reflecting similar resistance observed in these lines in previous screening trials at AVRDC.

Brazil. Dr. Simon Cheng of EMBRAPA (Brazilian Institute of Agricultural Research) reports that after several generations of selection from the cross Caraibe × CL 1131-0-0-38-40 × Dina, two varieties, 'C-38-D' and 'Compacto', were released in 1990 to tomato growers in the humid tropical flatlands of the Amazon. These cultivars have the combined traits of bacterial wilt resistance and good fruit texture, color, flavor and suitable marketable size. Dr. Cheng reports that a suitable production technology for the Amazon consisting of the use of these cultivars under a plastic house cropping system is now successfully in place.

Costa Rica. Ing. Jorge Canessa of CINDE (Coalicion Costarricences de Iniciativas de Desarrollo), in cooperation with the Ministry of Agriculture and the University of Costa Rica, reported the excellent performance of AVRDC processing tomatoes, especially PT 4060 and PT 4026 in the hot, dry areas of Guanacaste. PT 4060 gave the highest yield of 85 t/ha but had a soluble solids content of only 4.7. On the other hand, PT 4026 yielded 67 t/ha but had a brix value of 5.2 which makes it more suitable for processing. More seeds of these and other entries have been procured for further commercial-scale planting.

India. The Department of Vegetable Science and Floriculture, Himachal Pradesh Krishi Visvavidyalaya in Palampur reported that two lines, CL 143 and CL 5915-223, provided in 1989 proved to be resistant to bacterial wilt in the area. However, these lines were small-fruited, averaging only 40 g/fruit.

A previously unrecorded release of two varieties in Western India in 1979 was noted from the report of Mr. H. Bedekar, a former training scholar at the Center. The two varieties, released by the Nimbkar Agricultural Research Institute in Phaltan after further selection from the AVRDC germplasm, were N 96 and N 100.

Panama. Ing. Jose Cedeno of Nestlé Panama S.A. reported the high level of bacterial wilt resistance of at least four of 10 AVRDC lines he tested in 1989. The four which are known to be bacterial wilt-resistant in previous AVRDC screening trials had an average survival rate of 95% and above. L 285, the most resistant accession in the Center's tomato collection, showed a 100% survival rate.

Papua New Guinea. Mr. M. E. Millar of the Pacific Adventist College in Boroko compared five fresh market lines from AVRDC with commercial hybrid Takii No. 63 and with Marikit, an introduced variety from the Philippines. Four AVRDC entries significantly outyielded Takii No. 63 although the latter produced larger fruits. Nonetheless, fruits of the AVRDC fresh market entries averaged over 100 g. FMTT 22 gave the highest yield, whereas Marikit yielded the lowest, yielding about three times less than FMTT 22. Mr. Millar considered the performance of the AVRDC materials as exceptional and he said they had never had as good a yield from tomatoes in Boroko as those obtained from the AVRDC entries he tried.

Réunion. Dr. J. C. Girard of IRAT-Réunion reported that PT 4026, PT 4165 and FMTT 23 gave very good results in their trials, yielding up to 60 t/ha under drip irrigation and plastic mulching. Some farmers are now growing these varieties commercially in small scale and IRAT is interested in producing their own seeds if needed in large quantities. Dr. Girard is now testing newer sets of more promising fresh market materials from AVRDC.

Saudi Arabia. In a 1989 replicated trial at Qassim Agricultural Research Center, Mr. J. Y. Lin of the ROC Technical Mission reported that two AVRDC lines significantly outyielded Pearson. These lines were also resistant to cracking and had firm fruits. However, they generally produced smaller fruits than Pearson. Mr. Lin compared another set of five AVRDC fresh market lines against

a popular local variety, Pearson Improved, in a trial transplanted on 24 March 1990 and harvested from 6 June to 15 August. All AVRDC materials significantly outyielded Pearson Improved. FMTT 138, a heat-tolerant hybrid, outyielded Pearson at least five times. However, Pearson had larger fruits. Taking both the yield and fruit size criteria into consideration, CLN 657-285 appears to be a suitable replacement for Pearson, yielding about four times higher and having comparable fruit size as the latter.

Solomon Islands. Mr. Y. S. Chen, Team Leader of the ROC Technical Mission, selected eight best performing entries in the preliminary yield trial of 22 introduced cultivars. The top three yielders and seven of the eight selections were from AVRDC . CL 5915-206D4-2-2-0 gave the highest yield of 31.5 t/ha. In contrast, the three check cultivars (N-63, N-69 and Island Red) had a yield range of 9-11 t/ha. The eight selections and two local check cultivars are currently in an advanced testing stage.

Sri Lanka. Dr. S. Raveendranath, Department of Agronomy, Eastern University in Chenkalady, conducted one trial at the university farm to compare five AVRDC lines with an old local cultivar, Marglobe. All AVRDC lines significantly outyielded Marglobe. Other apparent advantages of some of the best AVRDC lines included cracking and blossom end rot resistance.

Taiwan. Mr. U. Busse of BASF, Taiwan, conducted a comparative trial of FMTT 22 and Known You 301 for response to various fruit setting hormone treatments during the 1990 hot wet season (May to July). FMTT 22 not only outyielded KY 301 without the hormone treatment but its response to the hormone treatment was generally more positive. Of the hormones tested, BAS 113 02W at 16 ppm application rate appeared to elicit the best response from both varieties, but especially in FMTT 22. Mr. Busse also reported the remarkable resistance of FMTT 22 to bacterial spot. Whereas KY 301 produced only four harvestable clusters because of heavy bacterial spot infection, FMTT 22 produced marketable fruits until the termination of the experiment.

A new fresh market tomato variety was named Hualien ASVEG No.5 and released in Taiwan in 1990. ASVEG No. 5 is moderately heat tolerant, resistant to tomato mosaic virus and moderately resistant to bacterial wilt. It bears fruits with light green shoulder and has an average weight of 103 g.

Vietnam. Ms. Nguyen Thi Binh, a former training scholar at the Regional Training Center in Thailand, reported that CL 5915-223 performed very well in the 1989 hot season trials conducted by the Scientific Federation of Seed Multiplication in Ho Chi Minh City. This breeding line is considered the best variety for off-season tomato production in Vietnam. Ms. Binh produced stock seeds with farmer's assistance for wide-scale distribution in 1990. Informally, CL 5915-223 has now been officially released as 'No. 12' in Vietnam and fruits of this line have already been seen in the commercial market.

Tomato Entomology

Characterization of Tomato Fruitworm Resistance in *Lycopersicon pinnellii*

Summary

A *Lycopersicon pinnellii* accession which showed resistance to a wide range of insect pests elsewhere is being utilized at AVRDC to breed tomato fruitworm-resistant breeding lines. The resistance of this accession is due to an antibiotic factor in the foliage. These accessions also showed certain levels of resistance to tomato fruitworm. In this laboratory test the presence of the antibiotic factor was investigated. Tomato fruitworms were raised on the foliage of either *L. pinnellii* or *L. esculentum* from first instar larvae to the adult stage. The insect larvae suffered significantly higher mortality and had significantly less pupation when fed on *L. pinnellii* than on *L. esculentum*. Most mortality was confined to the first instar. Pupae from larvae that were fed on *L. pinnellii* were lighter and had longer pupal period than those derived from larva fed on *L. esculentum*. These results showed that *L. pinnellii* has antibiotic factors that adversely affected growth and development of tomato fruitworm.

Introduction

Lycopersicon pinnellii, a wild relative of tomato, has been reported to be resistant to many arthropods, including aphids, mites and whiteflies. Because of its resistance to aphids, this species is being used at AVRDC in breeding for cucumber mosaic virus resistance. Tomato fruitworm TFW, *Helicoverpa* (= *Heliothis*) *armigera* Huebner, a polyphagous insect, attacks tomato fruits in Taiwan and most of Asia. Since *L. pinnellii* is resistant to other insects and is being utilized in AVRDC's breeding program, its resistance to TFW was investigated. If found resistant, the progeny screened for aphid/CMV resistance can be screened and selected for TFW resistance.

Materials and Methods

Two *L. pinnellii* accessions (BL-630-2 and BL-630-3) and one TFW-susceptible *L. esculentum* cultivar (TK 70) were grown in the greenhouse. Leaves of each accession were placed individually in each of four petri dishes; each dish represented one replicate. Ten first instar larvae of TFW were reared on the foliage until pupation. Every day each petri dish was observed to record insect mortality and pupation and monitor the status of leaves used for feeding. Old leaves were replaced with fresh foliage whenever the insects consumed them or they became unusually dry. Pupal weights, pupal period and sex ratio were also recorded.

Results and Discussion

Table 1 gives details of the effect of TFW feeding on certain biological characteristics of TFW. TFW larvae suffered significantly higher mortality and had significantly less pupation rate when fed on *L. pinnellii* than on *L. esculentum*. Most of the mortality was confined to the first instar larvae. The pupae that developed from the larvae fed on *L. pinnellii* were lighter and had significantly longer

pupal period than those fed on *L. esculentum*. There was no definite effect on sex ratio of the adults that emerged. Because of high larval mortality, very few insects survived until adult emergence. Hence, the sex ratio data were based on total number of insects which emerged in all four replicates, rather than from each replicate. These results showed that *L. pinnellii* possessed antibiotic factors that adversely affected the growth and development of TFW. These factors, however, were not strong enough to eliminate TFW infestation.

Table 1. Effect of larval feeding on the foliage of *L. pinnellii* and *L. esculentum* on growth and development of TFW.[a]

Accession[b]	Larval mortality	Pupation (%)	Pupal weight	Pupal period	Sex ratio
BL-630-2	85 ab	15 ab	0.17 a	13.63 a	1.00:1
BL-630-3	0.90 a	10 b	0.19 a	10.67 b	3.00:1
TK70	0.65 b	35 a	0.21 a	11.67 b	2.66:1

[a]Means in each vertical column followed by the same letter are not significantly different at 5% level according to DMRT. [b]BL-630-2 and BL-630-3 are *L. pinnellii* accessions and TK 70 is an *L. esculentum* cultivar.

Tomato Pathology

Evaluation of Tomato Breeding Lines and Accessions for Resistance to *Xanthomonas campestris* pv. *vesicatoria*

Summary

Bacterial spot occurs in most tomato growing regions of the world. Control of the disease is difficult especially under conditions of high rainfall. Host resistance can be used to reduce losses caused by this disease. In AVRDC studies, BL 263R and CLN 65-349D_5-2-0 had the lowest levels of leaf area infected when inoculated with four bacterial concentrations. These two lines were reconfirmed as resistant sources in previous experiments. Of 544 accessions screened, 138 were selected for further evaluation for sources of resistance to bacterial spot.

Introduction

Xanthomonas campestris pv. *vesicatoria* causes lesions on leaves, petioles, stems and fruits of peppers and tomatoes. The pathogen occurs over a broad geographical area. The disease is most prominent under conditions of heavy rainfall. Because leaves drop prematurely and fruit infection drastically reduces the marketable yield, growers frequently and regularly apply copper-based fungicides for control. There are reports of *X. c.* pv. *vesicatoria* strains having copper resistance. Currently, there are no commercially available tomato varieties with resistance to *X. c.* pv. *vesicatoria*. These studies therefore aim to 1) assess selected tomato lines for resistance to *X. c.* pv. *vesicatoria* using four concentrations of the bacterium, and 2) screen accessions for new sources of resistance.

Materials and Methods

Reaction of six lines inoculated with four concentrations of *X. c.* pv. *vesicatoria*. Seeds of six lines, BL 263R (resistant), CLN 65-349D_5-2-0 and CLN 399BGF_2-2-6 (moderately resistant), CL 5915-93D_4-1-0-C-1 and CLN 466BGF_2-45-34-9-9-0 (moderately susceptible), and CL 5915-153D_4-3-30 (susceptible) were sown on 15 August in 10-cm diameter pots and thinned to one plant per pot after germination. The resistant reaction of these genotypes was reported in previous AVRDC Progress Reports.

A colony typical of *X. c.* pv. *vesicatoria* (XVT-11) was selected after streaking the stock culture on nutrient agar. The selected colony was transferred to 523 medium in a slant and incubated for 24 hours at 28°C. A bacterial loop was used to transfer cells to sterile distilled water. A drop (0.01 ml) of the suspension was spread on 523 medium with a bent glass rod and incubated as previously described. Sterile water was used to wash the cells from the medium. The suspension was diluted with sterile water before the optical density (OD) value was taken.

Plants were grown just outside the greenhouse. A plastic cover was used during heavy rains to enhance the humidity after inoculation. Treatments were arranged in a factorial design with four concentrations of the bacterium using six tomato lines. Each treatment had 16-24 plants, and treatments were completely randomized in two replications. Plants were inoculated on 21 September (38 days after sowing). The bacterial concentrations were 5×10^8, 1×10^8, 1×10^6, and 1×10^4 cfu/ml. Plants were atomized at 1.5 kg/cm^2 until runoff. After inoculation, plants were covered under plastic for 2 days. Foliage was sprayed with water three times daily for 20 days.

Bacterial spot was assessed on 27 September, and on 4 and 11 October by estimating the percent leaf area infected. Ratings of individual plants within treatments were averaged. Data were analyzed by ANOVA, and means were separated by Fischer's Least Significance Difference (FLSD). The percent leaf area infected (log_{10}) was regressed on bacterial concentration (log_{10}).

Evaluation of accessions for resistance. Seeds of 544 accessions were sown directly in the field in 1 m row plots on raised beds with four accessions per bed on 21 June. There were approximately 5-20 plants per accession. The plants were inoculated with 10^8 cfu/ml of *X. c.* pv. *vesicatoria* (XCT-11) on 2 August. The disease was rated by estimating percent leaf area infected on a per row basis on 9 and 16 August.

Seeds of 544 accessions were also sown in 6-cm diameter pots in the greenhouse on 21 June. There were six pots for each accession. Plants were inoculated on 18 July and placed in a growth room for two days at 90% relative humidity and 30°C. After incubation, the plants were placed outside the greenhouse. Bacterial spot was assessed by estimating the percent leaf area infected on 7 August and on 25 September.

Data on percent leaf area infected was averaged for each accession for the greenhouse trial. Accessions with ratings of 1 standard deviation (SD) above the mean in both the field and greenhouse trials and at each rating date were selected again for rescreening.

Results and Discussion

Reaction of six lines inoculated with four concentrations of *X. c.* pv. *vesicatoria*. The percent leaf area infected increased from early to later assessments for all treatments (Fig. 1a & 1b). There was a significant effect due to bacterial concentration, lines and the interaction of bacterial concentration and lines. Leaf area infected was lowest for BL 263R and CLN 65-349D_5-2-0 within each date (Fig. 1a) and bacterial concentration (Fig. 1c). Plants inoculated with concentrations of 5×10^8 and 10^8 cfu/ml had a higher percent leaf area infected (17 and 16%) than plants inoculated with concentrations of 10^6 and 10^4 cfu/ml (5 and 3%) for all dates and lines (Fig. 1b).

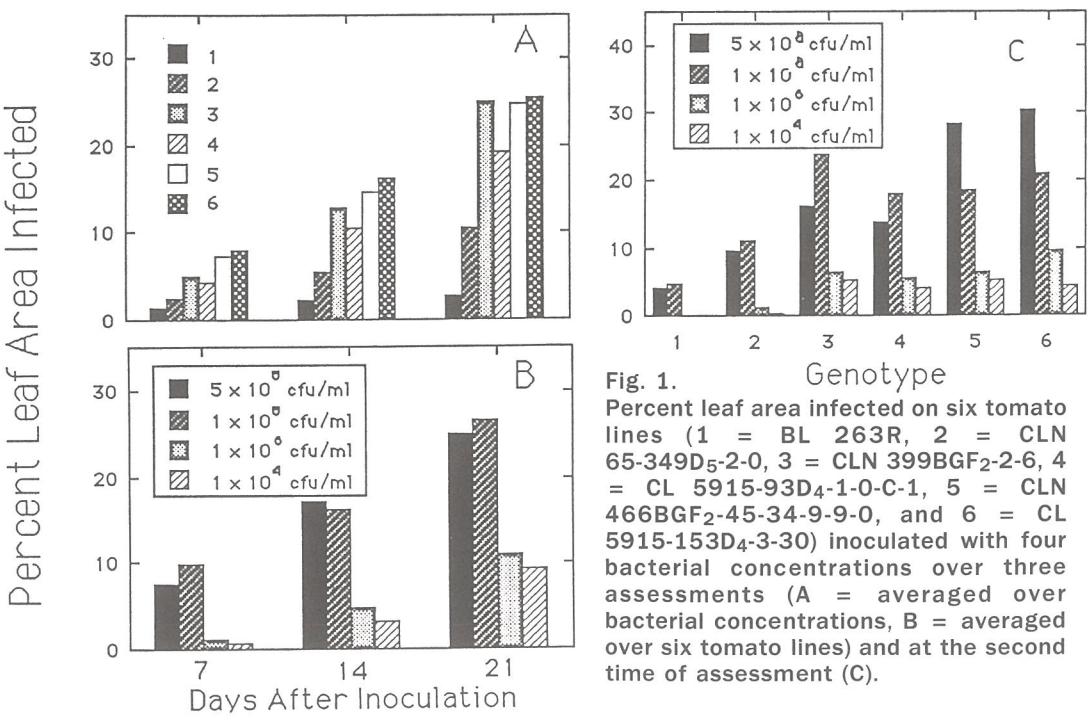


Fig. 1. Percent leaf area infected on six tomato lines (1 = BL 263R, 2 = CLN 65-349D_5-2-0, 3 = CLN 399BGF_2-2-6, 4 = CL 5915-93D_4-1-0-C-1, 5 = CLN 466BGF_2-45-34-9-9-0, and 6 = CL 5915-153D_4-3-30) inoculated with four bacterial concentrations over three assessments (A = averaged over bacterial concentrations, B = averaged over six tomato lines) and at the second time of assessment (C).

At the second assessment, BL 263R and CLN 65-349D_5-2-0 had the lowest percent leaf area infected compared to the other lines within each of the bacterial concentrations (Fig. 1c). Regressions of percent leaf area infected (log_{10}) to bacterial concentration (log_{10}) were all significant. Bacterial spot infection increased as concentrations increased; however, the slopes of the regression lines increased more for BL 263 R and CLN 65-349D_5-2-0 because when inoculated at lower concentrations the percent leaf area infected was about eight times less than that of the other lines.

The data show that lower bacterial concentrations caused negligible disease in resistant lines. Breeding line CLN 399BGF_2-2-6 was found susceptible and not moderately resistant as reported previously. Lines ranked similarly in percent leaf area infected at each bacterial concentration. At 5×10^8 or 10^8 cfu/ml, the percent leaf area infected was similar within each line. When inoculated at high concentrations, BL 263R had atypical lesions that did not expand like lesions on the other lines. To assess lines partially resistant to bacterial spot, further research will concentrate on evaluating lesion numbers and their sizes, and will determine population levels of *X.c.* pv. *vesicatoria* in leaf tissues.

Evaluation of accessions for resistance. The average leaf area infected was 30% for the first field rating (SD = 12) and 45% (SD = 18) for the second field rating, and 15% (SD = 11) and 18% (SD = 8) for the greenhouse. The leaf area infected ranged from 1.5 to 90% in the field and 0-70% in the greenhouse. Several accessions, L 29, L 30 and L 32, ranked well in both the field and greenhouse tests. Although no accessions were immune, 138 were selected for further assessment. The best of these accessions will be evaluated for partial resistance and for their potential use in the breeding program.

Incidence of Bacterial Wilt on Hybrids of Fresh Market Tomatoes in Taiwan

Summary

Bacterial wilt of tomato, caused by *Pseudomonas solanacearum*, continues to be the most important disease of tomato throughout the humid tropics. Breeding for disease resistance has been the primary means of control. A number of resistant hybrids are available to growers. In this survey, incidence of bacterial wilt on AVRDC hybrids averaged 7% in 23 fields while other non-AVRDC hybrids averaged 57% in 14 fields. The population density of *P. solanacearum* was 34 times higher in the soil surrounding roots of wilted plants than in soil surrounding nonwilted plants. The average density of *P. solanacearum* from soil surrounding wilted plants was 2.0×10^6.

Introduction

Bacterial wilt (BW) of tomato, caused by *Pseudomonas solanacearum*, is consistently the most important disease in wet, humid tropical and subtropical environments. In Taiwan, the disease occurs wherever tomatoes are grown in summer.

In 1989 and 1990, two AVRDC hybrids that have less susceptibility to *P. solanacearum* were released as Taichung AVRDC No. 4 (FMTT 22) and Hualien AVRDC No. 5 (FMTT 3). This study aimed to determine the incidence of bacterial wilt on these and other hybrids in growers' fields in selected areas of Taiwan.

Materials and Methods

A questionnaire was distributed to tomato growers in Taiwan with the help of Mr. Ts'eng, Hualein DAIS, Lanyang substation, Ilan County; and Mr. Hong in Taichung DAIS, Puli substation, Nantou County. Twenty growers responded to the survey, providing the following information: date planted, variety, crop planted before tomato, hectares planted, number and age of plants and the incidence of bacterial wilt and other diseases.

Along with the questionnaire to the farmers, three separate disease surveys were conducted in Ilan (17 July), Taitung (31 July 1 August) and Nantou counties (20 September and 18-19 October).

A varietal trial of 14 hybrids was evaluated for BW at the Taitung DAIS. Two fields in Kuanshan, Taitung County were assessed for BW incidence, and soil was sampled and pooled from three wilted plants per field.

In Ilan County, eight fields were assessed for incidence of bacterial wilt by averaging several estimations made by surveyors while walking through and around the fields. Soil samples were collected from around the roots of diseased plants from five fields.

In Nantou County, 10 fields were assessed for incidence of BW. The number of wilted plants were counted in smaller fields and estimated in larger fields by counting the percent incidence on 100-200 plants at four to five locations in the field. Soil samples were taken from around the roots of diseased and symptomless plants from three fields at Hsinyi and Yuchih and from nine lines at Puli, Nantou County.

Soil samples were assayed for *P. solanacearum* using a selective medium described in the 1989 AVRDC Progress Report. Populations were presented as per gram dry weight of soil.

Results and Discussion

Based on the questionnaire, the incidence of bacterial wilt in Ilan County was 3% for FMTT 3 and 65% for Known You 283 and 301 (Table 1). In Nantou County, the average incidence was 11% for FMTT 22 and 49% for Known You 301.

In the field surveys, no bacterial wilt was observed at the Lanyang substation in Ilan County. From the seven fields in the Sanhsing area of Ilan County, bacterial wilt incidence averaged 30%. In Nantou County, the average incidence of bacterial wilt was 20% on FMTT 22 and 31% on all other hybrids.

This survey indicated that the incidence of bacterial wilt was extremely severe, especially when hybrids that had not been through rigorous selection for bacterial wilt resistance were grown by farmers. In a few cases, the AVRDC hybrids also had unacceptable levels of bacterial wilt incidence. The reasons for this breakdown of resistance may be complex. Environmental factors and microbes associated with the rhizoplane and rhizosphere no doubt influence the host-pathogen interaction.

The bacterial population from soil sampled around wilted plants averaged 3.5×10^6 cfu/g of dry soil from growers' fields in Nantou County, 2.1×10^6 in Ilan County, and 1.9×10^4 in Taitung County. Bacterial populations from lines grown at Puli, Nantou County were 5.9×10^4 for symptomless plants and 2.0×10^6 cfu/g of dry soil for wilted plants. Soils surrounding the roots of FMTT 269 and L 390 had the highest populations of *P. solanacearum* on symptomless plants.

Table 1. Incidence of bacterial wilt caused by *Pseudomonas solanacearum* on hybrids of fresh market tomatoes in Ilan and Nantou Counties, Taiwan, 1990.

County	Hybrid	Date planted	Ha	Plant pop.	Bacterial wilt (%)
Ilan	FMTT 3a	3 May	0.14	2,680	1
	FMTT 3	10 June	0.20	4,800	1
	FMTT 3	21 May	0.18	3,400	5
	FMTT 3	23 May	0.21	4,900	4
	Known You 283	28 April	0.11	2,400	87
	Known You 283	30 April	0.15	3,100	49
	Known You 301	30 April	0.15	3,100	49
	Known You 301	14 April	0.15	3,200	8
	Known You 301	1 May	0.12	2,600	86
	Known You 301	12 April	0.12	2,700	85
	Known You 301	11 May	0.10	2,100	92
Nantou	FMTT 22b	16 April	0.16	4,925	3
	FMTT 22	30 April	0.10	3,015	5
	FMTT 22	4 May	0.15	4,560	32
	FMTT 22	8 April	0.12	3,700	20
	FMTT 22	18 April	0.11	3,500	6
	FMTT 22	29 March	0.12	3,200	2
	Known You 202	16 April	0.05	1,496	69
	Known You 658	1 May	0.12	3,650	68
	Known You 658	17 April	0.05	600	11

[a]Released as Hualien AVRDC No. 5. [b]Released as Taichung AVRDC No. 4.

Bacterial populations in soil are important in the dynamics of the host-pathogen interaction. Studies dealing with population levels in relation to various genotypes and on their root exudates are lacking. Future research should concentrate on determining which factors affect population levels of the bacterium in the soil and how bacterial densities may influence host susceptibility to the pathogen.

Characterization of *Pseudocercospora fuligena*, the Causal Agent of Black Leaf Mold of Tomato

Summary

Pseudocercospora fuligena, the causal agent of black leaf mold of tomato, was studied in pure culture and on inoculated tomato plants. The fungus grew slowly in culture on both potato dextrose agar (PDA) and tomato oatmeal agar (TOA). The optimum temperature for mycelial growth was 26°C. Conidia germinated on water agar within 5-10 hours and by 24 hours, 98% of the conidia had germinated. Conidia production in culture was lower on PDA than on TOA. After 17 days, tomato plants inoculated with 5×10^3 or 0.5 conidia/ml had 96% and 1% leaf area infected, respectively. In cross inoculation experiments, isolates from *Solanum nigrum* inoculated on tomato and vice versa caused infection.

Introduction

Black leaf mold of tomato or Cercospora leaf mold, is caused by the fungus *Pseudocercospora fuligena* (Roldan) Deighton (syn. *Cercospora fuligena* Roldan). The disease and pathogen were first described in the Philippines in 1938. They are also known to occur in India, Ivory Coast, Japan, Kampuchea, Malaysia, Solomon Islands, Taiwan, Thailand and the United States (Florida).

The initial symptoms of black leaf mold occur as pale yellow to light green lesions, 1-20 mm in diameter. Lesions on the lower leaf surface are initially covered with white mycelium that turns grey to black as it ages. Infected leaves wilt, dry with age, and often defoliate. Epidemics of black leaf mold occur when conditions of warm temperatures and high relative humidities prevail. In Japan, the disease was found to be widely distributed and caused severe reductions in yield.

P. fuligena was first described by Roldan in the Philippines as *C. fuligena*. Conidiophores are fasciculate, 2-8 celled, and 20-210 μm long and 3-6.5 μm wide. Conidia range in length from 13.3 to 170 μm and in width from 2.5 to 6.1 μm.

There are only a few reports that have shown the distribution and relative importance of black leaf mold, or on characterizing the fungus in pure culture. These studies were conducted to 1) isolate, sporulate, and assess the growth of the fungus in pure culture; and 2) inoculate tomato plants under controlled conditions to study disease development.

Materials and Methods

***Pseudocercospora fuligena* — isolation, identification and growth.** The pathogen was isolated from tomato leaf lesions of field-grown tomato plants in February and March. Conidia from infected leaf lesions were directly streaked on 2% water agar (WA) medium with a wire loop and incubated at 28°C. After 16-18 hours, germinated conidia observed through a stereomicroscope were cut out of the agar individually and transferred to potato dextrose agar (PDA) in 9-cm culture dishes.

Leaf lesions, 5-10 mm in diameter, were cut from greenhouse-inoculated tomato plants and placed adaxial side down in a drop of cotton blue stain on a microscope slide. The leaf sections were removed 30-60 sec later and observed under a light microscope (× 250). The length, width and the number of septations of 500 conidia were recorded.

Conidia harvested from leaf lesions by washing were seeded on 2% WA in 9-cm diameter culture dishes and incubated at 28°C for 23 hours. Every odd hour, beginning with 1 hour after incubation, one dish was removed and flooded with 5-8 ml of FA fixer (50 ml formalin, 50 ml acetic acid and 900 ml of water). Germination and germ tube lengths of 50 conidia were randomly selected and recorded at each interval. The number of cells per conidia were counted. Germinated cells from the tip, base, or from cells between the tip and base were recorded separately. The experiment was repeated twice, but the observation time was limited to 13 hours after seeding conidia on WA.

Effect of media and temperature on fungal growth. Conidia obtained from a single leaf lesion were smeared on WA. Conidia were transferred individually to 9-cm culture dishes containing PDA, V-8 agar, carrot agar (CA) and tomato oatmeal agar (TOA). TOA was made by chopping 50 g of tomato leaf pieces, boiling 15 g oatmeal, and sieving these suspensions through cheesecloth. The sieved suspensions were mixed at equal volumes and then mixed with 25 g agar and the volume adjusted to 1 l before autoclaving at 121°C for 30 min. All of the inoculated media were maintained at 28°C for 24 hours under darkness. The colony diameter was measured and 6-mm diameter pieces were cut out weekly, inserted in distilled water, and shaken for 1 min before counting the conidia using a hemacytometer.

After germination, conidia were transferred individually to culture plates containing either PDA or TOA. These were incubated in the dark from 10 to 34°C at 4°C intervals. There were three replications per temperature for PDA and four replications for TOA. The diameter of the colonies was measured weekly. After 3 weeks the dishes were flooded with 10 ml of water, and the colony surface brushed to release conidia which were harvested and then counted using a hemacytometer.

Effect of relative humidity and high temperature on conidial growth. Fifteen milliliters of the following saturated solutions were poured into culture dishes: $MgCl_26H_2O$; $Ca(NO_3)2\ 4H_2O$; $(NH_4)_2SO_4$; KCl; KNO; KH_2PO_4; K_2SO_4 and H_2O representing 32.5, 47, 80, 84.5, 91, 93.5, 96.5 and 100% relative humidities (RH), respectively. One drop of a conidia suspension was placed on a glass slide and allowed to dry. After air-drying, the slides were placed inside culture dishes on top of 1-cm high glass rings. All dishes were sealed with parafilm and incubated at 28°C. There were three replications for each humidity level. Germination of conidia was recorded 3, 6 and 24 hours after incubation.

The effect of high temperatures on survival of conidia was tested by placing lesions of infected tomato leaves into 10 ml of distilled water in a test tube. After agitation for 1 min, aliquots of 1 ml were transferred to test tubes and placed in water baths at 40°, 45°, 50° and 55°C. For each temperature, incubation times of 5, 10 and 15 min were used. Each temperature and time combination had three replications. At the end of each period, a drop of the suspension was placed on a glass slide, air-dried, and then placed at 100% relative humidity inside a 9-cm culture dish. Dishes were sealed with parafilm and incubated at 28°C. In a related experiment, aliquots of 1 ml of the conidial suspension were transferred to 24 test tubes, and maintained at 40°C for 30, 45, 60 and 120 min. Germination of conidia was recorded for both experiments after 24 hours.

Inoculation of plants. Two-week old cultures grown on PDA were cut into 6-mm diameter pieces, streaked on TOA, and incubated for 2 weeks at 28°C. Ten milliliters of sterile water was poured on the colonies. The end of a microscope slide was used to rub the colony surface. The water was decanted through a 40 μm-mesh copper sieve. The concentration of the stock solution was determined with a hemacytometer and adjusted to 0.5, 5, 50, 500 and 5,000 conidia/ml. Four replications (one plant/rep) of 3 week-old tomato plants (breeding line CL 5915-153D_4-3-3-0) were atomized with each concentration using hand sprayer until runoff occurred. Percent leaf area infected was assessed 14 and 17 days after inoculation.

Three-week old tomato plants (CL 5915-153D_4-3-3-0) were atomized with a conidial suspension of 500 conidia/ml and were incubated at 28°C and 98% RH. Five plants were removed after 1, 2, 4 and 10 days and placed in the greenhouse. Percent leaf area infected was recorded 11 and 14 days after inoculation.

A suspension of 500 conidia/ml was atomized until runoff on 3 week-old tomato plants (CL 5915-153D_4-3-3-0), on seedlings of *Solanum nigrum* L. that were transplanted from outdoors to pots, and on 4 week-old *Nicotiana benthamiana* Domin. Inoculated plants were placed inside a growth room at 28°C and 98% RH. There were three replications per species. Percent leaf area infected was recorded after 2 weeks.

Conidia of *P. fuligena* harvested from infected leaves of *S. nigrum* were diluted with water before atomizing 3 week-old tomato plants. Inoculated plants were incubated in a growth room and the percent leaf area infected was recorded after 2 weeks.

Two to 10 week-old plants (CL 5915-153D_4-3-3-0) were inoculated until runoff with 500 conidia/ml. Percent leaf area infected of four plants for each age was recorded 14 and 21 days after inoculation.

Results and Discussion

***Pseudocercospora fuligena* — isolation, identification and growth.** The pathogen was identified as *Pseudocercospora fuligena* using taxonomic keys. Conidia were subhyaline to pale olivaceous, and cylindrical to cylindrical obclavate and straight to slightly curved. The tip cells were rounded while basal cells were long obconic to long obconical truncate. Conidia range and mean length were 9-(85.1)-137 μm with a width of 4.0-(4.7)-6.1 μm. The septa number range and mean were 2-(9.5)-27. The hilum was unthickened. Some conidia were branched or forked at the tip cell.

Conidia germinated most frequently from tip and basal cells, and least from cells in the middle of the conidia (Fig. 2a). Germ tubes from the tip cells were longer and grew to 150 μm after 13 hours (Fig. 2b).

Effect of media and temperature on fungal growth. There were no significant differences in colony diameter on the four media tested. The colony diameter averaged 2.5, 6.8 and 9 cm at 7, 14 and 21 days, respectively.

The optimum temperature for growth was 26°C on PDA and TOA (Fig. 3a & b). No growth occurred at 34°C. The greatest increase in the diameter of the colony was between 2 and 3 weeks (Fig. 3b).

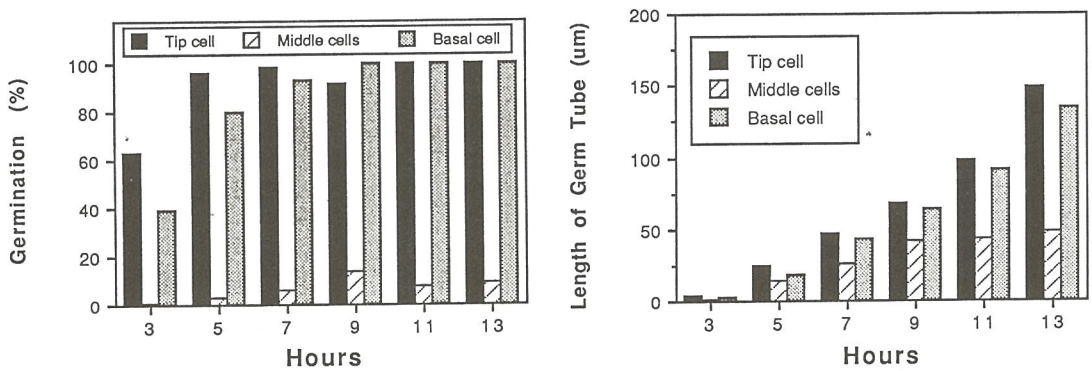


Fig. 2. Percent germination (a) and germ tube lengths (b) of *Pseudocercospora fuligena* conidia from tip, middle and basal cells grown on water agar over a 13-hour period (n = 500 conidia).

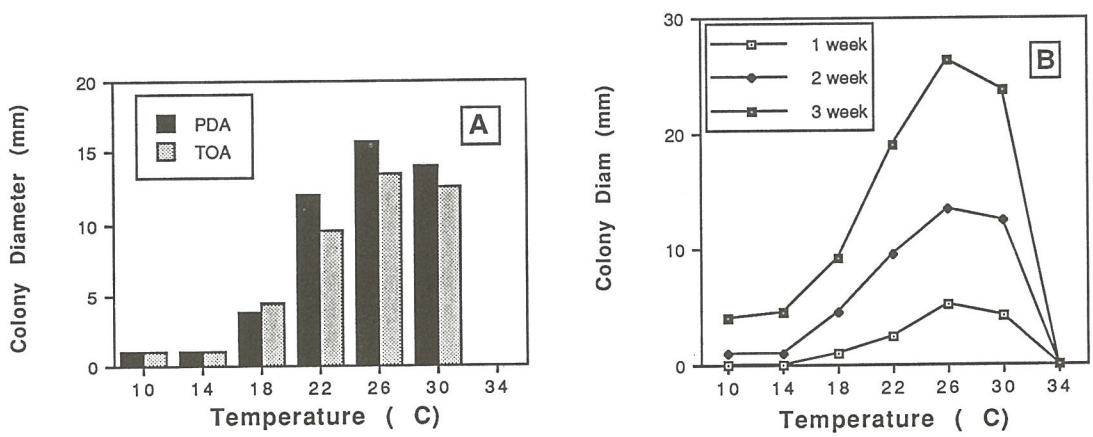


Fig. 3. The effect of temperature (10-34°C at 4°C intervals) on growth of *Pseudocercospora fuligena* after 2 weeks on (a) potato dextrose agar (PDA) and tomato-oatmeal (TOA); and (b) growth on TOA between 1 and 3 weeks.

Effect of relative humidity and high temperature on conidial growth. Germination occurred in water, and at 100% and 96.5% RH. There was no germination at 80% RH after 24 hours. When incubated at 40°C for 15 min, conidia germination was over 98% , but was reduced to less than 50% when conidia were kept for 30 min or longer at 40°C (Fig. 4a). Conidia exposed to 50 or 55°C did not germinate, but germinated at 40 or 45°C (Fig. 4b).

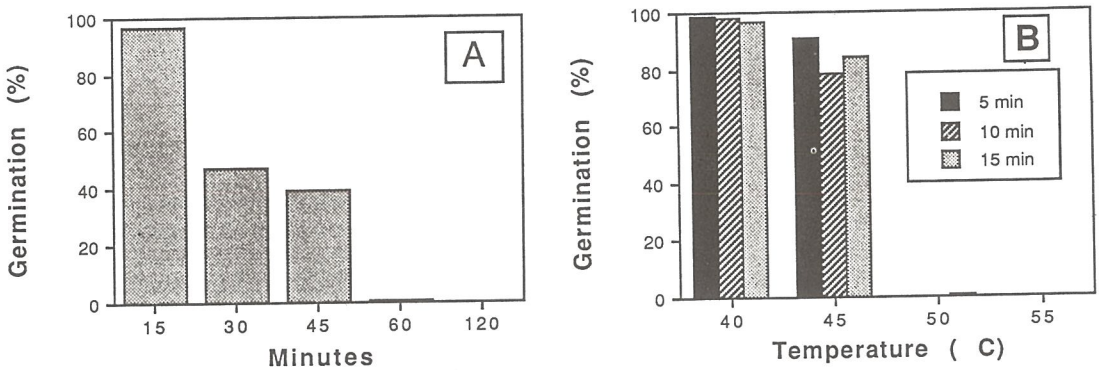


Fig. 4. Conidial germination of *Pseudocercospora fuligena* after exposure to (a) 40°C for 15, 30, 45, 60 and 120 min, and (b) at 40, 45, 50 and 55°C for 5, 10 and 15 min.

Inoculation of plants. All conidial concentrations caused infection. The greatest amount of leaf area infected occurred at the highest concentration (Table 2).

Infection was greatest on plants that were kept at high humidities inside the growth room. Greenhouse-incubated plants had some symptoms, but less than any other incubation treatments (Table 3).

An isolate from tomato when inoculated on *S. nigrum* and vice versa caused infection.

Four to 7-week old tomato plants had more leaf area infected than younger and older plants.

Conidia germinated after 3 hours, although there was no germination below 84.5% RH. Free moisture was apparently not necessary for conidia germination. This, coupled with the ability to germinate quickly are primary reasons why the disease is difficult to control when humidities are high.

Table 2. Effect of *Pseudocercospora fuligena* conidial concentration on the percent leaf area infected on a tomato breeding line (CL 5915-153D$_4$-3-3-0).

Concentration (conidia/ml)	Leaf Infection (%)	
	14 Days	17 Days
0.5	0.5	0.8
5	0.7	9.9
50	7.3	31.8
500	47.0	73.5
5000	88.1	96.3

Table 3. Effect of relative humidity on the percent leaf area infected on a tomato breeding line (CL 5915-153D$_4$-3-3-0) inoculated with *Pseudocercospora fuligena*.

Treatments	Incubation[a]	Leaf area infected (%)	
		11 Days	14 Days
Greenhouse	–	44.5	50.6
Growth room	1	31.0	53.8
Growth room	2	68.0	86.8
Growth room	4	78.0	96.1
Growth room	10	80.1	93.3
Growth room	C	90.1	99.5

[a]Dash represents inoculation in the greenhouse under ambient conditions; 1-10 represent days in the incubation growth room; C = continuously grown in the growth room.

The cross inoculation studies using isolates from *S. nigrum* and tomato prove that *S. nigrum* is an alternative host. How important this host is to the overseasoning or the epidemiology of the disease is not known, however. So far, there are no other reported hosts of *P. fuligena*. Future efforts will be directed toward studying the survival of the fungus and the epidemiology of the disease.

Yield Reduction in Tomato Caused by *Pseudocercospora fuligena*, the Causal Agent of Black Leaf Mold

Summary

Black leaf mold is an important foliar disease of tomato in tropical production areas. There are no experimental studies qualifying the yield losses caused by *Pseudocercospora fuligena* on tomato. In this study, a breeding line, CL 5915-153D$_4$-3-3-0 (CL 5915), and a commercial cultivar, TN 2, had an average yield loss of 32%. Fruit number loss was 11% for CL 5915 which was significantly less than 28% for TN 2; weight loss per fruit of CL 5915 was 20% and only 7% for TN 2. Without fungicide applications, a significant yield reduction due to black leaf mold may occur. Future studies using disease-resistant lines to help reduce losses caused by black leaf mold will be evaluated under controlled conditions.

Introduction

Pseudocercospora fuligena causes black leaf mold of tomato. The fungus sporulates profusely on infected leaf surfaces, often causing the leaves to wither and drop from the plant. The disease occurs throughout Southeast Asia under conditions of high humidity. So far, there are no commercially available tomato culvars with resistance to *P. fuligena*. The general method of control used is fungicide application.

This study aimed to assess and monitor black leaf mold under field conditions, and to determine the relationship between disease and yield.

Materials and Methods

Seeds of a breeding line, CL 5915-153D$_4$-0-3-3-0 (coded CL 5915), and a commercial variety, TN 2, were sown in flats in the greenhouse on 2 September 1989. Twenty-four seedlings were transplanted in two rows, 40 cm apart in 3 × 5 m raised beds on 3 October. The experiment was a split plot in a randomized complete block design with four replications. Main plot treatments used were: 1 = inoculated with *P. fuligena* on 3, 6, 14, 20, 27 November and 4 December; 2 = inoculated on 27 and 29 November and 4, 12 and 15 December; 3 = not inoculated; and 4 = not inoculated and protected biweekly with Benlate and Dithane M-45 biweekly beginning 17 October. Subplots consisted of two tomato genotypes, CL 5915 and TN 2, that were randomized within main plot treatments.

Conidia of *P. fuligena* were harvested by adding 10 ml of distilled water to 10-day old colonies grown on tomato oatmeal agar. The concentration of conidia was adjusted to approximately 10^3 conidia/ml. Plants were inoculated by atomization until runoff with a pressurized sprayer. Before inoculating, plants were overhead irrigated for approximately 10 min.

Disease was assessed 12 times at 7-day intervals from 23 November 1989 to 6 February 1990. The percent leaf area infected was recorded for each plot. The values for the area under the disease progress curve (AUDPC) were calculated using a formula to determine the area under the curve.

Fruits were harvested from a 3 × 5 m area 11 times from 20 December 1989 to 28 February 1990. Total fruit weight and number of fruit per plot were recorded from each harvest and summed over harvest dates. Data were converted to tons per hectare. Individual fruit weight was calculated by total fruit weight/number of fruit.

Data were analyzed by ANOVA. Means of main plots, subplots and interactions were compared by FLSD. Regressions of yield parameters to disease severity were calculated.

Results and Discussion

No disease occurred on plants in noninoculated and fungicide-protected plots. Disease development was delayed from earlier to later inoculations. There was a significant difference in the values of AUDPC for the inoculated treatments and the genotypes (Table 4). The average treatment means over genotypes were 2,941, 1,641 and 491 for 1, 2 and 3, respectively. These were significantly different from each other. Treatment averages between CL 5915 (2,119) and TN 2 (1,427) were significantly different. Differences between AUDPC values within the same treatment and between genotypes with different treatments were significantly higher for CL 5915 than TN 2 (Table 1). Both genotypes were susceptible to black leaf mold although TN 2 had lower values for AUDPC and percent leaf area infected.

Fruit weight was reduced 4-32% compared to control plots (treatment 4) (Table 5). Total fruit weight averaged over treatments was not significantly different between CL 5915 (167) and TN 2 (168). There were significant differences between treatment means as total fruit weight of treatment 1 was significantly less than the other three treatments (Table 5).

Fruit number was reduced from 4 to 19% compared to control plots (Table 5). There was a significant difference between genotypes averaged over all treatments (CL 5915 = 3,659 and TN 2 = 5,631), but there was no significant genotype × treatment interaction.

Fruit weight was reduced from 4 to 20% (Table 2). Fruits of CL 5915 averaged 46 g/fruit which was significantly higher than TN 2 which averaged 30 g/fruit. The interaction of genotype × treatment was not significant.

Regressions of yield parameters to values of AUDPC were significant as yield variables decreased as AUDPC values increased. Predicted yields of the two genotypes and their slopes were similar; however, the number of fruits and their weights were different. CL 5915 produced less but larger fruits than TN 2.

This is the first experiment that measured yield loss in tomatoes due to black leaf mold. Future research will be directed toward developing or evaluating lines that have some resistance or tolerance to *P. fuligena*.

Table 4. Area under disease progress curve for CL 5915-153D$_4$-3-3-0 and TN 2 inoculated or not with *Pseudocercospora fuligena*.

Treatment[a]	Genotype	
	SCL 5915-153D$_4$-3-3-0	TN 2
1	3733	2519
2	2041	1409
3	581	353
FLSD ($P < 0.05$)[b]	134	
FLSD ($P < 0.05$)	111	

[a]1 = inoculated six times, 2 = inoculated five times, and 3 = not inoculated. [b]Difference between means of genotypes within the same treatment. [c]Difference between means of genotypes with different treatments.

Table 5. Total fruit weight, fruit number and weight per fruit of CL 5915-153D$_4$-3-3-0 and TN 2 in plots inoculated or not with *Pseudocercospora fuligena*.

Treatment[a]	Total fruit Weight		CL 5915		TN 2		CL 5915		TN 2	
	Tons/ha	Loss	Fruit no.	Loss	Fruit no.	Loss	Wt./fruit	Loss	Wt./fruit	Loss
1	130	32	3369	11	4587	28	40	20	28	7
2	164	15	3772	0.1	5620	12	44	12	29	3
3	184	4	3695	3	5914	8	48	4	32	–
4	192		3800		6403		50		30	
FLSD ($P<0.05$)[b]	17									
FLSD ($P < 0.05$)[c]			684		684		3.9		3.9	
FLSD ($P < 0.05$)[d]			708		708	4.1	4.1			

[a]1 = inoculated six times, 2 = inoculated five times, and 3 = not inoculated. [b]Difference between main plot means. [c]Difference between means of genotypes within the same treatment. [d]Difference between means of genotypes with different treatments.

Tomato Physiology

Regeneration of Tomato Explants

Summary

Efforts were made to establish a protocol for the regeneration and multiplication of transformed tomato explants as part of a Council of Agriculture-funded AVRDC/DCB collaborative project to develop tomatoes with resistance to fruitworm.

Introduction

Leaf disc transformation is the model used for *Agrobacterium*-mediated transformation of plant tissues and subsequent selection and regeneration of transgenic plants. This system allows efficient gene transfer, selection and regeneration to be coupled together in a simple process. This study was conducted to establish a protocol for the induction of shoot bud and roots, and regeneration and multiplication of transformed tomato explants.

Materials and Methods

Seeds of three tomato cultivars, Tainan Selection No. 2, CL 5915-206-2-2-0-4 (female parent of FMTT 22) and L 4783 (male parent of FMTT 22), were surface-sterilized by immersing in 1% sodium hypochlorite for 5 min, and then in 85% alcohol for 10 sec. After being rinsed thoroughly with sterile, distilled water three times, seeds were germinated on MS medium at 25°C with 13 hours of light at 2000 lux and 11 hours of darkness. Two weeks after germination, leaves were excised, cut into small segments (0.2-0.5 cm), wound, and then transferred to MS basal salt medium containing sucrose 30 g/l, and agar 1 g/l at pH 5.8. The MS basal medium was modified with different combinations of hormones to induce callus formation, and regenerate plantlets from explants or calli. The explants were first maintained in the dark at 25°C, but were transferred under the light at 2,000 lux for 12 hours after shoot buds were formed.

Results and Discussion

Callus proliferation in explants of tomato cultivars started within 8-10 days after they were transferred to MS basal medium with all combinations of hormones. Furthermore, after 10-14 days of culturing a number of shoot buds were produced on the calli of three tomato cultivars cultured on MS basal medium with high levels of cytokinins, BA or kinetin (Table 1).

Table 1. Callus induction and plantlet regeneration of tomato explants by plant hormones.

Treatment	TN-2	CL 5915-206	L 4783
1 ppm NAA + 0.5 ppm BA	Callus	Callus	Callus
2 ppm 2,4-D	Callus	Callus	Callus
2 ppm NAA + 0.5 ppm BA	Callus	Callus	Callus
2 ppm 2,4-D + 0.5 ppm BA	Callus	Callus	Callus
0.35 ppm IAA + 1.13 ppm BA	Shoot	Shoot	Shoot
2.26 ppm BA	Shoot	Shoot	Shoot
4 ppm IAA + 4 ppm kinetin	Shoot	Shoot	Shoot
0.5 ppm 2,4-D + 5 ppm IAA + 0.3 ppm kinetin	Callus	Callus	Callus

Responses of Isogenic Lines of Determinate and Indeterminate Tomatoes to Flooding and Uniconazol at High Temperatures

Summary

Isogenic lines of indeterminate 4290-5 (CL 6046 BC_5-F_1-22-6-5) and determinate 4290-9 (CL 6046 BC_5F_1-22-6-9) tomatoes were treated with uniconazol on the fourth week after emergence, and flooded for 72 hours 2 weeks after uniconazol treatment. Indeterminate 4290-5 tomato plants have higher survival rates and less leaf epinasty than determinate 4290-9 tomato plants, indicating that indeterminate tomato is more tolerant to flooding than determinate tomato. Ready formation of adventitious roots could be one of the important attributes for flooding tolerance in indeterminate tomatoes. Indeterminate 4290-5 tomato plants partitioned less dry matter into the reproductive part; this may have contributed to flooding tolerance. Uniconazol further reduced survival rate and adventitious roots of flooded plants, although it caused little epinasty, high chlorophyll content and little wilting. Uniconazol increased the proportion of dry matter partitioned to reproductive organs. However, the gain in preferred partition of dry matter to reproductive organs did not compensate for the loss of overall dry matter production caused by flooding.

Introduction

High temperature and excess soil moisture are two major factors which cause tomato yield reduction in the tropics. High temperature increases abscisic acid level and decreases indole acetic acid and gibberellin (GA) levels in reproductive organs of tomato. It also disrupts assimilate partition and growth pattern. Flooding also invokes a wide range of metabolic, growth and developmental processes. Among hormonal changes caused by flooding are leaf epinasty, aerenchyma formation, adventitious rooting and leaf senescence. Exogenous applications of certain growth regulators also change growth patterns and dry matter partition in tomato plants. Uniconazol, an inhibitor of GA biosynthesis, retards plant growth without effecting damage and increases tolerance to stresses. To determine if there is a relationship between growth pattern and flooding tolerance at high temperatures, this study investigated the effects of flooding on growth and dry matter partition of two isogenic lines of determinate and indeterminate tomatoes treated with or without uniconazol.

Materials and Methods

Seeds of isogenic lines of indeterminate 4290-5 (CL 6046 BC_5-F_1-22-6-5) and determinate 4290-9 (CL 6046 BC_5F_1-22-6-9) tomatoes were sown in small plastic pots on 11 June; later seedlings were transplanted to 25-cm ID clay pots on the third week after emergence. Plants of both tomatoes were grown in the greenhouse from July to September at temperature means (and range) of 34.5°C (26.0-37.7°C) and 25.3°C (27.7-23.3°C). Four weeks after emergence, uniconazol [S-3307, E-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-pentan- 3-ol, Sumitomo Co.] at 5 ppm in aqueous solution was applied to the pots at 100 ml/pot; equal amounts of water without uniconazol were applied to control plants. On the seventh week after emergence, plants with or without uniconazol were separated into two groups with or without flooding. For the flooding group, plants were submerged in the water up to 1 cm above the soil for 3 days. An RCB design with three replicates was used.

Cumulative plant height, number of leaflets and axillary buds, and fruit set were recorded weekly, starting from the first week after uniconazol application. Leaf wilting and plant recovery were observed for 2 weeks after flooding. Three plants from each replicate were sampled every 3 weeks three times, starting the day after the completion of flooding. Leaf area per plant was also estimated. Dry weights of roots, leaves below and above the first cluster, stems and fruits were also measured. The first leaf below the first cluster and newly developed leaves were sampled weekly for 5 weeks, starting 1 week after uniconazol application, and determined for total chlorophyll content. One day after

the completion of flooding, epinastic growth of petiole was determined by measuring the angle between the adaxial surface of the petiole and the main stem.

Results and Discussion

Both flooding and uniconazol applications significantly hindered plant height to about 50% of the control, and leaf expansion (Table 2). Indeterminate 4290-5 tomato plants have higher survival rates than determinate 4290-9 tomato plants (Table 3). This suggested that the indeterminate tomato is more tolerant to flooding than determinate tomato. Ready formation of adventitious roots could be one important attribute in flooding tolerance in indeterminate tomatoes.

Table 2. Effects of flooding and uniconazol applications on vegetative growth of isogenic lines of determinate and indeterminate tomatoes.

Entry	Treatment	Plant height (cm)	Leaflet no. (/plant)	Leaf area (cm^2)	Axillary bud no. (/plant)
Indeterminate 4290-5	Cont/Cont	140 a[a]	119 a	3513 a	6.2 b
	Cont/Uni	70 c	87 ab	1524 b	9.5 a
	Flood/Cont	114 b	80 b	1731 b	6.3 b
	Flood/Uni	64 c	76 b	1343 b	9.7 a
	Mean	97	91	2028	7.9
Determinate 4290-9	Cont/Cont	114 a	67 ab	2202 a	4.2 c
	Cont/Uni	53 c	85 a	1144 b	7.7 b
	Flood/Cont	86 b	54 b	1356 b	4.2 c
	Flood/Uni	43 c	73 ab	1005 b	9.7 a
	Mean	74	70	1427	6.5

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

Table 3. Effect of flooding and uniconazol applications on survival rate, relative epinasty and adventitious roots of isogenic lines of determinate and indeterminate tomatoes.

	Survival rate (%)[a]			Relative epinasty[b]			Adventitious roots[c]		
	4290-5	4290-9	Mean	4290-5	4290-9	Mean	4290-5	4290-9	mean
Control	85 a[d]	60 a	73 a[e]	1.26 a	1.34 a	1.30 a	9.6 a	5.8 a	7.7 a
Unicon	52 b	44 a	48 b	1.09 b	1.17 b	1.13 b	5.1 b	4.0 a	4.6 b
Mean	69 a[f]	52 b		1.17 a	1.26 a		7.4 a	4.9 b	

[a]Survival plants were counted 2 weeks after flooding. [b]Expressed as ratio of flooding/control at 1 day after the completion of flooding. [c]Number of adventitious roots formed on the soil surface at the completion of flooding. [d]Mean separation within a column of the same entry at 5% level by DMRT. [e]Mean separation within a column of the same entry at 5% level by DMRT. [f]Mean separation of uniconazol application at 5% level by DMRT.

Both indeterminate and determinate tomatoes flooded for 72 hours without uniconazol were not able to fully recover even until 5 weeks after flooding. High death rates and wilting damage percentages after flooding could be due to severe loss of water potential in tomato plants under high temperature and light conditions. Uniconazol application had no apparent synergistic effects with flooding on plant growth, but it alone increased axillary bud formation (Table 2). Both tomatoes treated with uniconazol and flooding had lower survival rates than plants flooded without uniconazol (Table 3). Uniconazol increased, while flooding decreased chlorophyll content in the leaf, and caused little wilting. Increased chlorophyll content is due to high levels of potassium and cytokinins. High chlorophyll content in tomato plants treated with uniconazol could thus be an indication of high endogenous cytokinins. However, this is not reflected in better plant survival or increased adventitious root formation under flooding conditions. It is possible that although uniconazol causes physiological and morphological changes in tomato plants, these changes may not necessarily be related to flooding tolerance.

Isogenic lines of determinate 4290-9 and indeterminate 4290-5 tomatoes without flooding and uniconazol had comparable flower and fruit numbers, and average fruit size (Table 4). However, flooding for 72 hours tended to reduce flower formation, promote floral wilting and abscission, delay next flush of flowering, arrest fruit growth and enhance early fruit ripening in both tomato types. Lower flower number caused by uniconazol is likely due to less assimilates available for floral development. Although floral abscission was related to endogenous ethylene, no ethylene was detected in all floral organs of all treatments. Uniconazol increased fruit set rate mainly due to decreased flower number by chemical application. Furthermore, uniconazol decreased fruit number in determinate 4290-9 tomato but not in indeterminate 4290-5 tomato. Both flooding and uniconazol seemed to have no effect on fruit size in both tomato types.

Determinate 4290-9 tomato plants with or without flooding had high proportion of dry matter partitioned to reproductive plant parts than indeterminate 4290-5 tomato plants. This was likely due to less branching tendency (axillary bud formation) in determinate tomato plants. This may also have some bearing on flooding tolerance in indeterminate tomato plants. On the other hand, high temperature is usually unfavorable for reproductive growth because partition of assimilates to reproductive organs is limited.

Uniconazol application resulted in high proportion of dry matter partitioned to reproductive organs, but less to the stem, in both tomato types 4 and 7 weeks after flooding. It is possible that assimilates produced in small leaf area caused by uniconazol may be fully utilized during the reproductive growth. However, the efficiency of assimilates translocated to reproductive organs must still be augmented by the ample production of assimilates from the leaf. High proportion of dry matter partitioned to reproductive organs by uniconazol application did not compensate for the loss of assimilate production caused by flooding.

Table 4. Effects of flooding and uniconazol applications on flower and fruit number, fruit set rate and average fruit weight of isogenic lines of determinate and indeterminate tomatoes.

Variety	Treatment	Flower no. (/plant)	Fruit no. (/plant)	Fruit set (%)	Ave. fruit weight (g)
Indeterminate 4290-5	Cont/Cont	86.7 a[a]	21.9 a	25.1 b	22.7 a
	Cont/Uni	54.6 bc	21.9 a	39.5 a	23.7 a
	Flood/Cont	73.8 ab	16.5 a	22.1 b	17.8 a
	Flood/Uni	39.8 c	14.6 a	29.5 ab	22.0 a
Determinate 4290-9	Cont/Cont	81.2 a	27.5 a	33.8 ab	23.4 a
	Cont/Uni	51.3 b	18.1 b	36.1 a	25.8 a
	Flood/Cont	68.8 ab	18.5 b	26.7 b	21.6 a
	Flood/Uni	48.8 b	15.7 b	31.9 ab	20.7 a

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

Genetic Resources and Seed Unit

Germplasm Introduction

Six hundred sixty-two accessions were introduced in 1990 (Table 1). Of these, 472 were collected from Malaysia (East Malaysia, Sarawak and Sabah) during two collection trips carried out in March and June, 1990. The collection trips were part of the implementation of the project 'Conservation, Evaluation and Utilization of Vegetable Genetic Resources: A Collaborative Network Project for Southeast Asia' funded by the Japanese government.

Table 1. New germplasm introductions at AVRDC, 1990.

Source	*Glycine* spp.	*Vigna* spp.	*Brassica* spp.	*Lycopersicon* spp.	*Capsicum* spp.	Others	Total
Australia	–	–	–	–	–	4	4
Brasil	–	–	–	–	3	14	17
Bulgaria	–	–	–	–	–	19	19
China	–	–	–	–	1	–	1
Costa Rica	–	–	–	–	20	–	20
Czechoslovakia	–	–	–	–	–	8	8
Ethiopia	–	–	–	–	2	–	2
France	–	–	–	–	2	16	18
India	–	8	–	–	1	–	9
Indonesia	–	–	1	4	2	5	12
Italy	–	–	–	–	8	–	8
Japan	–	–	2	–	–	3	5
Malaysia	2	1[a]	41	14	72	342[b]	472
Philippines	–	–	–	11	11	2	24
Sri Lanka	–	4	–	–	5	–	9
Taiwan	–	–	–	4	2	–	6
Thailand	–	–	–	–	2	3	5
U.S.A.	–	–	2	4	6	6	18
Vietnam	–	5	–	–	–	–	5
Total	2	18	46	37	137	422	662

[a] *Vigna radiata* only; other *Vigna* spp. are included in others. [b] Includes 26 genera collected from Malaysia.

Germplasm Conservation

The current status of germplasm maintained at GRSU, totaling 32,187 accessions, is shown in Table 2. The increase in nonprincipal crops came from the collection trips to Malaysia.

The current status of the base collections in long-term storage is shown in Table 3. The germination test of multiplied tomato and pepper seed will be carried out soon. Presently, GRSU is concentrating on the multiplication of tomato and pepper for the base collection.

Table 2. Germplasm maintained by GRSU in 1990.

Crop	Accessions	Missing	Available	Temporarily numbered acc.	Suspected duplicates[a]
AVRDC principal crops					
Soybean	12,505	920	11,585	157	2,111
Mungbean	5,274	202	5,072	819	985
Tomato	5,831	138	5,693	345	40
Sweet potato	1,437	38	1,399	251	9
Chinese cabbage	856	42	814	519	0
Pepper	5,593	110	5,483	0	0
Subtotal	31,496	1,450	30,046	2,091	3,145
Other crops					
Adzuki bean	125	–	125	25	0
Amaranth	86	–	86	18	0
Black gram	408	–	408	339	0
Rice bean	72	–	72	223	0
Others	–	–	–	1,121	0
Subtotal	691	–	691	1,726	0
Total	32,187	1,450	30,737	3,817	3,145

[a]Based on variety names.

Table 3. Current status of the base collection in long-term storage at AVRDC.

Crop	No. of accessions stored	% of total accessions	Seeds/ accession[a] (No.)	Moisture content (%)	% of accessions tested for germination rate
Soybean	2,620[b]	22	4,000	8	0
Mungbean	5,252	100	4,000	8	100
Tomato	2,037	36	12,000	5	25
Chinese cabbage	341[c]	42	12,000	5	100
Pepper	970	18	12,000	5	77

[a]Recommended number of seeds per accession. [b]Non-USDA accessions. [c]Open-pollinated varieties.

In vitro Conservation of Sweet Potato and Germplasm Transfer

A total of 1,076 sweet potato accessions are being conserved in AVRDC's genebank. Only 214 accessions have been virus-indexed. One hundred accessions remain to be meristemmed (Table 4).

Since AVRDC is terminating its research activities on sweet potato sometime after 1991, the germplasm collection in its repository should have been safely and completely transferred to all interested institutions by then. The entire set of sweet potato germplasm, consisting of 1,395 accessions, has been transferred to the Taiwan Agricultural Research Institute (TARI) Chiayi Substation in the form of cuttings. The transfer of sweet potato germplasm to the International Potato Center (CIP) will be done primarily in tissue culture form. To date, 203 accessions have been sent to CIP safely. It is expected that the transfer will be completed before the end of 1991.

Table 4. Status of in vitro sweet potato genebank.

No. of accessions	Remarks
1,076	Number of accessions successfully meristemmed and being maintained
219	Number of accessions to be transferred to TARI
42	Missing
100	Number of accessions to be meristemmed

Distribution

Some 3,692 seed samples were requested by various AVRDC research units in 1990 while 10,939 seed samples (including true seeds and in vitro materials) of germplasm and breeding lines were distributed to 79 countries and territories in 1990. Appendix 1 shows the major institutions that received AVRDC germplasm in 1990.

Vegetable Germplasm Collection in Malaysia

Introduction

From 1974 to 1989, AVRDC distributed a total of 86,194 seed samples to ASEAN countries resulting in numerous cultivar releases of AVRDC lines by the national programs. There is good prospect for AVRDC and the national programs to actively engage in collaborative vegetable germplasm collection, conservation, characterization, evaluation, documentation, utilization and distribution network activities. Valuable germplasm and advanced breeding lines could be multiplied and distributed to the national programs in the network, thus extending the genetic base of each species being tested by the national programs. Through these collaborative activities, the national vegetable germplasm program could be strengthened.

Malaysia was given top priority for collection because of the severe genetic erosion of local vegetable germplasm. The objectives of the collecting mission were to collect the remaining local vegetable landraces and to study the distribution of the local vegetable germplasm so that future collecting expeditions can be planned.

Expeditions

In West Malaysia, the states of Johor, Melaka and Penang were collected with the cooperation of the Malaysian Agricultural Research and Development Institute (MARDI).

In Sarawak, the districts of Kuching, Siburan, Serian, Sri Aman, Saratok, Sari Kei, Bintangor, Sibu, Asa Jaya, Muara Tuang, Miri, Karabungar, Bekenu, Batu Niah and Bintulu were collected.

In Sabah, the districts of Kota Kinabalu, Tuaran, Kundassang, Tambunam, Keningau, Tenom, Sandakan, Lahad Datu and Tawau were collected.

Collecting Strategies

At each site, samples were obtained from local markets, seed shops and farmers. These sources represented a sample of the entire variation. However, only seed shops and farmers were collected in West Malaysia because the vegetables in the market were duplicates of those available in seed shops and from farmers since the growers are well organized and highly commercialized.

In Sarawak, vegetable markets are organized into native and ordinary markets. The native market is usually composed of Dayak vendors whose displays range from cultivated vegetables to jungle-collected products. Many of the cultivated ones are local landraces. The variations represent a wider area of hinterland compared to those found in the ordinary market as the vendors often come from far-away interior country. A variant of the native market is the weekly Sunday vegetable market, e.g., the Satok market in Kuching that was collected. The native market is, therefore, a very important collection site.The ordinary market had to be sampled too because the vegetable growers in Sarawak are less commercialized and, therefore, often still keep their own varieties, e.g., pumpkin, *Brassica* spp., yardlong bean, bitter gourd, eggplant, etc. These variations are normally displayed in the market. Since some of the fruit vegetables such as pumpkin, eggplant and cucumber can withstand long distance transportation, e.g., Kuching to Sri Aman or Sibu to Sri Aman, duplicates may have been collected from different collecting sites.

The collection situation in Sabah was quite similar to that in Sarawak. Many vendors from the interior mountain jungle bring their agricultural products to the roadside for sale. Variable landraces

were found and collected. Most farmers in the mountain area still keep their own seeds of species such as cucumber, *Capsicum*, yardlong bean, bottle gourd, etc.

Interesting materials were also found in backyards of some villages. For instance, five to six kinds of peppers and four or five varieties of eggplants may be found within an area covered by four houses on the average; most of the available varieties were never seen in the market.

Usually, mature fruits of vegetable species belonging to Cucurbitaceae and Solanaceae as well as mature pods of legumes were collected in the market. Seeds were extracted in hotels at night or in the base laboratories. Occasionally, seed vendors can also be found in markets selling the seeds produced from their own farms.

Seed shops in both East and West Malaysia usually stock imported seeds from Taiwan, China (sometimes via Hong Kong), Thailand, Australia, etc. However, they also have seeds of local varieties as well. Some of the imported seeds were actually selected local varieties being contract-produced overseas by local seed dealers. They were, therefore, treated as local varieties. As a result, many of the variations in seed shops were collected during the mission.

Farm sites included farmer stores, field plantings and home gardens. They provided the richest sources of germplasm. Usually, a visit to a farmer's field gave a good idea of the kinds of vegetables that were available because different vegetable farmers in Malaysia specialize in growing different species. Mature seeds were sampled directly from the fields from a random sample of 10-20 fruits coming from different plants. Otherwise, they were obtained from the farmers' stores. Some collections were heirloom varieties that were still being kept in tin containers in the kitchen (or even under the bed on one occasion). Usually, the farmers were very eager to share their seeds and talk about them.

If the amount of seeds was adequate, each accession was divided into two equal portions; one sample was deposited with the national program and the other was shipped to AVRDC.

Output

A total of 448 accessions were collected, of which 102 came from West Malaysia, 243 from Sarawak and 113 from Sabah (Table 5). Thirty genera were collected (Table 6).The most interesting materials were the distinctive local landraces of *Capsicum*, *Cucumis* and *Solanum* from Sarawak and Sabah. In these sites, most of the important vegetable growing areas were collected.

Table 5. The number of accessions collected from several sites.

Site	Number of accessions
West Malaysia	
Johor	43
Malaka	35
Penang	22
East Malaysia	
Sarawak	235
Sabah	113
Total	448

Table 6. Number of accessions collected for each genus.

Genus	No. of accessions	Genus	No. of accessions
Allium	3	*Lagenaria*	8
Amaranthus	21	*Luffa*	27
Apium	2	*Lycopersicon*	13
Basella	4	*Momordica*	18
Benincasa	9	*Ocimum*	1
Brassica	40	*Pachyrrhizus*	1
Capsicum	70	*Pisum*	4
Cucurbita	26	*Phaseolus*	20
Cucumis	34	*Psophocarpus*	9
Dolichos	3	*Raphanus*	4
Glycine	2	*Rumex*	1
Hibiscus	22	*Solanum*	30
Ipomoea	4	*Trichosanthes*	1
Lactuca	9	*Vigna*	51[a]
		Others	11
Total			448

[a] 1 *V. radiata*, 45 *V. unguiculata* and 5 others.

Germplasm Recipients 1990

Argentina

EEA La Consulta, INTA
Instituto Nacional De Technologia Agropecuaria
Universidad de Buenos Aires

Australia

Bairnsdale District Centre
CSIRO
Department of Primary Industries
Frank Wise Institute of Tropical Agricultural Research
Garden Centre & Florist
Quarantine and Export Centre
Redlands Research Station
Western Australian Department of Agriculture

Bangladesh

Bangladesh Agricultural Research Institute
Bangladesh Agricultural University
Bangladesh Institute of Nuclear Agriculture
Mennonite Central Committee (MCC)

Botswana

Department of Agricultural Research

Brazil

EMBRAPA — CNPH
EMBRAPA/UEPAE de Belem
Empresa Brasileira De Pesquisa Agropecuaria (EMBRAPA)
Instituto Biodinamico De Desenvolvimento Rural

Cameroon

Fokpayono
University Center of Dschang

Canada

Agriculture Canada Research Station

Canary Islands

Semiplant, S. A. T.

China

Academy of Agricultural Sciences
Chinese Academy of Agricultural Science
Gansu Grassland Agric. Systems Research and Development Project
Guangdong Academy of Agricultural Sciences
Harbin Vegetable Research Institute
Hubei Academy of Agricultural Science
Ssuchuan Academy of Agricultural Science

Congo

Agricongo

Costa Rica

CINDE
Ministerio de Agricultura y Ganaderia

Czechoslovakia

Research Institute for Vegetable Growing and Breeding

Dominican Republic

Secretaria de Estado de Agricultura
Universidad Autonoma de Santo Domingo

East Germany

Zentralinstitut fur Genetik und Kulturpflanzenforschung

Ecuador

Minister of Agriculture and Livestock

Egypt

Faculty of Agriculture
Field Crops Research Institute
MUSTAFA
Vegetable Research Department

El Salvador

Centro Nacional de Tecnologia Agricola
Ministerio de Agricultura

England

Fourteen Renewable Resources Limited
Institute of Horticultural Research
University of Bristol
University of Reading
University of Wales

Ethiopia

I.A.R. Awasa Center
Institute of Agricultural Research

Fiji Islands

Ministry of Primary Industries
Sigatoka Research Station
South Pacific Commission

France

Andre Blondeau
INRA
INRA-CNRS

Ghana

Rural Farmers Resources and Technology Dissemination Centre
Rural Seeds Company

Guatemala

Cristiani Burkard, SA
Ministerio de Agricultura

Haiti

Ministere de L'Agriculture
Operation Double Harvest

Holland

De Ruiter Zonen c.v.

Honduras

Instituto Nacional Agrario Colonia Alameda

India

Central Agricultural Research Institute
Govind Ballabh Pant University of Agriculture & Technology
ICAR Research Complex GOA
Indian Agricultural Research Institute
Indian Council of Agricultural Research
Indian Institute of Horticultural Research
Khedut Sahakari Jin Ltd.
Navalakha Seed Pvt. Ltd.
NBPGR
Nu Tech. Farm
Punjab Agricultural University
Regional Agricultural Research Station, Andhra Pradesh
Regional Research Station, Punjab Sakthi Soyas Limited
Sri Venkateswara Hybrid Seeds Co.
Tamil Nadu Agricultural University
The University of Agricultural Sciences
University of Agricultural Sciences & Technology
University of Horticulture and Forestry

Indonesia

Agriculture Training Center of GKE
Balai Penelitian Tanaman Pangan Sukarami
Balittan Maros
Balittan Sukarami
Bogor Agricultural University
Central Research Institute for Horticulture
Cipanas Experimental Garden
Directorate of Horticulture Production Development
ESCAP CGPRT Centre
Lembang Horticultural Research Institute
Malang Horticultural Research Institute
Malang Research Institute for Food Crops
P. T. Ledokombo
University Lampung

Iran

Shiraz University

Israel

Hebrew University of Jerusalem

Italy

Food and Agriculture Organization
MFM Azienda Agricola
Seed Exchange and Information Centre/FAO

Ivory Coast

IDESSA

Japan

Asahi Industries Co., Ltd.
Asian Seed Co., Ltd.
Economic Affairs Section
Japan Tobacco Inc.
Kagawa University
Kagome Research Institute
Keisen Women's Junior College
Kirin Brewery Co., Ltd.
Minami-miyazaki Farmers Association
National Museum of Ethnology
Sakata Seed Company
Snow Brand Seed Co., Ltd.
The Musashino Seed Co., Ltd.
Tokyo Agricultural University

Kenya

Kenya Seed Company

Korea

Crop Experiment Station, RDA
Horticultural Experiment Station, RDA
Rural Development Administration

Kuwait

The Public Authority for Agriculture Affairs and Fish Resources

Laos

Lao Australian Livestock Feeds Project
Project of Integrated Rural Development

Lesotho

Agricultural Research Division
Ministry of Agriculture

Liberia

Central Agricultural Research Institute
Cuttington University College

Madagascar

Ministere de la Production Agricole

Malawi

Bvumbwe Agriculture Research Station
Chitedze Research Station

Malaysia

Agricultural Research Centre, Semongok
CIBA-GEIGY Agricultural Experiment Station
Department of Agriculture
Department of Agriculture Cameron Highlands
IBU Pejabat MARDI
Malaysian Agricultural Research and Development Institute (MARDI)
MARIF
TLJ Integrated Sdn. Bhd.
University of Malaya

Mexico

1SARH, CIAPAN

Morocco

University Moulay Ismail

Nepal

Department of Agriculture
Lumle Agricultural Center
P.O. Box 1, Pokhara

Nigeria

Ahmadu Bello University
Emotan College
International Institute of Tropical Agriculture
Ministry of Agriculture & Water Resources
National Horticultural Research Institute
NIHORT
University of Ibadan

Pakistan

Nuclear Institute for Agriculture and Biology
Pakistan Seed Corporation Limited

Panama

Ministerio de Desarrollo Agropecuario
Nestlè Panama, S. A.

Papua New Guinea

D.P.I. Food Crops Section
Dept. of Agriculture and Livestock Food Management Branch
Fresh Produce Development Company Pty. Ltd.
Pacific Adventist College

Paraguay

Paraguay Institute de Investigacion y Extension Agricola

Peru

International Potato Center (CIP)

Philippines

ART-RTC XT
ATI-RTC XI, Bangoy St.
ATI-RTC-VI, AAC
ATI-RTC-X
AVRDC/POP
Benguet State University
Bureau of Plant Industry
Central Post Entry Station
Daet Seed Farm
Department of Agriculture, Region IV
Don Severino Agricultural College
Don Severino Research Center
East-West Seed Company, Inc.
Hortanova Vegetable Farm
Isabela State University
National Plant Genetic Resources Laboratory
Panay State Polytechnic College
PCARRD
University of the Philippines at Los Baños

Poland

Polish Academy of Sciences

Qatar

Ministry of Municipal Affairs and Agriculture

Reunion

Cooperation Internationale en Recherche Agronomiqe pour Development
IRAT-CIRAD-Reunion

Saudi Arabia

Ministry of Agriculture and Water

Senegal

CDH
Institut Senegalais de Recherches Agricoles

Seychelles

Ministry of Agriculture and Fisheries

Sierra Leone

Egypt Embassy
Rice Research Station

Singapore

Sluis & Groot B. V. Singapore Representative Office
World Farm Co. (Pte.) Ltd.

Solomon Islands

Committee of International Technical Cooperation
Dodo Creek Research Station

Somalia

Bonka Dryland Agricultural Research Station
Mashinkila FAOR A.I.

Sri Lanka

Central Agricultural Research Institute
DAI
Department of Agricultre
Eastern University
University of Ruhuna

St. Christopher and Nevis

Chinese Agricultural Technical Mission

St. Lucia

Inter-American Institute for Cooperation on Agriculture
The Agricultural Technical Mission of the ROC

St. Vincent and the Grenadines

Ministry of Agriculture, Industry and Labour

Tahiti

Societe Hortiplos

Taiwan, ROC

Academia Sinica
ASPAC-FFTC
Evergrow Seed Co., Ltd.
Fu Jen Catholic University
Fu Lan Seed Company
Kaohsiung DAIS
National Chung Hsing University
National Taiwan University
Penghu DAIS
Tainan DAIS
Taiwan Agricultural Research Institute (TARI)
Taiwan Agricultural Research Institute Chiayi Substation
Taiwan Seed Improvement and Propagation Station
Taoyuan DAIS

Tanzania

Horticultural Research and Training Institute
Sokoine University of Agriculture
URT/86/015
Uyole Agricultural Centre

Thailand

Ayutthaya Provincial Agricultural Extension Office
Church World Services
Department of Agricultural Extension
Department of Agriculture
DOAE
East-West Seed Company Ltd.
Eastern Regional Agricultural Extension Office
Farm Lert Phan
Kasetsart University
Khon Kaen Provincial Agricultural Extension Office
Maejo Field Crop Research Center
Ministry of Agriculture and Cooperatives
Nan Horticultural Research Station
Phang Nga Provincial Agricultural Extension Office

Phitsanulik Seed Center
Phrae Seed Center
Phuket Provincial Agricultural Extension Office, DOAE
Pichit Horticulture Research Center
Pisanulok Seed Center
Planning and Special Projects Division, DOAE
Prince of Songkla University
Surat Thani Provincial Agricultural Extension Office
TOP/AVRDC
Western Regional Agricultural Extension Office

Tonga

Hango Agricultural College

U.S.A.

Asgrow Seed Company
Beltsville Agricultural Research Center, USDA
CIBA-GEIGY Seed Division
Louisiana State University
New Mexico State University
New York State College of Agriculture and Life Sciences
NPI
Oklahoma State University
Peto Seed Company
Plma County Branch Office
Texas A & M University
The University of Florida
The University of Vermont
The World Bank
University of Arkansas
University of Florida
University of Maryland Eastern Shore
University of Minnesota
USDA
USDA Plant Germplasm Quarantine Center
Virginia State University
Washington State University

Uganda

American Embassy

Vietnam

Hungloc Agricultural Research Center
National Institute of Agricultural Sciences
University of Cantho

Western Samoa

Ministry of Agriculture
The University of the South Pacific

Zambia

FAOR
Kabwe Regional Research Station
Ministry of Agriculture and Water Development
Zambia-Canada Wheat and Soybean Project

Production Systems Program

Analytical Laboratory

Carbohydrate Patterns of Vegetable Soybean

Summary

The carbohydrate pattern of vegetable soybean can be characterized as high sucrose,high starch and low oligosaccharides. The timing of harvest may not be very critical to the carbohydrate patterns. Presence of oligosaccharides could be a useful indicator of delayed harvest of vegetable soybean. The usefulness of this property in predicting proper harvest time will be further studied. Preliminary studies have shown that a scanning type of NIRS instead of the filter type might be able to determine sugars individually within a short time.

Introduction

Vegetable soybeans are green pods harvested between R_6 and R_7 growth stages (end of seed filling stage) and before the start of the seed drying process. As a common practice, vegetable soybeans are harvested when 80% of the pods reach their physiological maturity. The chemical composition of vegetable soybean seeds is different from those of the grain soybeans and the young seeds.

Carbohydrate, or nitrogen-free extracts, contributes 30% of the dry matter in vegetable soybean. The composition of carbohydrate changes with the different ripening stages. It is known that young pods are rich in fructose and glucose, and low in disaccharides. The accumulation of sucrose increases with cotyledon development. Prior to the pod yellowing stage, the accumulation of oligosaccharides increases sharply while fructose decreases. The 10% dry matter in vegetable soybean is starch, which generally is not detectable in grain soybean and which suggests that starch could be a temporary reserve substance during the seed development process.Carbohydrate pattern is an important characteristic of good quality vegetable soybean for good taste and texture. The carbohydrate patterns of three popular cultivars of vegetable soybean were examined and the feasibility of the Near Infrared Reflectance Spectroscopy (NIRS) as a rapid analytical technique is discussed.

Materials and Methods

Sample preparation. Samples of vegetable soybean were harvested from trials at AVRDC in fall 1989 and spring 1990. The sample preparation procedure basically followed the actual practices used by processing companies. The graded pods were blanched not later than 6 hours after harvest to prevent postharvest degradation in quality. After precooling with tap water, the blanched pods were frozen at -40°C and kept below -18°C before further use. The sample preparation procedure is presented in Figure 1. Dehydrated and ground powder samples were used for both chemical analysis and NIRS prediction.

Chemical analysis. Starch content was determined by anthrone colorimetric method after hydrolysis with perchloric acid. The total soluble sugars were extracted with 80% alcohol solution and determined by anthrone reaction.

Analysis of individual sugars was carried out with high performance liquid chromatography with carbohydrate column (Waters sugar-pak I) as the stationary phase; solution of deionized water was used

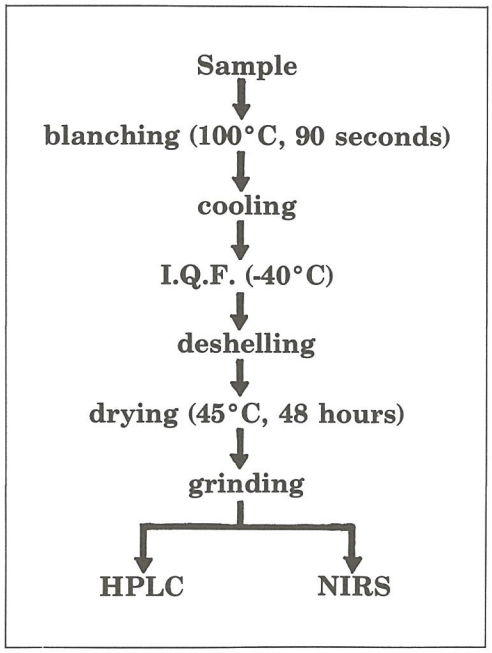


Fig. 1. Flow chart of sample preparation of vegetable soybean for analysis.

as the mobile phase at a flow rate of 0.5 ml per minute. The quantitations of individual sugars were monitored by an RI detector calibrated with standards of known concentrations.

NIRS systems. Two NIRS systems, a Technicon InfraAlyzer 400 and an NIRS System 6500 were used in this study. InfraAlyzer 400 is a filter type of instrument installed with 19 fixed wavelengths, whereas the NIRS System 6500 is a scanning type of equipment with wavelengths ranging from 400 to 2500 nm. The advanced spectral transformation is only applicable to NIRS System 6500. Second derivatives were used for calibration in this study.

Results and Discussion

Carbohydrates in vegetable soybean. Total sugar, starch and crude fiber contents of three vegetable soybean cultivars harvested when 60%, 80% and 100% of the pods have physiologically matured were ananlyzed. The results are listed in Table 1. The carbohydrate patterns of grain soybean of respective varieties were also included. Although there was a clear distinction between the carbohydrate patterns of vegetable soybean and grain soybean seeds, there was no major difference among vegetable soybean samples harvested at different maturity stages. A positive relationship between sugar content in vegetable soybean and grain soybean seeds was noticed. The possibility of determining sugar content of grain soybean seeds for screening high sugar variety of vegetable soybean will be further clarified.

Seasonal effect on carbohydrate patterns of vegetable soybean was also studied. Results are summarized in Table 2. Statistical analysis showed that there was a significant difference in sugar content due to varietal and seasonal effects. Interactions between season and variety were also significant.It seemed that the sugar content in vegetable soybean harvested in the summer tended to be higher than those harvested in other seasons. The significance of the slightly higher sugar content in summer crop needs to be further evaluated by panel tests.

Table 1. Carbohydrate composition of vegetable soybean harvested at three maturity stages.

Variety	Maturity			
	60%	80%	100%	Grain soybean
		Sugar contents (%)		
Kaohsiung #1	11.59	9.73	10.41	6.15
Tzurunoko	10.37	11.02	8.40	6.00
Ryokkoh	9.70	10.58	8.58	5.98
		Starch contents (%)		
Kaohsiung #1	9.24	11.64	10.78	6.44
Tzurunoko	9.28	9.29	9.68	7.28
Ryokkoh	10.16	9.34	9.78	6.13
		Fiber contents (%)		
Kaohsiung #1	5.01	4.14	4.23	5.43
Tzurunoko	4.09	4.49	4.26	5.20
Ryokkoh	4.22	4.14	4.33	5.20

Table 2. Effect of seasons of vegetable soybean on carbohydrate patterns.

Planting Season	Variety	Sugar	Starch	Fiber
Fall	Kaohsiung #1	11.13	9.13	4.45
	Tzurunoko	10.44	7.26	4.31
	Ryokkoh	9.99	7.75	4.13
Spring	Kaohsiung #1	11.50	9.86	4.54
	Tzurunoko	10.21	8.21	4.28
	Ryokkoh	10.41	9.48	4.32
Summer	Kaohsiung #1	11.86	7.79	5.05
	Tzurunoko	11.47	7.11	4.65
	Ryokkoh	12.25	8.33	4.76
LSD		0.13		

Contents of individual sugars in vegetable soybean. High quality vegetable soybean tasted slightly sweet. Sweetness is mainly controlled by sugar content. Concentrations of individual sugars in vegetable seeds were determined by HPLC. A typical program which successfully separates sugars was adopted. Sucrose was the major sugar in vegetable soybean. Monosaccharides, such as glucose and fructose, were also found. Galactose, which constitutes a part of oligosaccharides in soybean, was not detected in vegetable soybean seeds. A small amount of oligosaccharides, raffinose and stachyose, can be detected in some vegetable soybean samples.

The concentrations of individual sugars in vegetable soybeans harvested at different maturity stages are summarized in Table 3. No definite trend can be drawn based on the limited data available. The sucrose concentration in Tzurunoko, harvested at 80% maturity stage, was higher than that in other samples. Tzurunoko is a variety known for good flavor. More studies are needed to confirm the property of higher sucrose concentration in Tzurunoko at proper harvest time. The general conclusion that can be drawn from the data is that sugar content may not be a critical concern if vegetable soybeans are harvested a bit earlier or later.

Samples of delayed harvest (100%) were low in oligosaccharides (stachyose). This could be a possible indicator to determine proper harvest time of vegetable soybean. A rapid analytical method needs to be developed and more data are required to further confirm the usefulness of this indicator.

Table 3. Composition of sugars in vegetable soybean harvested at three maturity stages.

Variety	Sugar	Maturity			
		60%	80%	100%	Grain soybean
Kaohsiung #1	Glucose	12.54[a]	11.23	16.33	10.81
	Fructose	7.35	7.07	12.12	0.57
	Sucrose	90.46	85.39	97.56	66.48
	Raffinose	0.92	0.05	2.62	14.07
	Stachyose	3.47	0.76	0.15	26.03
Tzurunoko	Glucose	12.52	12.72	6.59	10.79
	Fructose	7.94	8.78	3.42	1.12
	Sucrose	85.01	124.03	42.83	58.26
	Raffinose	0.54	0.43	6.38	15.11
	Stachyose	1,17	2.08	ND	27.73
Ryokkoh	Glucose	12.78	16.24	10.71	11.94
	Fructose	8.35	11.01	8.33	0.50
	Sucrose	80.86	88.01	69.38	61.41
	Raffinose	ND[b]	ND	0.01	15.37
	Stachyose	0.07	ND	0.18	23.38

[a] Unit : mg/g on dry weight basis.
[b] ND : not detectable.

Analysis of individual sugars by NIRS. Since concentrations of individual sugars in vegetable soybean were able to provide more useful information than total sugars, an attempt was made to adopt near infrared analyzer as a rapid analytical tool. Two types of instruments, one filter type and the other, scanning type, were used for comparison. Calibration statistics obtained are presented in Table 4. The filter type instrument used was a Technicon InfraAlyzer 400, which consisted of 19 filters of fixed wavelength. Regression coefficients (R^2) obtained were generally poor. The unsatisfactory results from their filter type instrument could be due to the limitation of wavelengths available. The performance of the scanning type instrument, NIR System 6500, was much better. Except for stachyose prediction, the regression coefficients for other sugars were all above 0.9 with a lower standard error of calibrations (SEC). This result suggested that one may be able to use a scanning type near infrared analyzer to determine sugars in vegetable soybean seeds individually in a relatively short time. The performance of these calibration equations in predicting unknown samples will be further tested next year.

Table 4. Calibration statistics of the filter and scanning types of NIRS.

Sugar	Filter type			Scanning type	
	Content Range (mg/g)	R^2	SEC	R^2	SEC
Glucose	7.35- 13.71	0.90 (48)[a]	0.9316	0.99	0.14
Fructose	2.96- 14.95	0.83 (49)	1.1092	0.97	0.35
Sucrose	42.47-102.74	0.85 (49)	6.5125	0.99	1.30
Raffinose	0.01- 4.74	0.67 (51)	1.4167	0.94	0.32
Stachyose	0.01- 4.06	0.61 (51)	0.7286	0.77	0.57

[a]Values in parentheses indicate the number of samples used.

Composition Analyses of Soybean Leaf by Near Infrared Reflectance Spectroscopy (NIRS)

Summary

Near infrared analyzer system can be used to determine total nitrogen, total carbohydrate, starch and potassium in soybean leaves. The performance of predicting phosphorus is not satisfactory under experimental conditions.

Introduction

Chemical analyses of plants often provide useful information on nutritional status, physiological conditions and composition distribution of crops. Leaf analysis is routinely used for selected crops to estimate the fertilizer applications. The applications of plant analyses are limited by the requirement of a chemical analysis laboratory and the high analytical cost involved. Traditional analytical procedures are often slow in providing answers. Automation of analytical process is thus essential for a successful plant analysis project. Most of the laboratories have adopted autoanalyzer systems for this type of work.

An attempt was made to study the possibility of adopting Near Infrared Reflectance Spectroscopy (NIRS) as a rapid method to estimate the chemical compositions of plant samples. A calibrated instrument can be operated independently from a wet chemistry laboratory by a technician with minimum training in analytical skills. Soybean leaf samples of different varieties, harvested at different locations and seasons were used in this experiment to cover a wide range of sample materials. Two sets of NIRS instruments, the Technicon InfraAlyzer 400 and the NIRS 6500, respectively, represent filter type and scanning type of NIRS.

Materials and Methods

Sample preparations. Soybean leaf samples, including the petioles, were dried at 45°C in a hot air oven for 48 hours. The dehydrated samples were ground with a cyclone mill passing through a 0.5 mm screen. Powdered samples were used for both chemical analysis and NIRS predictions.

Chemical analysis. Analytical procedures used for total nitrogen, carbohydrates, phosphorus and potassium basically followed the AOAC methods. Wet digestion was applied for N, P and K determination. Total nitrogen determination did not include nitrate nitrogen. The anthrone colorimetric method was applied for carbohydrate determinations.

Near Infrared Analyzer System. Light absorptions at the near infrared region were detected by two types of instruments - a Technicon InfraAlyzer 400 and NIRS 6500. The software package of IACAL and ISI-NIRS 2 were used for data management of the respective instruments. Transformation of the second derivative of absorption spectrum was applied to establish calibration equations of NIRS 6500.

Results and Discussion

Chemical compositions,including total nitrogen, carbohydrates, phosphorus and potassium in soybean leaves were analyzed by manual methods to calibrate near infrared analyzers (NIRS). The performance of the calibration equations obtained were further tested by a separate set of leaf samples. Compositions of interest may be divided into two groups: organic and inorganic. The mechanism of predicting these two types of compositions by near infrared analyzers could be different. The calibration statistics on organic compositions observed are summarized in Table 5. Satisfactory predictions for total nitrogen, total carbohydrate, and starch were obtained by using either filter type or scanning type of near infrared analyzer. The performance of the scanning type instrument was found better than the filter type. The calibration statistics for sugar contents though, were not as good as one might expect from both filter type and scanning type of instruments; this is also the case for other leafy vegetables.It was suspected that the sample preparation procedures adopted may not be suitable for sugar determination of leaf samples. Further studies may be needed to improve the procedure of sugar calibrations for leaf samples.

The molecular behaviors expressed in the absorption spectrums at the near infrared region were mainly caused by the hydrogen stretching overtones and hydrogen bondings. Thus, NIRS is an ideal analytical tool for organic compositions but not for the inorganic ones. Theoretically, there is no light absorption at the near infrared region by inorganic salts. However, successful experiments that predicted salt concentrations by NIRS for certain commodities have been reported. It was surmised that the presence of salts may change the light absorption patterns of other compositions, especially in hydrogen bonding, due to the secondary effects.

The calibration statistics for the analysis of phosphorus and potassium in soybean leaves, by a filter type infrared analyzer, are presented in Table 6. A relatively good result for potassium analysis was obtained. The values of the standard error of calibration (SEC) and standard error for prediction (SEP) were comparable, which suggested that the five filters selected did not provide over-fitting calibration equations and that the predictions obtained were true estimations. The calibration statistics for phosphorus were rather poor, possibly due to the lower concentrations of phosphorus in the leaf samples (0.12-0.23%). The small amount of phosphorus was not able to generate a sufficient frequency of energy shift at the near infrared region. Analysis of inorganic compositions by scanning type of near infrared analyzer was made and no improvement was observed. Poor phosphorus prediction was due to the limited wavelength of the filter type instrument.

Table 5. Calibrating statistics of soybean leaves by filter type and scanning type NIRS.

Constituent	Content range (%)	Filter type		Scanning type	
		R^2	SEP	R^2	SEP
Total nitrogen	2.63- 6.23	0.97 (33)[a]	0.20(31)	0.99	0.10
Carbohydrate	4.44-26.19	0.97 (33)	1.24(32)	0.99	0.78
Starch	1.78-21.80	0.98 (33)	1.11(32)	0.99	0.75
Sugar	1.96-11.34	0.82 (33)	1.90(32)	0.89	0.91

[a]Values in parentheses indicate the number of samples used.

Table 6. Prediction statistics for potassium and phosphorus content of vegetable soybean leaves by filter type NIRS.

Constituent	Calibration curve				Performance Test			
	No. of filter	Content range (%)	SEC	R^2	Intercept	Slope	SEP	R
Potassium	5	1.21-2.68	0.13	0.94 (37)[a]	-0.09	1.06	0.15	0.91 (31)
Phosphorus	5	0.12-0.23	0.01	0.79 (50)[a]	0.01	0.96	0.01	0.76 (31)

[a]Values in parentheses indicate the number of samples used.

Chemical Compositions of Fermented Pepper Fruits for Chili Sauce Preparation

Summary

The chemical compositions of fermented chili pepper fruits suggested that the process was basically a lactic acid fermentation. Lactate consisted of more than 2% of total weight at the completion of fermentation. The sugar content decreased with time and reached a very low level after aging.The hot principles and capsaicin remained rather constant throughout the fermentation period. Gas chromatogram analyses of volatiles suggested that there will be smaller molecule compounds formed during the fermentation period.Decoloration during the fermentation period was observed.Liquid chromatogram of carotenoids showed that pigments of hydrocarbon and monols were more stable in fermentation condition than diols and keto carotenoids.

Introduction

Capsicum fruits and processed products are popular food additives for diets in many parts of the world. These processed products are valued for their color, pungency and aroma. Depending on the major emphasis of the products, the quality requirement on pepper fruits used can be different. Paprika and oleoresin are two of the most popular products processed from pepper fruits in western diets. Color and pungency are principal characteristics required for these two products. In Asia, the popular products are chili powder, chili sauce and chili oil. However, the quality requirements for the same product can be different in different regions.

Chili sauce is used as a table spice in the Orient. Fermented chili paste, soy sauce and vinegar are principal ingredients in preparing pepper sauce.Color, pungency, aroma and texture are major concerns of quality products. A six-month fermentation of pepper fruits is generally required to develop the desired properties. High quality products can be made only from raw materials with specific properties and that are handled with care after harvest.

Chili sauce is usually prepared by small-scale industries using traditional methods. Changes in chemical composition during the fermentation process has not been studied yet. Information on composition changes can be useful in understanding the nature of fermentation and development of quality evaluation procedures for variety screening of breeding programs.

Materials and Methods

Pepper samples. Samples were collected at different stages of fermentation from a local hot sauce processor. The stepwise flow chart of the processes involved is illustrated in Figure 2. Since the samples were collected from different tanks of various fermentation stages, they were not from the same batch of raw materials.

Chemical analysis. The contents of lipid, sugars and starch were determined according to the AOAC methods. Analysis of individual sugars and organic acids was carried out by HPLC with an Ion-300 organic acids column. The formaldehyde titration method was used to determine total free

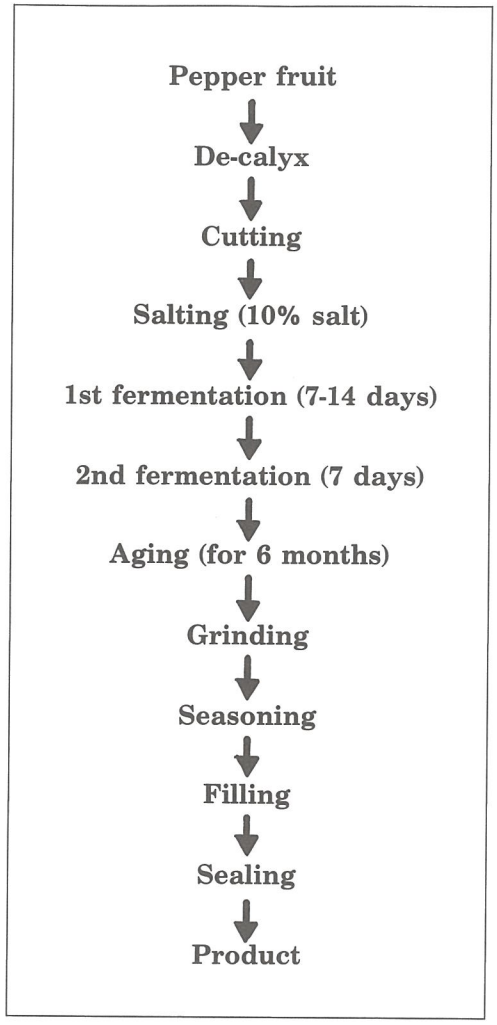


Fig 2. Flow chart of pepper sauce processing.

amino nitrogen. Concentration of pigments extracted with acetone solution were used to express the color. The optical density at 460 nm was used as color value of the samples. Capsaicin content was determined with HPLC and content of dihydrocapsaicin was also included.

Results and Discussion

As described in the procedures, the fermentation of pepper fruits is similar to that of soybean for soy sauce. There were two fermentation stages involved using different salt concentrations and a relatively long period of aging. The salt applied at the initial stage was intended to control the undesirable microorganisms. Carbon dioxide gas was released during this stage with periodical stirring required. The second stage of fermentation was carried out under higher concentrations of salt. The actual salt concentration used varied among processors. In general, the salt concentration for pepper fermentation was lower than 15%. Thus microorganisms might still have been active during the aging stage. Fermentation is a process carried out among microorganisms, enzymes and nonenzymatic reactions.

Samples were collected at 12, 19, 74, 90, 150, 180 and 390 days after salting. Fresh pepper fruits of a popular local variety, Szechuan, were also included for composition analyses. The chemical compositions of pepper samples collected are listed in Table 7.

Monosaccharides,glucose and fructose are major carbohydrates in fresh pepper fruits. The concentration of monosaccharides decreased rapidly during the first stage of fermentation and further decreased at the second fermentation stage. The sucrose concentration remained at a low level during the first and second fermentation stages. Ninety days after salting, the amounts of sucrose and glucose were no longer detectable. A small amount of fructose, about 1%, can still be detected even after 390 days. Citric acid was the dominant endogenous organic acid in pepper fruits. It decreased with the fermentation process and became undetectable in samples collected after 90 days. There was no lactic acid in fresh samples but it developed rapidly under fermentation.This organic acid accounted for over 2% of the weight in fermented pepper broth after 150 days of fermentation. This acid was the major contribution to the lower pH value of fermented samples. There was only a very small amount of free amino nitrogen detected in peppers throughout the fermentation process. It may not be an important composition in the quality of hot sauce. Changes in color values of samples were observed. The color values of fermented samples were about half that of the fresh samples. Reduction of color value was evident mainly at the second stage of fermentation. This could be due to the lower pH at the later part of the fermentation process.The capsaicins were found quite stable and remained consistent throughout the fermentation period.

The changes in chemical compositions during fermentation of pepper fruits suggested that it was a typical process of anaerobic fermentation of lactic acid. The completion of fermentation was characterized by the accumulation of lactic acid at the cost of sugars. During the long aging period, desired aroma, and esters, were formed from acids and alcohols. The decoloration that occurred was

Table 7. Chemical composition of fermented pepper fruits.

	Days after fermentation							
	0	12	19	74	90	150	180	390
Color value[a]	2337.2	2203.2	2024.7	1593.3	916.5	1019.3	969.7	843.2
pH	4.44	4.54	4.49	4.37	3.86	3.65	3.91	3.91
Free amino N (%)	0.04	0.05	0.07	0.07	0.10	0.08	0.09	0.12
Crude fat (%)	1.79	2.66	2.31	2.13	2.56	1.97	1.86	1.87
Carbohydrates--								
starch (%)	ND[b]	0.33	ND	0.29	ND	ND	ND	ND
glucose (%)	2.25	0.53	0.89	0.42	ND	ND	ND	ND
fructose (%)	2.01	0.81	1.07	0.06	0.14	0.04	0.23	0.10
sucrose (%)	0.06	0.06	0.15	0.06	ND	ND	ND	ND
Organic acids--								
citric (%)	0.72	0.41	0.21	0.14	ND	ND	ND	ND
lactic (%)	ND	0.62	0.13	0.32	1.74	2.20	2.27	2.95
Ethanol (%)	ND	0.46	1.35	ND	1.43	0.67	0.56	0.32
Capsaicin (mg/g)	0.27	0.36	0.26	0.30	0.17	0.23	0.29	0.26

[a]Color value is expressed by optical density of acetone extracts at 460 nm. [b]ND: not detectable.

understandable since carotenoids are not stable under low pH conditions. The concern of this process was how to create a condition wherein fermentation takes place, allowing color to be maintained and good aroma to develop.

The volatiles of hot pepper and its processed products have been studied by many researchers. Hundreds of compounds have been identified. The volatiles of fruits and fermented products were monitored by gas-liquid chromatography. The chromatograms of fresh pepper fruits and fermented products were compared. There were 174 peaks observed in the chromatogram of fresh pepper samples and only 134 in fermented products. The total peak area estimated after fermentation was only 40% of that of fresh fruits. It was also noted that many higher molecule compounds disappeared after fermentation and new smaller molecules formed. Further studies will be needed to identify these compounds and locate the major compositions which could contribute to the aroma of high quality hot sauce.

As decoloration is a major concern in the fermentation of chili sauce, the stability of pigments was studied. Individual carotenoids were separated by HPLC in the reversed phase with a column of Merck C18 glass cartridge and gradient elution with acetone/water. Thirteen major peaks were detected at 436 nm from samples of early fermentation stages (less than 19 days). Concentrations of all peaks decreased with fermentation time.

More minor peaks were observed from chromatograms of samples with prolonged fermentation. This could be epoxides or cis isomers formed during fermentation. Preliminary studies on peak identification showed that hydrocarbons or monols were more stable than diols and red keto carotenoids. The recovery of β-carotene and β-cryptoxanthin after fermentation for 180 days were 74% and 56%, respectively. But the recovery of capsanthin and capsorubin were only 43% and 37%, respectively. One peak contributed about 6% of total light absorption at 430 nm in fresh pepper fruit but disappeared after fermentation. The nature of this compound is under further investigation. How to modify fermentation to stabilize the color and improve the flavor development could be the major concern in improving the fermentation process.

Effects of Methionine Treatment on Mungbean Sprouts

Summary

Mungbean seed treatment with methionine solution tended to produce more ethylene gas during the sprouting period. However, the amount of ethylene produced was not enough to replace the physical pressure or ethylene inducing chemicals. This result explained the fact that quality of mungbean sprouts treated with methionine is lower than those treated with physical pressure. A combination of methionine and physical pressure treatment could be a better way of producing quality sprouts.

Introduction

Good quality mungbean sprout is white, crispy in texture, short-rooted or rootless, with plump hypocotyl about 9 cm long. Long and straight hypocotyls are preferred for 'sprout noodles' which are sprouts without cotyledons. It has been demonstrated in the literature that ethylene gas, endogenously induced or externally applied, was able to shorten the root length, increase the hypocotyl diameter, and improve the sprout quality. Application of physical pressure or ethylene-inducing chemicals was practiced by some processors for commercial production of mungbean sprouts.

The effect of methionine treatment of mungbean seeds on sprout properties was studied at AVRDC. As a precursor of ethylene, methionine is expected to enhance ethylene production during sprouting, thus improving the quality. Previous results, however, indicated that methionine treatment is more effective in increasing the length of hypocotyls than increasing the diameter. This suggested that the effects of methionine treatments were different from ethylene treatments. The accumulated ethylene gas during the sprouting period of eight mungbean varieties was measured with a gas chromatograph to study the effect of methionine on ethylene production.

Materials and Methods

Mungbean Seeds. Mungbean samples were obtained from AVRDC mungbean breeders. All samples were mixtures of seeds harvested from several planting seasons of the last two years. Due to the difference in the storage period, a higher variation of sprout quality among seeds of the same sample was observed. Instead of plain water, seeds that required methionine treatment were soaked in 1000 ppm methionine solution for 6 hours prior to sprouting.

Sprouting condition. Sprouting was carried out in a home-made sprouting machine with an automatic waterspray device. Eight samples of 40 g seeds each were used simultaneously in separate sprouting chambers. The quality of sprouts was evaluated at the fourth day with 30 representative sprouts. Physical pressure of 5.2 g/cm^2 was applied when needed.

Ethylene Analysis. Sproutings were carried out under gas-tight chambers incubated under 30°C. Air samples were taken at the fourth day and injected into a gas chromatograph (Hitachi G-3000) for quantification of ethylene gas. A carbowax-20 M column and flame ionization detector were used.

Results and Discussion

Four treatments were applied to study the effects of methionine on sprout quality: methionine treatment, physical pressure, methionine treatment with physical pressure and control without treatment. The sprout quality and sprout yield of varieties tested are listed in Table 8. The effect of methionine treatment on sprout quality was easily noticeable by the appearance of the sprout. However, the data obtained were not as pronounced as expected due to the variations among seeds.

Application of physical pressure generally increased the diameters of mungbean sprouts and reduced the hypocotyl length, root length and the sprout yield of most of the varieties tested. This was a typical effect of ethylene. On the other hand, methionine treatment generally increased the hypocotyl length and the root length. Its effect on hypocotyl diameters was not as clear as physical pressure. Best sprouts were obtained when both methionine and physical pressure were applied. Methionine treatment was not able to regenerate the sprout yield reduced by physical pressure.

The amount of ethylene accumulated during the sprouting period with or without methionine treatment was monitored. The results are presented in Table 9. Methionine treatment increased the ethylene production of most varieties tested. As physical pressure treatment was not included in the experiment, no direct comparison can be made between methionine and physical pressure treatments. Comparing the data with information available in the literature showed that the amount of ethylene induced by methionine treatment was less than that induced by physical pressure or ethylene-inducing chemicals.

An experiment was carried out to study the ethylene induction when methionine was added to spraying water throughout the sprouting period. The accumulated ethylene under various treatments

is listed in Table 10. Only one variety (VC 1168B) was included in the experiment. Continuous treatment with methionine did not significantly improve ethylene production. This result suggested that concentration of precursor of ethylene may not be the limiting factor of ethylene production for sprouting.

Blackgrams are used for sprouting in certain countries and it is known that blackgram is high in methionine in the form of r-glutamyl-methionine. The ethylene production of blackgrams was monitored during the sprouting period. The amount of ethylene released by blackgram ranged from 0.09 to 0.19 μl/g. This was about the same level for mungbean with methionine treatment. This result further suggested that increasing endogenous methionine concentration can induce ethylene production only to a certain level. Other treatments, such as physical pressure, will still be needed to produce high-quality sprouts.

Table 8. Effect of methionine treatment on mungbean sprout quality and yield of various varieties.

Treatment	Variety								
	VC 1638A	VC1973A	VC1560D	VC2768A	VC1000D	VC168B	VC2750A	VC3890A	LSD
Hypocotyl Length (cm)									
WO/M	11.99	12.07	11.99	10.46	11.06	12.21	12.01	10.73	0.68
W/M	11.92	12.94	11.33	10.82	11.90	11.75	12.49	12.59	0.73
W/P	8.89	9.67	9.39	9.09	9.37	8.09	9.94	8.64	0.18
W/PM	9.37	9.12	10.38	9.61	9.82	8.95	10.78	9.32	0.66
LSD	0.58	0.69	0.80	0.28	0.53	0.49	0.78	0.57	
Hypocotyl diameter (mm)									
WO/M	2.94	3.07	2.83	3.16	2.76	2.75	2.84	2.97	0.18
W/M	3.04	3.21	3.11	3.31	2.75	2.98	2.67	2.95	0.16
W/P	3.28	3.37	2.92	3.38	2.89	3.15	2.60	3.21	0.37
W/PM	3.46	3.42	2.98	3.60	3.11	3.03	2.85	3.44	0.18
LSD	0.71	0.17	0.12	0.18	0.12	0.15	0.17	0.18	
Root Length (cm)									
WO/M	3.57	3.29	4.19	4.02	4.08	3.15	3.70	3.18	0.59
W/M	2.98	3.38	4.09	4.43	4.18	2.82	3.50	3.26	0.65
W/P	2.84	2.73	3.44	3.19	3.75	2.05	3.45	2.22	0.43
W/PM	2.35	2.05	3.45	3.26	3.52	2.60	3.54	2.48	0.46
LSD	0.40	0.51	0.80	0.53	0.63	0.39	0.64	0.46	
Yield (sprouts g/g seeds)									
WO/M	9.95	9.05	9.35	9.72	9.89	9.20	9.85	9.31	
W/M	9.49	9.20	8.66	10.24	10.10	9.35	10.19	10.14	
W/P	7.91	7.56	7.45	8.38	8.31	7.20	7.16	7.15	
W/PM	8.19	7.38	7.80	8.63	9.49	7.23	8.44	7.53	

WO/M: without methionine. W/M: with methionine. W/P: with physical pressure. W/PM: with methionine and physical pressure. Methionine CONC: 1000 ppm.

Table 9. Amount of ethylene accumulated during the sprouting period.

Treatment	Ethylene Production (μ/g seed)							
	Variety							
	VC1638	VC1973A	VC1560D	VC2768A	VC1000D	VC168B	VC2750A	VC3890A
WO/M	0.06	0.11	0.13	0.11	0.14	0.15	0.20	0.18
W/M	0.07	0.14	0.14	0.13	0.17	0.19	0.19	0.18

WO/M: without methionine. W/M: with methionine.

Table 10. Ethylene accumulation under continuous treatment of methionine.

Treatment	Ethylene production (μ/g)
WO/M	0.15
W/M	0.19
CW/M	0.20

WO/M: without methionine. W/M: with methionine. CW/M: continuous methionine treatment. Variety: VC 1168B.

Crop Management

Vegetable Soybean Plant Density Trial

Summary

Experiments were run in autumn (1989) and spring (1990) to compare the yield responses of three vegetable soybean varieties (AGS 292, G 9053, and G 10134) under four spacing treatments (10 cm × 50 cm, 15 cm × 50 cm, 20 cm × 50 cm and 25 cm × 50 cm), with two plants per hill. Closer spacing led to taller plants, greater light interception and more total pod yield than at wider spacing. Grading ratio of G 10134 increased at closer spacings in autumn and decreased in spring, whereas it increased with wider spacing for AGS 292. For G 9053, grading increased significantly as a result of close spacing only in spring. Maximum graded yield for all three varieties was evident at the two closer spacings. Quality differences between varieties were consistent across seasons, and unaffected by spacing treatments.

Introduction

Fresh soybean harvested at the green pod stage is utilized as a vegetable by the Japanese, Chinese and Koreans. The vegetable soybean pod produced in Taiwan is mainly sent to processing companies to make frozen vegetable soybean for export to Japan. Vegetable soybean quality criteria are crucial when serving the export market. Pods must be at least 4.5 cm long and have two or more seeds. Pod color is also important. Competition associated with differing plant populations alters plant morphology in various ways. Plants at higher densities are usually taller, and have fewer branches. Lack of light penetration into soybean canopies is thought to be a major factor affecting seed yield. Therefore this experiment evaluated the effect of altering plant population density on yield and pod quality of three vegetable varieties to improve the grading ratio and pod color.

Materials and Methods

The experiment was conducted in autumn 1989 and spring 1990. Three vegetable soybean varieties, AGS 292 (Kaohsiung Sel. No. 1), G 9053 (Tzurunoko) and G 10134 (Tainung 305) were planted in four within-row spacings: 10 cm × 50 cm, 15 cm × 50 cm, 20 cm × 50 cm, and 25 cm × 50 cm (2 plants/hill). A split-plot design was used with varieties as main plots and spacings as subplots, and replicated three times. Subplots comprised of four 5 m long and 1 m wide raised beds. Seeds were sown at 4-5 per hill, and thinned to two after emergence. The crops were planted on 5 October 1989 and 12 March 1990, and harvested 67-71 days after sowing (das), and 71-73 das, respectively. Light interception ratio was measured weekly after plants reached the R_1 stage. Six plants were removed from each plot at R_1 and R_4 stages for analysis of growth and a 6 m^2 bordered area was harvested for pod yield determination; random subsamples of 6 plants in spring and 10 plants in autumn from that area were used to determine yield components.

Data from growth analyses presented in Tables 1 and 2 show that in both spring and autumn seasons plants grew taller, became more sparsely branched and weaker, and produced fewer pods per plant as plant population increased. Stem, leaf and petiole dry weight per plant were also less at closer spacings, but their reduction was not so marked as that for pod dry weight. Although plants from

wider spacing produced more pods (Table 4), graded pod yield in both seasons was significantly greater at plant population densities of 27 and 40/m^2 than at the lower populations. Plants in the wider spaced treatments had a lower leaf area index, less light interception and resulted in lower plant dry matter production per unit land area (Tables 3 and 4).

Table 1. Growth characters of three soybean varieties and four spacing treatments at the R_4 stage, autumn 1989.[a]

Treatment	Plant height	Node no.	Branch no.	Dry weight (g/plant)				
				stem	petiole	leaf	pod	total
Main treatment								
AGS 292	31.0 a	8.3 b	0.9 b	1.8 b	0.9 c	3.4 b	9.2 a	15.3 b
G 9053	33.4 a	8.5 ab	2.2 a	2.4 a	1.6 a	4.0 a	9.9 a	17.9 a
G 10134	35.9 a	8.7 a	0.7 b	2.8 a	1.3 b	4.2 a	9.2 a	17.4 a
Sub-treatment								
10 × 50 cm	37.0 a	8.2 a	0.4 c	1.7 c	0.9 b	2.5 c	6.3 d	11.3 d
15 × 50 cm	33.9 b	8.4 a	1.1 b	2.3 b	1.2 a	3.6 b	8.2 c	15.4 c
20 × 50 cm	32.3 bc	8.8 a	1.5 ab	2.6 ab	1.4 a	4.4 a	10.6 b	19.0 b
25 × 50 cm	30.6 c	8.7 a	1.9 a	2.8 a	1.5 a	4.8 a	12.7 a	21.8 a

[a]Numbers of the same letter designations are not significantly different at 5% level by DMRT.

Table 2. Growth characters of three soybean varieties and four spacing treatments at the R_4 stage, spring 1989.[a]

Treatment	Plant height	Node no.	Branch no.	Dry weight (g/plant)				
				stem	petiole	leaf	pod	total
Main treatment								
AGS 292	35.9 b	6.8 a	1.3 a	2.8 b	3.3 b	0.8 b	10.3 a	17.2 a
G 9053	34.4 b	6.7 a	1.6 a	3.3 b	3.7 ab	1.4 a	9.1 a	17.4 a
G 10134	40.9 a	7.0 a	0.6 b	4.2 a	4.2 a	1.4 a	9.3 a	19.1 a
Sub-treatment								
10 x 50 cm	41.4 a	6.6 a	0.7 c	2.9 b	3.0 c	1.1 b	7.5 c	14.4 d
15 x 50 cm	36.6 b	6.7 ab	1.2 b	3.3 b	3.6 b	1.2 ab	9.7 b	17.8 b
20 x 50 cm	34.9 b	6.8 ab	1.2 b	3.5 ab	4.1 ab	1.2 ab	9.6 b	18.3 b
25 x 50 cm	35.5 b	7.1 a	1.6 a	4.0 a	4.3 a	1.3 a	11.6 a	21.2 a

[a]Numbers of the same letter designations are not significantly different at 5% by DMRT.

Table 3. Final yield and components of yield for three vegetable soybean varieties and four spacing treatments in autumn, 1989.[a]

Treatment	Plant no. (/m^2)	Plant dry wt. (g/m^2)	Pod yield (t/ha)	Pod number (/plant)	Pod wt. /plant (g)	LAI	Light interception ratio (%)	Harvest index (%)
Main treatment								
AGS 292	25.3 a	387 b	7.72 a	14.96 a	34.6 a	1.64 b	83 b	60 a
G 9053	25.7 a	453 a	8.30 a	16.10 a	35.3 a	2.02 a	91 a	55 b
G 10134	25.8 a	449 a	8.38 a	14.68 a	31.8 a	1.73 b	88 ab	53 b
Sub-treatment								
10 × 50 cm	39.6[a]	492 a	8.81 a	10.44 d	22.1 d	2.17 a	94 a	56 ab
15 × 50 cm	27.2 b	452 ab	8.43 a	13.80 c	29.3 c	1.95 ab	91 a	54 b
20 × 50 cm	19.8 c	407 bc	7.71 b	16.92 b	37.8 b	1.66 bc	82 b	56 a
25 × 50 cm	15.8 d	368 c	7.59 b	19.81 a	46.3 a	1.41 c	82 b	58 a

[a]Numbers of the same letter designations are not significantly different at 5% by DMRT.

Total pod yield was markedly less at wider spacings, more so in the spring season (Tables 3 and 4). There were significant interactions between variety and spacing treatments for grading ratio in both seasons, and for graded pod yield in autumn. Grading ratio of G 10134 was particularly poor at wider spacing in the autumn crop (Fig. 1), possibly due to excessive pod set and great inter-pod competition

Table 4. Final yield and components of yield for three vegetable soybean varieties and four spacing treatments in spring 1989.[a]

Treatment	Plant no. ($/m^2$)	Plant dry wt. (g/m^2)	Pod yield (t/ha)	Pod number (/plant)	Pod wt. /plant (g)	LAI	Light interception ratio (%)	Harvest index (%)
Main treatment								
AGS 292	23.0 b	384 a	7.41 a	18.00 ab	4.63 a	1.33 b	55 a	60 a
G 9053	24.4 a	402 a	7.44 a	18.61 a	4.71 a	1.66 a	66 a	52 b
G 10134	23.8 ab	434 a	6.94 a	15.83 b	4.23 a	1.62 a	57 a	49 b
Sub-treatment								
10 × 50 cm	36.0 a	518 a	8.46 a	13.87 c	5.10 a	2.13 a	69 a	52 a
15 × 50 cm	25.3 b	449 b	8.08 a	17.39 b	5.13 a	1.64 b	64 ab	55 a
20 × 50 cm	18.6 c	341 c	6.72 b	18.33 ab	4.25 b	1.29 c	60 b	53 a
25 × 50 cm	15.0 d	318 c	5.80 c	20.33 a	3.62 b	1.09 d	45 c	55 a

[a]Means separation within columns of the same entries at 5% level by DMRT.

for assimilates, and led to much lower graded yield at wide spacing than for the other two varieties (Fig. 2). In the spring crop, although the absolute range for the grading ratio over treatments was less than that in the autumn, there was a trend for the grading ratio to decline at lower populations in the variety G 9053, in contrast to the responses of G 10134 and AGS 292 (Fig. 3).

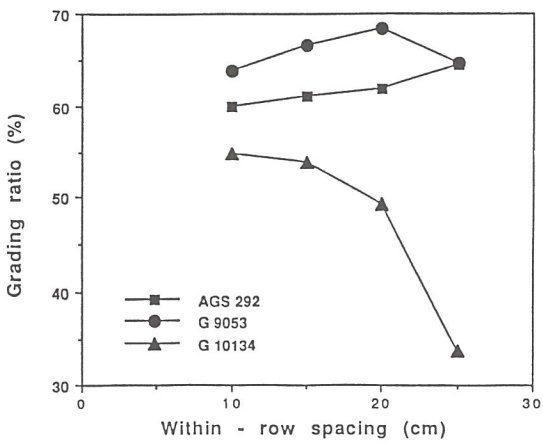


Fig. 1. Grading ratio in autumn as affected by vegetable soybean variety and within-row spacing.

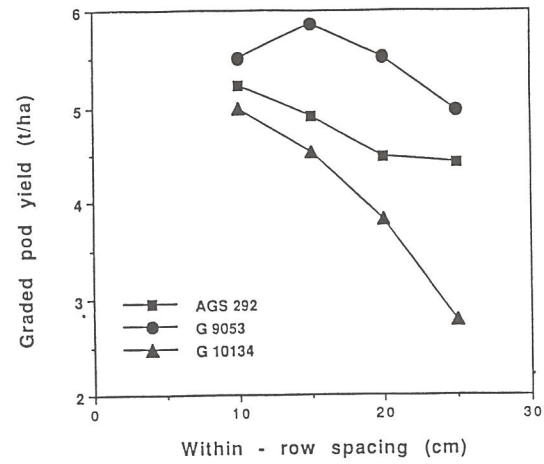


Fig. 2. Graded pod yield in autumn as affected by vegetable soybean variety and within-row spacing.

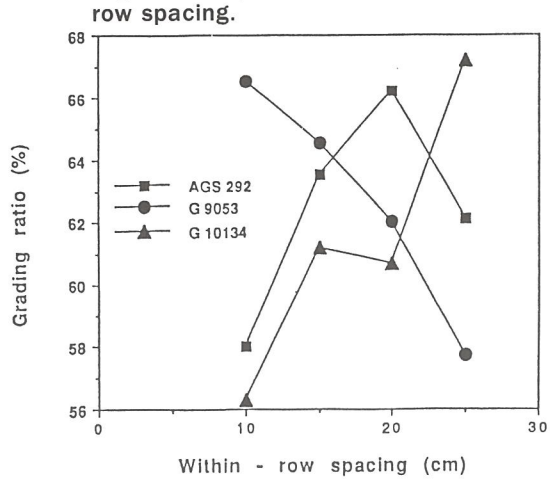


Fig. 3.
Grading ratio in spring as affected by vegetable soybean variety and within-row spacing.

Differences between varieties in total pod yield were slight (Tables 3 and 4), but graded pod yield of G 10135 was consistently less than that of the other two varieties. Harvest index was superior in the short variety AGS 292, but the superior grading ratio of G 9053 in both seasons led to greater graded pod yields in that variety. The low mean LAI and light interception ratio for AGS 292 suggested that total dry matter production for this variety might benefit from closer spacing, but grading ratio in this variety was particularly sensitive to closer spacing in the spring season.

Three types of genotypic response to closer spacing were evident: 1) that of G 9053 and AGS 292 in the autumn, when grading ratio was unaffected by spacing, 2) that of G 10134 in autumn and G 9053 in spring when grading ratio declined at wider spacing, and 3) that of AGS 292 and G 10134 in spring when their grading ratio declined at closer spacing. Physiological bases for these interactions await further statistical analyses.

Data on analysis of pod quality for the three vegetable soybean varieties as affected by plant density are shown in Table 5. Differences between varieties in most characters were consistent over seasons (e.g. AGS 292 had the greatest sugar and least protein, oil and dry matter) and their range of values was greater than those which were affected by spacing treatments (Table 5). Positive trends in oil and starch contents were apparent at closer spacing in the autumn crop, as was a negative trend in protein. Otherwise, no other quality character was significantly affected by spacing treatments.

Effect of Plant Spacing and Pruning Methods on Tomato Yield

Summary

To increase tomato fruit yield, various pruning and width-row spacing treatments were tested. Total yield (101.4 t/ha) and fruit number were greatest at closest spacing (30 cm × 75 cm) and least (95.1 t/ha) at widest spacing (50 cm × 75 cm), but differences were not significant. At closer spacings, yield from the single stem treatment was better, but at wide spacing, double-stem pruning produced greater yield, and could result in economically significant seedling production. Modified pruning (topping at the main stem after three clusters) led to lowest yield, and was not a recommended practice, also due to its labor requirement.

Introduction

Farmers often try to improve tomato fruit yield by increasing plant density. Besides altering plant density, growers of fresh tomato adopt different stem pruning methods to increase yields. This experiment evaluated three tomato pruning practices (i.e. single stem, double stem and modified stem) under three different plant population densities (i.e. 2.7, 3.3 and 4.4 plants/m^2).

Materials and Methods

This study was conducted in field no. 31 of AVRDC from October 1989 to February 1990 using seedlings of the fresh tomato variety FMTT 33.

Treatments of this study included three within row spacings, namely, 30 cm × 75 cm, 40 cm × 75 cm and 50 cm × 75 cm, and three management practices, namely, single stem pruning (i.e. removing all side-shoots), double stem pruning (i.e. leaving the first side-shoot and cluster and removing all successive side-shoots) and modified stem pruning (i.e. leaving the first side shoot and cluster, and removing the main stem growing point after three clusters). The experiment was conducted in a 3 × 3 factorial design with three replications.

Seeds were sown in September 1989 and seedlings were transplanted on in October 1989. Basal fertilizer was broadcast at the rate of 40 : 80 : 50kg/ha (N, P_2O_5 and K_2O). Immediately after

Table 5. Vegetable soybean pod quality analysis among different varieties and plant densities in autumn and spring (1989-1990).[a]

Treatment	Color	DM (%)	Oil (%)	Protein (%)	Sugar (%)	Starch (%)	Fiber (%)	Hardness (g)	Free AA
					Fall '89				
Variety (Main plot)									
AGS 292	2.91 b	31.05 b	17.30 b	37.69 b	14.14 b	10.49 ab	4.41 b	4.21 a	0.048 ab
G 9053	3.64 a	32.39 a	18.17 a	38.23 b	12.67 b	11.07 a	4.54 ab	4.04 b	0.033 b
G 10134	3.62 a	32.30 a	18.03 a	39.78 a	12.05 c	9.94 b	4.57 a	3.84 c	0.062 a
Spacing (Subplot)									
10 × 50 cm	3.49 a	32.08 a	18.21 a	37.78 c	13.06 a	10.90 a	4.54 a	4.10 a	0.042 a
15 × 50 cm	3.37 a	31.83 a	17.88 b	38.30 bc	12.97 ab	10.70 ab	4.52 a	4.13 a	0.045 a
20 × 50 cm	3.28 a	31.88 a	17.62 c	38.81 ab	13.08 a	10.35 bc	4.50 a	4.00 ab	0.052 a
25 × 50 cm	3.42 a	31.85 a	17.62 c	39.39 a	12.69 b	10.05 c	4.47 b	3.89 b	0.053 a
					Spring '90				
Variety (Main plot)									
AGS 292	2.15 c	30.19 b	19.91 a	39.40 b	10.74 a	8.71 a	5.02 a	3.23 b	0.092 a
G 9053	2.87 a	32.12 a	20.16 a	42.85 a	10.28 b	7.46 b	4.87 b	3.93 a	0.068 b
G 10134	2.41 b	32.01 a	19.61 a	42.45 a	9.97 b	7.87 b	4.85 b	3.48 b	0.075 b
Spacing (Subplot)									
10 × 50 cm	2.48 a	31.46 a	19.96 a	41.65 a	10.37 a	8.01 a	4.87 a	3.62 a	0.078 a
15 × 50 cm	2.48 a	31.32 a	19.97 a	41.52 a	10.27 a	8.05 a	4.95 a	3.58 a	0.072 a
20 × 50 cm	2.48 a	31.36 a	19.90 a	41.55 a	10.30 a	8.00 a	4.94 a	3.47 a	0.080 a
25 × 50 cm	2.46 a	31.60 a	19.73 a	41.54 a	10.37 a	7.98 a	4.91 a	3.54 a	0.082 a

[a]Means separation of the same entries in the different columns at 5% level by DMRT.

transplanting, the field was furrowed, irrigated and mulched with rice straw. Missing and weak plants were replaced 1 week after transplanting to ensure the desired treatment densities.

First side dressing was applied at 100 : 0 : 70 kg/ha (N, P_2O_5 and K_2O); the second and the third side dressings were applied at the rate of 60 : 0 : 60 kg/ha (N, P_2O_5 and K_2O).

The insecticides Decis and Sumicidin, and fungicide Benlate were applied routinely throughout the trial period to control pests and diseases. Staking, tying and pruning were also done throughout the growing period. Irrigation was applied six times, weeds were removed by hoeing.

Harvesting started in December 1989 (73 DAT) and finished in February 1990 (133 DAT).

Results and Discussions

The highest yield obtained from the closest spacing was mainly due to high plant population and higher fruit number (Tables 6 and 7). Greatest yield was obtained from single stem pruning at the closer within row spacings of 30 cm and 40 cm (Table 8). For double stem pruning, the greatest yield was

Table 6. Yield as affected by plant spacings.

Spacing	Yield (t/ha)	
	Marketable mature fruit[a]	Marketable fruit and green fruit[a]
30 cm × 75 cm	101.4 a	113.9 a
40 cm × 75 cm	98.2 a	108.5 ab
50 cm × 75 cm	95.1 a	105.7 b

[a]Means separation within columns of the same entries at 5% level by DMRT.

Table 7. Fruit number and fruit size as affected by spacing and pruning methods.[a]

Treatment spacing/pruning method	Marketable fruit no.[a] no./m^2	Marketable fruit size[b] g/fruit
30 cm/modified	96.9 a	106.4 d
30 cm/single	95.8 a	108.9 cd
50 cm/double	92.8 ab	108.0 d
30 cm/double	92.7 ab	104.8 d
40 cm/double	88.9 ab	109.9 cd
40 cm/single	84.4 abc	118.5 ab
40 cm/modified	83.5 abc	116.0 bc
50 cm/modified	80.4 bc	116.0 bc
50 cm/single	73.3 c	125.4 a

[a]Means separations within the columns of the same entries at 5% level by DMRT.

Table 8. Yield as affected by pruning methods.

Spacing	Pruning method	Yield (t/ha)	
		Marketable mature fruit	Marketable mature and green fruit
30 cm × 75 cm	Single	104.1 a	114.9 a
	Double	97.1 a	112.4 a
	Modified	103.0 a	114.3 a
40 cm × 75 cm	Single	100.1 a	108.7 a
	Double	97.7 a	110.4 a
	Modified	96.8 a	106.5 a
50 cm × 75 cm	Single	92.1 a	100.6 a
	Double	100.0 a	115.0 a
	Modified	93.1 a	101.5 a

at the widest (50 cm) plant spacing (Table 8) due to high fruit number in that treatment. Modified stem pruning at 30 cm spacing led to greater yield than at 50 cm within row spacing (Table 9 and Fig. 4). It was quite clear that yield and number of fruits obtained from closer spacing were greater than those obtained from the wider spacings (Table 6 and 7). There were no significant differences in fruit number among the three pruning methods, while there were significant differences between the closer (30 cm) and the wider (40 cm and 50 cm) spacings (Table 9). Size of fruit from the single stem pruning treatment was significantly different from those of the modified and double stem pruning methods. Double stem pruning had the smallest fruit. Spacings of 40 cm and 50 cm resulted in significantly larger fruits than 30 cm spacing (Table 9). The 30 cm spacing and single-stem pruning treatment resulted in greater yield at an early plant growth stage than the other treatments (Figs. 5 and 6).

Table 9. Marketable fruit number and fruit size as affected by spacings and pruning methods.[a]

	Fruit No. (no./m^2)	Fruit size (g/fruit)
Pruning methods		
Double stem	91.5 a	107.6 c
Modified stem	86.9 a	112.7 b
Single stem	84.5 a	117.6 a
Spacing within row		
30 cm	95.2 a	106.7 b
40 cm	85.6 b	114.8 a
50 cm	82.2 b	116.4 a

[a]Means separation of the same entries at 5% level by DMRT.

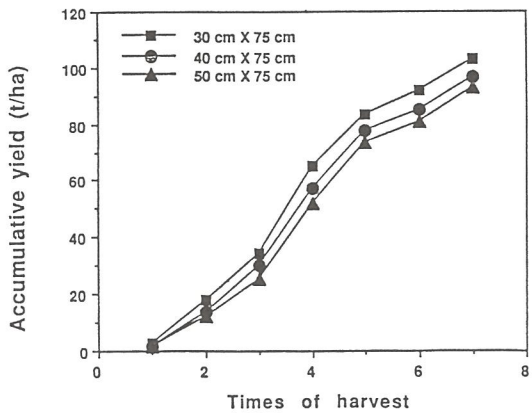


Fig. 4.
Effect of within-row spacing on tomato fruit yield in plants under the modified pruning treatment.

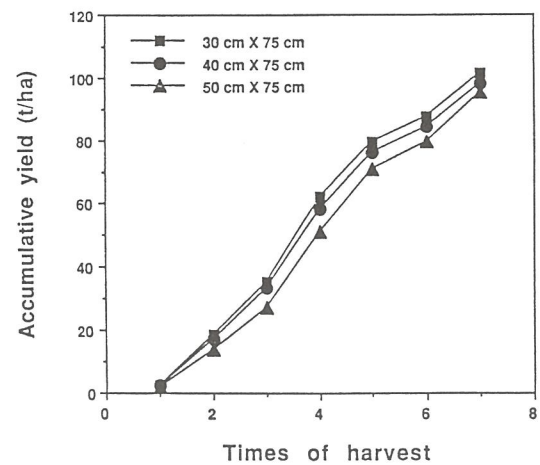


Fig. 5. Effect of within-row spacing on tomato fruit yield. (mean of 3 pruning treatments).

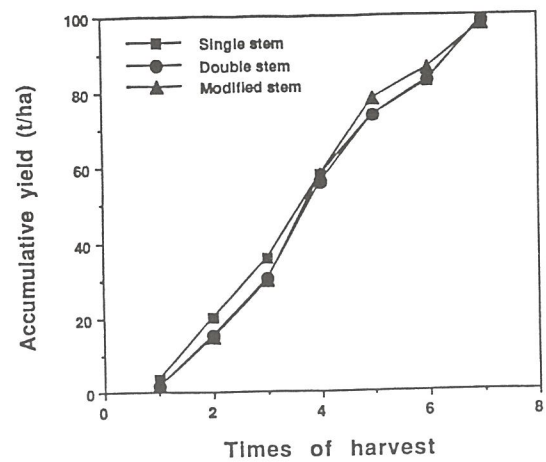


Fig. 6. Effect of pruning treatments on tomato fruit yield. (mean of 3 within-row spacings).

Assessment of Different Legumes as Green Manure

Summary

Four legume species were planted at three population densities in autumn 1989 and in spring 1990 to quantify their biomass production and potential contribution to soil fertility. Rates of dry matter accumulation until 2 weeks after flowering varied between species (approximately 30 kg/ha/day in mungbean to 59 kg in *Sesbania* and 77 kg in sunhemp) but not over seasons. Significant quantities of N accumulated in the aboveground crop, and up to 21 t/ha of aboveground biomass were produced.

Introduction

Diversification away from rice has led to continuous cropping with upland crops, including vegetables. Rotation with fallow or green manure crops to be incorporated prior to the next crop is less widely practiced now than in the past, with resulting deterioration of the physical, and at times chemical structure of the soil. Four legume species (*Sesbania*, *Crotalaria*, *Vigna* and *Glycine*) were planted in autumn 1989 and spring 1990, at three population densities, to measure their potential contributions to soil fertility. The same experiments have also been planted at five district stations in Taiwan.

Materials and Methods

Four soybean varieties (Myokosima, Blue, AGS 313 and G 2120), and one variety each of mungbean (VC 1160), *Crotalaria juncea* (sunhemp) and *Sesbania sesban* (sesbania) were drill-sown at three population densities (high, medium and low; low was half the high population) in September 1989 and in March 1990 (also in August 1990, but data await analysis) in 4.5 m × 8 m plots with a basal fertilizer application of 20:60:30 kg/ha of $N:P_2O_5:K_2O$. Irrigation was done 39 days after sowing (das) the first experiment; no pest control was practiced. A split plot design was used, with three blocks, legumes as main plots, and population densities as subplots. Aboveground samples of 1.5 m^2 were removed from each plot to estimate biomass production and nutrient content. A 19 m^2 portion of each plot was left for seed production.

Results and Discussion

Autumn 1989 crop. Sesbania was the earliest crop to flower (33 das) and mungbean the latest (91 das). These crops had the least and greatest biomass at flowering. However, sunhemp, flowering 47 das, had the fastest rate of accumulation of biomass per day (301 kg/ha/day f.wt.) and Miyokozima soybean the least (114 kg/ha/day f.wt.). Although there was a tendency for biomass yield to be greater at higher population densities, this was not true for all species (e.g. mungbean). Some self-thinning at higher populations and/or compensation at lower populations occurred.

Two weeks after flowering sunhemp had the greatest biomass, mungbean and sesbania, intermediate, and soybean, the least. Soybean and mungbean accumulated very little biomass in the two weeks following initial flowering; more so with sunhemp (372 kg/ha/day f.wt.), with sesbania producing the most (601 kg/ha/day f.wt.). This was a most likely development since conditions following flowering were warmer for the earlier flowering species.

Seed yields of sunhemp and Blue soybean were greater at higher population densities, but those of the other species and varieties were unaffected by population. Soybean (harvested 118 das) had the highest seed yields, followed by mungbean, sunhemp and sesbania.

Phosphorus and potassium removed at flowering and two weeks later, were proportional to total dry weights (i.e. + 1.7% K and 0.25% P by dry weight) over species and varieties, but this was not so for N; sunhemp had much less N per unit dry weight in both samples than did the other species (Fig. 7).

Spring 1990 crop. Sesbania, sunhemp and soybean AGS 313 were the first crops to flower (54 das), and mungbean and Miyokozima soybean, the last (91 das). In contrast to the autumn season

result, yield of sunhemp was extremely low due to its poor establishment following heavy rain the day after sowing. Dry matter production during the two weeks following flowering was greater than during the autumn crop (warmer temperature favored growth of the spring crop) and ranged from 56.8 to 123.5 kg/ha/day (Table 10).

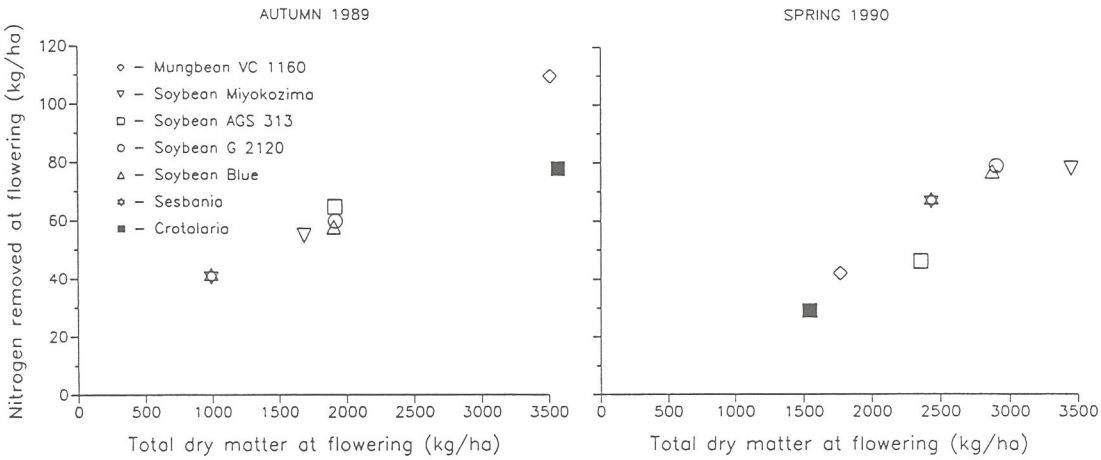


Fig. 7. Relationship between nitrogen and biomass removed between sowing and two weeks after flowering in autumn and spring, for seven legume genotypes.

Table 10. Absolute growth rates (kg/ha/day dry matter) during flowering + 2 weeks, and during the two weeks after flowering, in autumn 1989 and spring 1990.

Crop	Sowing to flowering + 2 weeks		2 weeks after flowering	
	autumn	spring	autumn	spring
Sesbania	60.9	59.2	138.1	117.6
Sunhemp	76.6	47.4	79.3	123.5
Soybean G 2120	35.2	43.5	16.7	56.8
Soybean AGS 313	37.2	53.3	25.2	94.2
Soybean Blue	40.1	42.8	39.1	54.4
Soybean Miyokozima	40.0	43.0	53.8	75.6
Mungbean VC 1160	33.7	30.4	9.2	102.1

There was less tendency for dry matter production to be greater at a higher population density in early flowering species. However, weed growth was suppressed at higher population densities in all species at 54 das.

Only soybean AGS 313 set seed; the other varieties and species, although flowering, exhibited photoperiod sensitivity to pod development during the spring crop.

Phosphorus and potassium content were stable across species ($\pm$1.6% K and 0.25% P by dry weight) but N was particularly low for sunhemp and soybean AGS 313.

Crops differed in their rates of accumulation of dry matter during flowering + 2 weeks, but the differences between spring and autumn seasons were not great. The rate during the final two weeks after flowering varied with species and variety, and, with the exception of the early sesbania, was 40% to 1109% greater in spring than in autumn (Table 10). Significant quantities of N accumulated in the aboveground part of the crops, but without soil analyses and labeled N it was not possible to determine how much resulted from N fixation.

In autumn, 9 to 21 t/ha of fresh crop residue were available for incorporation and in spring 16 to 21 t/ha, for improvement of soil texture. For further experiments larger plots will be sown, and test crops subsequently planted to quantify the beneficial physical effects of green manure on soil productivity.

Effect of Nitrogen Fertilization and Season on Vegetable Soybean

Summary

The influence of season (spring and autumn) and nitrogen (N) fertilizer regimes (timing and rate) on growth, yield and quality of one vegetable soybean variety was studied in 1989 and 1990. No significant effect of N was evident on pod yields, with the exception of the 1989 autumn crop in which a high and split late N application (total 40 to 80 kg/ha at R_1 and R_4 stage) resulted in greater graded pod yields. A similar trend was evident in the 1990 spring crop. High residual soil fertility probably masked the response to N rates. Pod yields were more favored by the warm dry condition of the 1989 spring season, than by the cooler and wetter 1990 spring. Total plant dry weight was least when conditions during the cropping progressed from warm to cool (i.e. autumn 1989). These conditions favored higher bean sugar content, but led to harder seed coats. Total irradiance through the crop season was unrelated to any yield or quality characteristics.

Introduction

The significant response of soybean grain yield to nitrogen (N) fertilization at different growth stages has previously been demonstrated, but the response of vegetable soybean to N is not so clear. Results from Kaohsiung DAIS have shown that the optimum amount of nitrogen fertilizer is 60 kg/ha, 50% applied as basal and 50% as topdressing at 15 days after sowing (das) in spring, and 70% as basal and 30% topdressed at 15 days in autumn. This trial was made to quantify the effect of nitrogen fertilization at different growth stages on plant growth, yield and pod quality of vegetable soybean, and to indicate a suitable nitrogen fertilization regime for an economically high yield of vegetable soybean.

Materials and Methods

A field experiment was conducted with one vegetable soybean cultivar, AGS 292 (KS No. 8), planted in March and September 1989, and March 1990. A randomized complete block design with four replications was used. Treatments are summarized in Table 11.

Seeds (2 per hill) were sown at 40 plants/m^2 in 3 × 5 m plots, with 60 kg P_2O_5 and 80 kg K_2O basal fertilizer together with the designated basal N. Non-destructive growth measures were made at R_1 stage, and plants were removed for component fresh and dry weights and leaf areas from 1-m row bordered strips from each plot at R_4 stage. At harvest, plants from 4 m^2 bordered areas were removed for yield and quality analysis, which included: separation of pods into those without seeds, and with one, two or three seeds; color ratings of pods; defective pods; and moisture, lipid and carbohydrate content of seeds.

Table 11. Nitrogen fertilization treatments (kg/ha)[a] used.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Basal	30	30	30	30	40	40	40	40	40	40
15 DAG[b]	30	0	0	0	0	40	0	0	0	40
R_1	30	30	30	0	0	0	40	0	40	40
R_4	0	30	0	30	0	0	0	40	40	0

[a]All references to 30 for spring 1989 were changed to 20 in autumn 1989 and spring 1990. [b]Days after germination.

Results and Discussion

The effect of nitrogen applied at different growth stages on yield of vegetable soybean planted in spring 1989 is summarized in Table 12.

Table 12. Effect of nitrogen fertilization on yield of vegetable soybean, spring 1989.[a]

Treatment no.	Pod yield (t/ha)	Graded pod yield (t/ha)	Grading ratio (%)
1	14.3	9.7	67.6
2	13.8	10.0	72.1
3	14.1	9.9	70.6
4	13.7	9.3	67.8
5	13.5	10.3	75.8
6	14.1	10.7	75.5
7	13.9	10.1	72.3
8	14.6	10.4	71.6
9	14.4	10.6	73.3
10	14.9	10.9	72.7

[a]No significant differences among treatments observed.

Although neither pod yield nor grading ratio was affected by the application of nitrogen at different periods, there was a trend of greater total pod yield when more N was applied at the early growth stages until flower initiation (13.9, 14.1, 14.3, 14.5 t/ha at 30, 40, 60, 80 kg N/ha respectively, error mean square (36 df) = 1.13).

The response of growth attributes, yield, and its components to the range of total N applied (40 to 120 kg/ha) suggested that inherent soil fertility was high, and masked yield response to applied N. Amount of nitrogen fertilizer (40 to 120 kg/ha) and application time for autumn vegetable soybean crop mainly affected graded pod yield. However, significant differences in grading ratio (ranging from 63.0 to 67.7%) were not apparent.

It appears that lower N application (20 kg/ha) at the early growth stage combined with higher N level (40 60 to 80 kg/ha, i.e. T2 and T9) topdressed and split during the flowering period could result in greater graded vegetable soybean yield, although these effects were not statistically significant.

Once again, in the spring 1990 planting no significant yield difference resulted from the different nitrogen fertilization treatments.

Higher rates of both total nitrogen (120 kg/ha) and top dressing (80 kg/ha) at the flowering stage would be preferable for greater total graded pod yields (Table 13).

Table 13. Influence of combined nitrogen fertilizer treatments on vegetable soybean yield, spring 1990.

Nitrogen rate (kg/ha)	Plant weight (t/ha)	Pod yield (t/ha)	Graded pod yield (t/ha)	Grading ratio (%)
Total N				
40	17.4	8.8	4.5	51.1
60	16.3	8.3	4.4	53.1
80	18.1	9.4	4.7	50.3
120	18.3	9.6	5.1	53.1
Basal + 15 DAG				
20	17.1	8.8	4.6	51.6
40	17.9	9.2	4.8	51.8
80	17.5	9.0	4.7	5.15
R1 + R4				
0	17.0	8.5	4.3	50.1
20	17.0	8.7	4.6	52.6
40	18.0	9.4	4.8	51.3
80	18.4	9.7	5.2	53.3

Note: Orthogonal contrasts still to be made.

In the different seasons no significant differences were observed in vegetable soybean pod quality as a result of N fertilization treatments, with the exception of spring 1990 where a 0.6% difference in sugar content (indiscernible by the palate) was observed between extreme treatments. Comparisons of soybean performances across seasons need close observation for yield and quality. Firstly, seasonal differences in yield and its components were marked, but trends attributable to seasons were not clear.

Yield was apparently favored by the warmer and drier condition of the 1989 spring than the wetter and slightly cooler 1990 spring, during which the grading ratio was also reduced. Total dry matter was favored by the progression from cool to warm conditions through the season, but surprisingly was not closely related to total available radiation. The plant height at harvest, and LAI, node number and total plant dry weight at the R_4 stage were closely related to final plant yield. Seeds were harder, with less fiber and oil, and more protein and sugar in the autumn crop.

Cropping Systems

Collection and Testing of New Vegetables

Summary

This study aimed to gather more information on tropical vegetables for AVRDC's nutrition garden project, bilateral programs, and cooperators. The second set of 15 new vegetables was selected in 1986. A total of 606 varieties of these crops have been collected. An observation trial for onion and advanced yield trials for broccoli, eggplant, onion and spinach were conducted in 1990. Broccoli, Variety No. 441; eggplant, F 100 and Nite King; onion XPH 3325; and spinach, Mrilis, Aturasu, Viroflex, Wolter, Variety No. 104 and Miko performed well in these trials.

Introduction

This study aimed to gather additional 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 15 crops were collected to evaluate their yields, horticultural characteristics and nutrient content under tropical environments. An observation trial of onion and advanced yield trials for broccoli, eggplant and spinach were conducted.

Materials and Methods

Twenty onion varieties were evaluated in an observation trial for their performances in autumn 1989. Varieties of broccoli (15), eggplant (15), onion (20) and spinach (20) were evaluated in advanced yield trials. A randomized complete block design with two replications was used in the observation trial with three replications in the advanced yield trials. The spacing treatments used were 75 × 50, 150 × 50, 20 × 10 and 30 × 20 cm, for broccoli, eggplant, onion and spinach, respectively. Broccoli was tested in late summer, autumn 1989, and spring 1990. Eggplant, onion and spinach were evaluated in autumn 1989.

Results and Discussion

Broccoli. Transplanting for the late summer trials was delayed because the field was flooded due to heavy rains brought about by a series of typhoons. Seedlings were transplanted on 2 October 1989, and it was only 17 days earlier than the autumn trial. The general performance of broccoli in the late summer trial was similar to that in the autumn trial. But the individual variety performed differently in these two trials. However, there was great variation among replications. There was no significant difference in yield and mean head weight of broccoli in the late summer trial.

In the autumn trials, Variety No. 441, 39913-556, BR No.5, and Green King outyielded the other entries, and they also had larger heads than the others. They all matured in about 65 days. The yield level of broccoli in the spring trial was as low as that in the spring trial in 1989. Stolto and Variety No. 02-067 with a yield of 10.3 and 9.0 t/ha, respectively, were the best yielders among entries (Table 1). All entries matured in 47-51 days, except Variety No. 443 which matured in 56 days. No entry performed well in all three trials.

Table 1. Yield and horticultural characters of broccoli in the spring of 1990.[a]

Acc. no.	Entry	Yield[a] (t/ha)	Days to maturity	Mean head wt (g)	Mean growth (g)	Head length (cm)	Head width (cm)
2	Comet 364	4.59 de	47	318	1,171	24.4	10.0
11	Sprinter	5.56 cde	51	363	1,578	24.8	9.8
12	39913-556	4.78 cde	51	324	991	23.6	10.3
13	No. 443	0.96 f	56	289	1,061	24.7	6.5
14	No. 441	4.82 cde	51	323	1,349	24.4	10.1
18	Dandy Early	5.41 cde	50	391	864	23.1	10.0
19	No. 02-067	9.04 ab	47	443	1,227	24.1	13.3
20	Moragod CT31	6.63 bcd	50	468	1,711	25.2	12.5
21	Toro CT21	5.74 cd	47	375	1,134	25.0	11.5
28	Stolto	10.30 a	47	455	1,270	25.4	12.4
32	BR #13	7.56 abc	47	417	1,192	24.6	12.1
33	BR #5	4.82 cde	51	339	1,120	20.0	10.4
40	YS 6163	5.48 cde	48	303	932	24.8	10.3
42	Ultra Green	2.67 ef	50	321	930	22.7	10.1
49	Green King	7.11 bcd	50	371	1,425	24.6	11.9
	LSD (0.05)	2.90	2.72	101	278	n.s.	1.97

[a]Mean separation within a column of the same entries at 5% level by DMRT. Date sown: 9 March 1990. Date planted: 19 April 1990. Date harvested: 4-15 June 1990.

Eggplant. The average yield (39.8 t/ha) of 15 selected eggplant varieties in autumn 1988 was lower than that in autumn 1989 (51.2 t/ha), but they matured about 10 days earlier (Table 2). F 100 which performed especially well last year, had a significantly higher yield than the other entries. Solara, Ma 83004, Nite King, Fontana, and Florida market also yielded well, especially Nite King which also matured early. Among them, Fontana, F 100 and Nite King had big fruits. There was substantial variation in fruit color and fruit shape for selection. It seemed that the long fruit-type eggplant did not perform as well as the oval fruit-type in autumn.

Table 2. Yield and horticultural characters of eggplant in autumn 1989.

Acc. no.	Entry	Yield[a] (t/ha)	Days to maturity	Mean plant yield (kg)	Fruit size (g)	Fruit length (cm)	Days to FLW	Fruit color	Fruit shape
1	Onita	33.7 fgh	90	2.5	188	5.0	18	Dark Purple	Semi Long
5	Terongungan bulat	19.5 i	101	1.8	157	7.7	24	Purple	Oval
8	Fontana	48.1 bcd	93	3.7	399	9.5	21	Dark Purple	Short Oval
11	CT Cha proya	14.8 i	106	1.1	52	5.9	32	Light Green	Oval
12	Florida market	43.9 b-f	103	3.3	309	9.8	22	Dark Purple	Short Oval
13	Black beauty	41.0 c-f	106	3.1	185	6.2	29	Dark Purple	Short Oval
19	Solara	53.4 b	94	4.0	264	7.6	16	Dark Purple	Semi Long
22	Ma 83004	53.1 b	104	4.0	283	7.1	16	Dark Purple	Short Oval
25	F 100	66.0 a	101	5.0	333	9.8	19	Dark Purple	Short Oval
26	Nite King	50.3 bc	87	3.8	318	9.3	13	Dark Purple	Oval
28	Easter egg	44.9 b-e	91	3.4	102	6.6	4	White	Oval
31	Masu eggpplant	24.9 hi	85	1.9	117	3.7	20	Dark Purple	Long
32	Pingtung long	30.1 gh	101	2.3	106	6.9	20	Purple	Long
33	Birde	35.9 efg	109	2.7	83	4.1	26	White L.P.	Long
34	Farmer's long	37.9 d-g	106	2.8	83	3.5	20	Purple	Long
	LSD (0.05)	10.4	4.99	0.75	8.75	3.16	–		

[a]Mean separation within a column of the same entries at 5% level by DMRT. Date sown: 16 August 1989. Date transplanted: 2 October 1989. Date harvested: 27 November 1989-12 February 1990.

Onion. Onion was transplanted on 6 December 1989. There were 20 entries in this autumn trial. Great variation in yields was observed among entries (Table 3). Red commander PPR38018/A4821R, NIZ 1003, XPH 3325, 4-LC 3-3, Gold rush 38051/A4452Y and Granex Y PRR had higher yields than the other entries. Among them, NIZ 1003 and XPH 3325 also performed well in 1988. XPH 3325 not only had firm bulbs but also had high brix (as was shown in the 1988 trial).

Table 3. Onion observation trial in autumn 1989.

Acc. no.	Entry	Yield (t/ha)		Days to maturity	Mean MKT bulb size (g)	Bulb ht. (cm)	Bulb diam. (cm)	Neck size (cm)	Firmness	Brix
		Marketable	Total							
15	Superlex	44.6	46.9	104	223	6.6	7.4	0.8	4.3	5.1
23	Hybrid yellow granex	24.2	27.5	104	193	6.1	7.9	0.8	4.8	5.6
24	AVX 1011	21.0	31.0	95	210	8.0	7.7	1.1	4.0	10.0
26	Granex 429 (F1)	35.5	39.0	106	254	7.0	8.1	1.2	4.4	5.0
27	XPH3325	57.0	67.0	119	300	7.2	9.2	1.2	4.6	9.6
31	Texano	15.0	15.0	99	375	6.8	6.6	0.8	–	–
38	Texas yellow grano	24.5	33.0	106	288	8.0	7.7	1.0	3.8	9.2
39	Texas grano 1015Y	46.0	68.0	114	354	8.9	8.6	1.3	4.2	5.8
40	PSX 680 (F1)	41.4	51.4	106	264	6.4	7.4	0.9	3.8	6.2
41	Granex Y PRR (F1)	53.0	46.4	106	204	6.7	8.2	1.1	4.5	6.0
42	PSX 1029	23.0	43.5	106	307	9.0	8.3	1.1	3.7	5.0
47	NIZ 1003	61.5	67.5	106	286	7.9	8.6	1.2	4.0	5.4
48	NIZ 1016	40.0	50.5	106	348	9.2	8.1	0.9	4.0	5.0
49	EVITA (NIZ 1006)	54.0	64.5	122	257	8.4	8.7	1.4	4.2	9.0
52	4-LC 3-3	57.0	71.0	114	326	8.4	8.6	1.0	4.7	6.5
53	4-1g 7-3	36.0	47.5	116	313	8.3	8.5	1.2	4.7	9.5
54	4-LC 7-4	20.5	29.5	104	241	7.5	7.2	0.8	4.2	7.6
58	Herry's special PR 38003/R711PR	46.0	61.5	106	383	9.6	8.3	1.0	3.7	4.5
59	Gold rush 38051/A4452Y	55.0	60.5	106	275	8.8	8.2	1.0	4.0	8.0
60	Red commander, PPR 38018/A4821R	65.0	74.5	114	361	8.2	8.7	1.4	4.2	9.0
61	Tainan No. 1	36.0	48.5	104	257	7.1	8.0	1.2	4.3	7.0
62	Tainung No. 3	37.5	50.5	104	242	7.2	8.0	1.0	4.2	8.5

Date sown: 27 October 1989. Date transplanted: 6 December 1989. Date harvested: 22 March-9 April 1990.

Spinach. There were 22 entries in the autumn trial started on 13 October 1989. This date was earlier than the previous year's trial which started on 1 November. The growing period for spinach was similar in these trials, but spinach had about a double number of leaves and hence, yield in this trial was comparable to that in 1989 (Table 4). Mrlis, Aturasu, Viraflex, Wolter, Variety No. 104, and Miko were the better yielders. Asron had a long growing period and might not be a real high yielding variety. On the other hand, Variety No. 104 had a particularly short growing period and should be a quick-growing spinach.

Intercropping of Hot Pepper and Other Vegetables

Summary

Hot pepper was intercropped with broccoli, Chinese cabbage and radish to study the possibility of increasing the interception of solar radiation for improving land productivity. Two trials were carried out in 1990, the first trial was on hot pepper genotype and the second one on hot pepper density. Results showed that intercropping of hot pepper with other vegetables such as broccoli, Chinese cabbage and radish could be a promising production system under tropical conditions if heat-tolerant varieties of such vegetables could be provided. Hot pepper should be very densely grown (more than five plants/m^2).

Introduction

Intercropping is a system of farming designed to accommodate two or more crops on the same piece of land in one cropping season. It has long been an important practice in the tropics and subtropics because it can reduce the risk of crop failure from over-dependence on a single crop.

Research has also shown recently that intercropping can give higher combined yield than a single cropping. This system allows plants to make better use of growth resources such as sunlight, moisture and soil nutrient (Willey 1979)[1]. Crops grown in combination with other plants are influenced by certain considerations, such as climate, soil, relative planting time, plant type and crop maturity.

Hot pepper (*Capsicum frutescens*) is one of AVRDC's principal crops. It is quite well adapted to hot weather. It is suggested that hot pepper should be grown with wide spacing to reduce disease infection. Thus, intercropping of dwarf-type vegetables between rows of hot pepper to utilize solar radiation more fully might have higher combined yield and hence a higher land productivity. This project studied the intercropping of different vegetables: Chinese cabbage (*Brassica campestris* ssp. *pekinensis*), radish (*Raphanus sativus*), and broccoli (*Brassica oleracea* var. *italica*,) and different types (tall and dwarf) and densities of hot pepper, as part of a project to establish the principles for intercropping with hot pepper and improve land productivity.

Materials and Methods

There were two trials conducted at AVRDC. The first one studied hot pepper plant types and the second hot pepper spacing. A randomized complete block design with three replications was used. Six intercropping treatments were performed on the following vegetables: two hot pepper genotypes (tall MC-4 and dwarf Szechuan) and three other vegetables: Chinese cabbage (AVRDC F_1 hybrid 82-156), radish (Ming-ho) and broccoli (Triumph No. 2). Five sole hot pepper cropping treatments of the crops mentioned above were used in the first trial. The spacing used was 100 × 30 cm for hot pepper, 50 × 40 cm for Chinese cabbage and broccoli, and 50 × 20 cm for radish in both sole hot pepper cropping and intercropping. Between-rows intercropping was used.

In the second trial, only the dwarf variety, Szechuan was used. Hot pepper types were replaced by densities 50 × 60 cm and 50 × 40 cm. The spacing used was 50 × 40 cm for broccoli and Chinese

[1]Willey, R.W. 1979. Intercropping — its importance and research needs. Part I. Competition and Yield Advantages. Part 2. Agronomy and research approaches. Field crop. Abst. 32:1-10, 73-85.

Table 4. Yield and horticultural characters of spinach in autumn 1989.

Acc. no.	Entry	Plant type	Leaf color	Leaf shape	Stem color	Days to maturity	Mean plant wt (g)	Seeds type	Tiller No.	Leaf No.	Leaf length (cm)	Leaf wt. (9)	Stem length (cm)	Leaf thickness (mm)	Yield[a] (t/ha)
4	Andros	3	2	2	3	56	317	1	2.9	29.8	29.9	14.6	13.0	41.1	30.1 cde
10	Viking	4	3	2	3	56	230	1	0.3	22.2	26.5	11.5	15.5	41.1	29.3 de
11	Torai	1	3	4	3	47	225	2	3.8	37.9	35.1	10.0	20.7	33.0	30.6 b-e
14	Ditate Dingegoli	4	3	1	3	59	240	2	0.9	24.7	26.6	11.0	12.9	34.5	30.4 b-e
25	XPH 1511	1	2	6	3	47	215	2	4.2	38.5	29.3	10.5	22.5	42.1	29.9 cde
32	Miko	4	3	1	3	56	286	1	1.3	23.7	39.8	19.0	20.3	40.1	38.3 a-d
33	Wolter	3	3	1	3	56	292	2	0.6	24.8	35.2	13.8	16.3	32.1	39.9 ab
36	OE 3288	2	3	6	3	59	231	1	0.6	26.4	37.1	16.5	19.4	37.3	31.9 a-e
38	Viroflex	2	2	1	3	56	302	1	1.1	24.8	36.3	19.5	19.6	22.2	38.9 abc
39	Polka	4	3	1	3	59	283	2	0.9	25.9	37.3	16.4	13.3	41.0	23.0 e
40	Marisca	3	3	2	3	56	287	2	0.6	25.5	33.5	13.5	17.4	52.7	36.6 a-d
43	Movera	3	2	2	3	56	288	2	2.3	32.2	23.3	8.9	17.4	33.9	36.7 a-d
48	ARCO 43	3	3	3	3	56	255	1	0.9	39.9	26.6	11.5	14.1	35.2	33.2 a-d
49	Eiko	3	3	3	3	76	285	1	1.2	28.2	34.0	15.6	18.6	40.3	37.7 a-d
50	Asron	2	3	6	3	76	276	2	1.7	30.3	40.5	13.8	29.6	37.9	38.7 a-d
51	Mrilis	2	3	6	3	56	356	2	1.1	25.3	38.7	15.5	26.9	38.3	41.0 a
52	Aturasu	2	3	6	3	56	316	1	1.1	25.1	32.4	11.7	27.1	30.1	39.3 abc
53	Ku-lin-chiaw	1	2	6	2	43	167	3	4.3	29.5	35.4	9.5	18.9	26.1	23.1 e
55	No. 104	2	1	4	2	41	253	3	6.2	38.7	28.9	10.5	9.4	32.8	35.6 a-d
56	Suparu	2	3	4	3	47	259	2	3.4	31.0	33.0	11.7	22.3	46.1	32.4 a-e
	LSD (0.05)	0.21	–	–	–	2.13	78.4	–	0.8	5.6	3.9	1.6	2.0	8.8	9.5

[a]Numbers having the same letter designations are not significantly different at 5% by DMRT. Date sown: 13 October 1989. Date harvested: 29 November-28 December 1989.

cabbage, and 50 × 20 cm for radish in both cropping systems. Within-row intercropping was used. Their code numbers are:

PaC: intercropping of hot pepper, MC-4 (50 × 60 cm), and Chinese cabbage.
PaR: intercropping of hot pepper, MC-4 (50 × 60 cm), and radish.
PaB: intercropping of hot pepper, MC-4 (50 × 60 cm), and broccoli.
PbC: intercropping of hot pepper, Szechuan (50 × 40 cm), and Chinese cabbage.
PbR: intercropping of hot pepper, Szechuan (50 × 40 cm), and radish.
PbB: intercropping of hot pepper, Szechuan (50 × 40 cm), and broccoli.
Pa: sole cropping hot pepper, MC-4 (50 × 60 cm).
Pb : sole cropping hot pepper, Szechuan (50 × 40 cm).
C : sole cropping Chinese cabbage.
R : sole cropping radish.
B : sole cropping broccoli.

Seeds or seedlings were sown or transplanted, respectively, in the field on 17 October 1989 in the first trial and 26 February 1990 in the second.

Plants from 1 m^2 in each treatment were sampled for horticultural characteristics. The total dry matter production and yield were estimated from plants in a 12 m^2 area. Light interception of canopies was measured.

Results and Discussion

The first trial was conducted during the end of the humid hot season towards the dry cool season, while the second trial was conducted during the dry cool to the humid hot season.

Trial 1: Effects of hot pepper genotypes. Broccoli and Chinese cabbage were attacked by diamondback moth (*Plutella xylostella*) three days after transplanting, the damage affecting about 20% of the population in two weeks after transplanting. Hence, fixed schedules of insecticide and fungicide sprayings were carried out. The seed germination rate of radish was poor and less than 50%. A second sowing was carried out and the germination rate was 80%.

Results showed that growing of associated hot peppers had no significance on maturity and number of plants harvested, yield, average curd weight and leaf and curd dry weight of broccoli. It appeared that broccoli was dominant in this particular intercrop when it was transplanted on the same day in the cool season.

Chinese cabbage intercropped with hot pepper tended to mature earlier than those in sole cropping (Table 5). However, there was no significant difference in the total number of plants harvested among treatments and there was no missing plant in each treatment. And neither total fresh weight, head yield, mean head weight, or leaf or head dry weight of Chinese cabbage was influenced by intercropping with hot pepper. It seemed that Chinese cabbage was not influenced by association with hot pepper.

Table 5. Number of plants of Chinese cabbage harvested under sole hot pepper cropping and intercropping with hot pepper.

Cropping	Intercropped hot pepper	Number of plants harvested in 8m^2		
		1st[a]	2nd	Total[b]
Inter	MC-4	35.0	7.3	42.3[a]
Inter	Szechuan	31.3	10.4	41.7[a]
Sole	Sole	26.0	15.0	41.0[a]

[a]The first and second harvest was made 43 and 50 days after transplanting respectively. [b]Numbers having the same letter designations are not significantly different at 5% level by DMRT.

Radish intercropped with hot pepper, MC-4, had significantly bigger roots than the radish in the other two treatments (Table 6). Thus, it had a significantly higher root yield than the others. However, the factors which contributed to these were not identified and warrant further study.

The growth of hot pepper was poor in the first trial. This might be attributed to the fact that the air temperature during this trial was lower than the suitable range of 20-30°C. This was evidenced by the light interception by the canopy of hot pepper in the single cropping which reached 20% only in the first trial.

Hot pepper also showed a deficiency symptom of micro-elements. The leaves turned yellow and their internodes were quite long, when intercropped with Chinese cabbage. Those intercropped with broccoli had green leaves, although their internodes were long. It appeared that Chinese cabbage might have competed with hot pepper for micro-elements.

Means in each vertical column followed by the same letter are not significantly different at 5% level according to Duncan's multiple range test.

Plant flowering dates clearly indicated that there were differences among hot pepper varieties and cropping systems. The hot pepper MC-4 flowered earlier than Szechuan. Both hot pepper cultivars flowered later when intercropped with Chinese cabbage than those in the other treatments. It was observed that the canopy of broccoli shaded pepper plants much earlier than Chinese cabbage. Furthermore competition for micro-elements between hot pepper and Chinese cabbage might have affected the flowering date and also caused the flowers to drop. It was very likely that the delay in flowering in hot pepper could be due to the competition for nutrients but not for light with Chinese cabbage.

There were significant differences in the growth of hot pepper among treatments. The tall type MC-4 had better growth in terms of plant height, stem and leaf dry weight, and yield than the dwarf Szechuan in both sole cropping and intercropping. The plant height of pepper increased in intercropping treatments, showing the competition for light between associated crops. On the other hand, the dramatic reduction in stem and leaf dry weights indicated strong competition for growth resources, and that pepper was dominant. Among the crops associated with pepper, radish had the least and broccoli the strongest effects on the growth of hot pepper. It appeared that broccoli was not a suitable crop to be intercropped with hot pepper under the current spacing arrangements.

Results of Land Equivalent Ratio (LER) showed that all intercrops of hot pepper and vegetables had a combined yield advantage of LER greater than one (Table 7). All vegetables associated with hot pepper dominated in intercropping. Their yields were not significantly affected when intercropped with hot pepper. However, the yield of hot pepper was too low to show evidence of competition in intercropping. On the other hand, yield of hot pepper was significantly affected except when intercropped with radish. The yield of Szechuan in sole hot pepper cropping was particularly low due to low temperature and virus infection. This could mean that intercropping reduced disease infection.

Table 6. Yield, mean root weight and dry weight of plant parts at the final harvest of radish.[a]

Cropping	Intercropped hot pepper	Yield[a] (t/ha)	Mean root wt. (kg/plant)	Dry wt. (g)	
				Leaf	Head
Inter	MC-4	18.0 a	0.42 a	413.8 a	25.8 a
Inter	Szechuan	12.8 b	0.29 b	276.9 a	24.1 a
Sole		10.0 b	0.15 c	450.2 a	22.7 a

[a]Means separation in each column of the same entries (same letter designations) at 5% level by DMRT.

Table 7. Yield and LER of hot pepper varieties and other vegetables under intercropping.[a]

Hot pepper/Vegetables		Broccoli		Chinese cabbage		Radish	
		Hot pepper	Broccoli	Hot pepper	Chinese	Hot pepper	Radish
MC-4	Sole	1.29 a	16.0 a	1.29 a	32.0 a	1.29 a	10.0 b
	Inter	0.21 b	15.0 a	1.00 b	34.6 a	1.75 a	18.0 a
	I/S	0.16	0.93	0.78	1.08	1.36	1.80
	LER	1.09		1.86		3.16	
Szechuan	Sole	0.21 b	15.0 a	0.21 d	32.0 a	0.21 b	10.0 b
	Inter	0.21 b	15.8 a	0.59 c	34.6 a	0.66 b	12.8 b
	I/S	1.00	1.05	2.81	1.08	3.14	1.28
	LER	2.05		3.89		4.42	

[a]Means separation in columns of the same entries at 5% level by DMRT.

Trial 2: Effects of the density of hot pepper. In the second trial, 300 mm precipitation was received in 10 days during middle April. This affected the quality of broccoli and Chinese cabbage, but not their yields. However, it totally destroyed the radish population.

Results of light interception clearly pointed out that hot pepper did not intercept much radiation during its early growth stages, and intercropping with other vegetables, especially broccoli, increased the total light interception dramatically. Increasing the density of hot pepper from 3.3 to 5.0 plants/m^2 enhanced light interception in sole hot pepper cropping, and intercropping after the crops associated with hot pepper were removed.

Compared to those in sole hot pepper cropping, the yields of broccoli and Chinese cabbage were slightly affected by associating hot pepper with other crops in intercropping (Table 8). However, these effects were not magnified by increasing the density of hot pepper. On the other hand, their influences on hot pepper were more significant. The yield of hot pepper was increased in both sole hot pepper cropping when population density was increased. It appeared that the population densities of hot pepper should be increased to a higher level than the test densities based on the results of light interception and yield.

The results indicated almost 100% yield in sole hot pepper cropping compared to cropping when hot pepper was associated with radish.

LERs showed that both intercropping of hot pepper with broccoli and Chinese cabbage had combined yield advantage, especially under the tested higher density of hot pepper. It might be concluded that intercropping of hot pepper with other vegetables such as broccoli, Chinese cabbage and radish could be a promising production system under tropical conditions, if heat tolerant varieties of such vegetables become available.

Table 8. Yield and LER of hot pepper with different densities and other vegetables under intercropping.[a]

Hot pepper/Vegetables spacing		Broccoli		Chinese cabbage		Radish	
		Hot pepper	Broccoli	Hot pepper	Chinese	Hot pepper	Radish
50 × 60 cm	Sole	8.8 ab	20.0 a	8.8 ab	51.3 a	8.8 ab	–
	Inter	2.9 b	16.0 b	6.9 b	41.9 b	9.2 ab	–
	I/S	0.3	0.8	0.8	0.8	1.0	–
	LER	1.18		1.60		1.05	
50 × 40 cm	Sole	14.4 a	20.0 a	14.4 a	51.0 a	14.4 a	–
	Inter	8.3 ab	17.9 b	9.4 ab	46.3 b	14.3 a	–
	I/S	0.5	0.9	0.6	0.9	1.0	–
	LER	1.48		1.55		0.99	

[a]Numbers having the same letter designations are not significantly different at 5% by DMRT.

A Non-Circulating Hydroponic System for Tomato Production in the Tropics

Summary

The noncirculating hydroponic system developed at AVRDC in 1986 was found economical, clean and easy to manage. It appeared that this system could be an economical way for tomato production under the adverse conditions in the tropics. This project aimed to scale up this system, examine its performances and improve it for commercial production of tomatoes in the tropics. A series of trials on effects of nutrient solution temperature, nutrient solution level, and simple structure on the growth and yield of tomato were conducted in 1990 to develop an effective and economical non-circulating hydroponic system for tomato production in the tropics.

A non-circulating hydroponic system with a simple structure was designed based on some of these trials, and was found feasible for application in the tropics. Seventy kilograms of tomatoes were harvested from a 13.5 m × 1.1 m hydroponic unit in 50 days.

Introduction

The noncirculating hydroponic system developed at AVRDC in 1986 was adopted for urban home gardens. It was found economical, clean, and easy to manage. It appeared that this system could be an economical way of producing under the adverse conditions in the tropics. This project aimed to scale up this system, assess its performance and improve it for commercial production of tomatoes in the tropics.

The level and temperature of nutrient solutions which affect root activities are important factors for the growth of tomato under the noncirculating hydroponic system, especially under high temperature conditions. Heavy rains and high temperature are the main abiotic constraints for tomato production in the tropics. Therefore, a series of trials on effects of nutrient solution temperature, nutrient solution level, and simple structure on the growth and yield of tomato were conducted in 1990 to develop an effective and economical noncirculating hydroponic system for tomato production in the tropics.

Materials and Methods

The constituents of a nutrient solution for the noncirculating hydroponic system had been discussed in the 1986 AVRDC progress report. In this project, a nutrient solution with the same constituents was prepared by a fertilizer company into two stock solutions. In the preparation of nutrient solutions, stock solutions were diluted and mixed. The trial on nutrient solution temperature was carried out using the urban garden setup. A temperature range of 20-23°C was maintained as 'low' temperature for comparison with that without manipulation which was considered as 'high' temperature.

The trial on nutrient level was conducted in large concrete containers ($2 \times 1.5 \times 0.6$ m^3). The container was covered by polystyrene boards, which had 6.0 cm diameter holes for inserting small pots in it. Small plastic seedling pots, 6.5 cm in diameter and 7.5 cm in height, each with a layer of window screen (3×2.5 mm), were utilized to support medium plants (1987 AVRDC Progress Report). The nutrient solution levels were kept at 15, 20 and 25 cm from the bottom of pots. For the third treatment, the noncirculating hydroponic system was put under a simple structure with a bamboo frame and plastic cloth on top only to compare with those in the greenhouse. The growth and yield of tomato, and nutrient consumption were recorded.

Results and Discussion

Trial 1: Nutrient solution temperature. Results showed that the shoot growth of tomato was not reduced by high air temperature during the hot season (a mean temperature of 28°C) compared to that in warm season (a mean temperature of 23°C), but the root growth was reduced. Reduced nutrient solution temperature enhanced the shoot growth during the warm season, but reduced the shoot growth during the hot season. The root growth was not affected significantly in each season. This indicated that reduction of the solution temperature for tomato growth under the noncirculating hydroponic system was not necessary.

Trial 2:Nutrient solution level. The growth of tomato roots, especially the air roots, was affected by the nutrient solution level significantly. Increasing the space between the bottom of pots and the solution level increased the dry weight of air roots (root in air) and reduced that of the water root (roots in solution). As a consequence the amount of nutrient solution (and water) consumed decreased. The pH and electrical conductivity of the solution did not differ significantly among treatments. The electrical conductivity increased gradually in all treatments during tomato growth. The tomato plants in the treatment with a solution level of 15 and 20 cm grew and yielded significantly better than those in the 25 cm solution level (Fig. 1). The 20 cm nutrient level appeared to be the best among three treatments in terms of yield and nutrient consumption.

Trial 3: Simple structure production. The simple structure was intended to work as a rain shelter, and not to increase the air temperature. Results showed that there was a lower daily minimum temperature in the simple structure than in the greenhouse. The tomato plants under the simple structure

produced more tomatoes and hence, yielded higher (Fig. 2). This indicated that the production of tomato under a noncirculating hydroponic system in the tropics should be made under a structure without increasing air temperature. The application of a simple structure for this purpose is feasible.

A noncirculating hydroponic system with a simple structure was designed based on the above-mentioned trials. The simple structure had galvanized lead pipes (a diameter of 1.27-2.54 cm) as skeleton; a roof covered with 0.2 mm of white plastic film, and a 24 mesh/in PVC wall. Wooden racks of 13.5 m × 1.1 m × 20 cm covered by plastic cloth (0.15 mm) was used as the medium container. The height was only 20 cm to reduce the total volume of nutrient solution. The medium used was smoked rice husk. The nutrient solution level was kept at 11 cm by a water sensor. There were two rows of tomato with 50 cm within-row spacing. A heat tolerant AVRDC F1 hybrid, FMTT 22 was transplanted on 24 September 1990. Plants were sprayed with tomatotone growth regulator to enhance fruit setting. Up to 13 November, 70 kg of tomatoes were harvested from 52 plants on one bed (wooden rack) with the highest being 3.2 kg/plant. The plants still bore fruits after harvest.

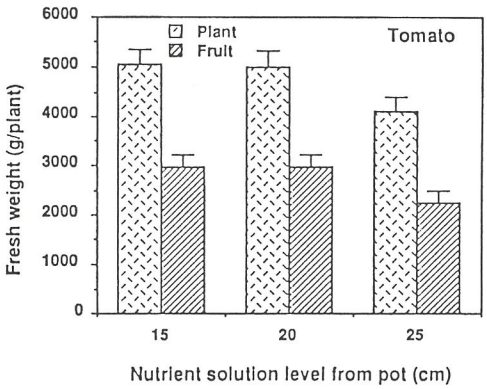


Fig. 1.
Growth and yeild of tomato under different nutrient solution levels.

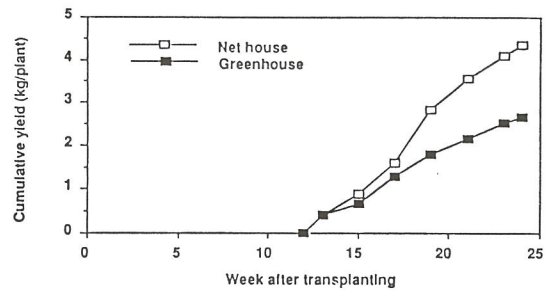


Fig. 2.
Yield of tomato in net house and greenhouse.

Assessment on the Applicability of a Soybean Growth Model, SOYGRO, for the Tropics

Summary

A network was set up in Taiwan to study the relationships of the growth and yield of soybean and environment factors. The data obtained were utilized for assessment of a soybean growth model, SOYGRO. Results showed that this model could predict physiological stages accurately. It is also feasible to apply this soybean growth model in the tropics for yield estimation, provided some modifications are made on the relationships of assimilates and environments, and nitrogen and yield.

Introduction

Crop production is affected by physical, biological and economic environments, and management. There is a great variation in climatic environment and hence in the performance of crops. It is important

to have better understanding of crop-environment relationships to identify the suitable production areas and also to fit the appropriate crop varieties into the existing cropping systems.

A crop growth model was developed to integrate these relationships by computer. It can assist in the evaluation of the interactions between plants and environment, in agronomic decision making, in predicting the suitability of any crop or cropping sequence in a given environment, and in estimating the potential yields and the probability of attaining them. Therefore, a crop growth model could be a useful tool in assisting agricultural technology transfer. However, developing an accurate crop growth model is too big a task for AVRDC. It might be feasible to apply existing models.

An assessment of the applicability of a crop growth model is necessary before applying it in regions different from where the model was originally developed. This project aimed to test, validate, and apply a soybean growth model, SOYGRO, that was developed at the University of Florida (Jones et al. 1986).

Materials and Methods

A network was set up in cooperation with Hualien, Kaohsiung, Tainan, Taitung, and Taoyuan District Agricultural Improvement Stations (DAIS), and the Taiwan Agricultural Research Institute (TARI) to collect data for model assessment. There was a total of 29 trials conducted in seven locations for three years with replications in seasons. Five soybean cultivars, Kaohsiung No. 8 (KS 8), AGS 129 (Kaohsiung No. 10, KS 10), AGS 66 (Tainan No. 1, TN 1), Hualien No. 1 (HL 1), and Tainung No. 15 (TN 15) were grown at seven locations across Taiwan. There were two crops (spring and summer plantings) a year in each location, except at KS DAIS and AVRDC where there were three crops a year.

A randomized complete block design with four replications was applied. Plant spacings used 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 the 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.

Results and Discussion

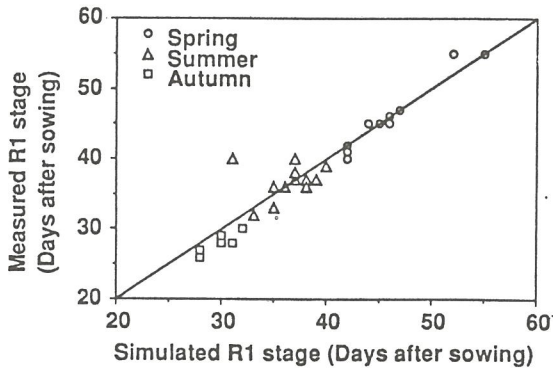
It was found in the study of rotation systems that accurate estimation of growing periods and yield level is important for designing an effective and feasible cropping pattern for a given environment. Results showed that the estimation of different physiological stages of soybean was quite accurate with the data collected from trials (Fig. 3). From data collected from trials in three planting seasons, it was found that two years was enough to establish genetic coefficients for accurate estimation of physiological stages for a variety. The data on physiological stages of flowering (R_1), first pod setting (R_4), physiological maturity (R_7) and harvesting (R_8) can be obtained during advanced yield trials.

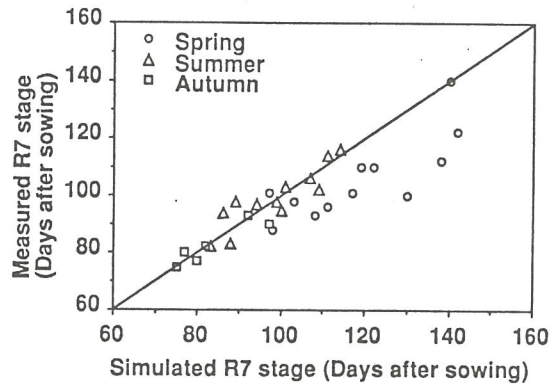
Although the model exhibited a highly significant linear relationship between predicted and measured yields, the estimation of yield was not as close as that for physiological stages (Fig. 4). This could be attributed to the fact that a model does not include the factor of nitrogen application, and the presence of a relatively high amount of nitrogen, 60 to 120 kg/ha, in these trials. The other factor could be the amount of water irrigated. Since the amount of water irrigated had not been precisely recorded, simulations were done without water stress, and the results were therefore not realistic. The third one might be the relationships of LAI and yield. It was noticed that excessive leaf areas of soybean under tropical conditions had an adverse effect on yield, and the model did not show these relationships (Fig. 5). It appeared that the relationships on assimilate distribution and environments, and the effects of nitrogen fertilizer on yield should be modified for the model to be more precisely applicable in the tropics.

Rotation of Vegetables with Paddy Rice

Summary

A long-term field trial on rotation of vegetables with cereal crops was conducted to incorporate AVRDC principal crops into rice-based cropping systems and increase the productivity per unit of land, and to develop principles and methodology for such rotations.





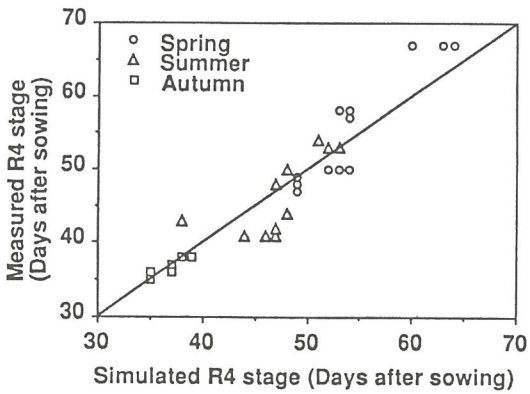


Fig. 3.
Comparison of simulated and measured physiological stages of soybean.

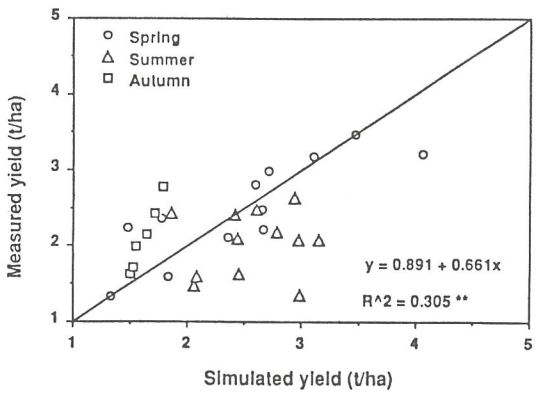


Fig. 4. Comparison of simulated and measured yield of soybean.

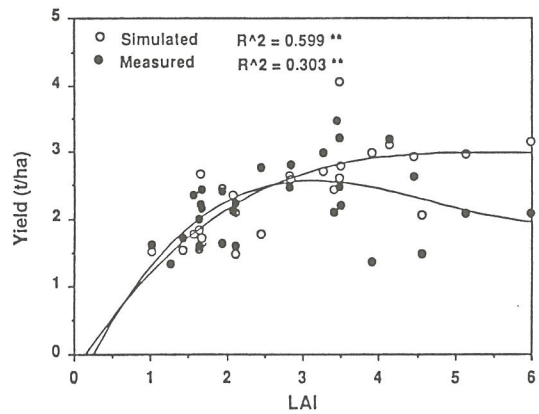


Fig. 5. Comparison of simulated and measured relationships of LAI and yield of soybean.

An accurate estimate of crop growth duration in a given environment was found important in designing a cropping pattern to fully utilize the land. The total crop duration including periods of fallow should be calculated in a cropping systems study. There was great variation in yield due to the changes in environmental conditions, and the possibility of success in obtaining a certain yield level for crop in a given environment should be estimated. Long term weather is necessary for this kind of prediction, and data should be collected for all seasons. Total soil nitrogen indicated that those cropping patterns which include soybean or mungbean in summer planting increased soil fertility. This suggests that leguminous crops should be incorporated into multiple cropping systems in the tropics to sustain soil productivity.

Introduction

Annual food production from a given land area can be increased by improving the yield of a crop and increasing the cropping intensity. In most tropical regions with long growing seasons, small land holdings, and high labor-land ratios, multiple cropping systems could be one of the most effective means of increasing farm productivity, especially for those areas under irrigation.

Vegetables are versatile and can be easily incorporated into different cropping systems and produce yields even at short intervals between staple crops. They can also be potential contributors to sustainable agriculture due to the great variation in vegetable genetic resources. Vegetable production also provides opportunity for high returns while improving soil properties. These make vegetables an important and as yet under-exploited resource for farm production systems in the tropics.

In tropical Asia, the prospect for new agricultural land is limited and vegetable availability is low. Considering the low ratio of irrigated land planted to vegetables (Table 9) and the successful vegetable production in Taiwan where the tropical and subtropical conditions are both conducive to vegetable production, there is a great potential in tropical Asia to increase vegetable production and hence, the farmers' income, thus incorporating vegetable production into existing staple food-based cropping systems.

This project aimed to incorporate AVRDC principal crops into rice-based cropping systems to increase the productivity of unit land, and to develop principles and methodology for such rotations. The effects of different rotations on crop yield, soil characteristics, and pests were investigated.

Table 9. Total arable land resource and extent of irrigation development, vegetable harvested area, and vegetable availability in some Asian countries, 1986.[a]

Country	Arable land			Population (million)	Vegetable availability (g/capita/day)
	Total (1000 ha)	Under irrigation (%)	Vegetable harvested area (%)		
Indonesia	14510	37.3	7.2	163.4	46
Philippines	7850	17.7	2.4	54.7	28
Thailand	17810	19.4	1.7	51.3	75
Taiwan, ROC	886	54.0	24.2	19.5	305

[a]Adapted from ADB (1987) and AVRDC (1988).

Materials and Methods

There were eight cropping patterns studied including:

1. Rice – Rice – Chinese cabbage – Garland chrysanthemum
2. Rice – Soybean – Maize
3. Rice – Mungbean – Maize
4. Soybean – Rice – Tomato
5. Chinese cabbage – Rice – Sweet potato
6. Soybean – Tomato – Maize
7. Sweet potato – Chinese cabbage – Soybean
8. Tomato – Soybean – Maize

The field trial started during the autumn planting in 1987 on the same plots. A randomized complete block design with two replications was applied. Yield data and soil samples after each harvest were collected and analyzed.

Results and Discussion

An accurate estimate of crop growth duration in a given environment was found important in designing a cropping pattern to fully utilize the land. In this project, the total crop growth duration was less than 365 days a year (Fig. 6). However, four patterns had an average beyond that limit between

croppings caused by delays in land preparation due to heavy rain and social activities (holidays). Total crop duration including these periods should be calculated in a cropping systems study.

Results also showed that there was great variation in yield due to changes in environmental conditions (Fig. 7). To predict successful yield of a certain crop in a given environment, data or long term weather should be collected. There was no clear crop-crop interaction observed in three-year trial. Vegetables such as tomato and Chinese cabbage seemed more sensitive to the environment than cereal crops. This implied that crop management techniques should be developed to mitigate these abiotic constraints in addition to the development of tolerant varieties.

Total amount of soil nitrogen in soil indicated that those cropping patterns which included soybean or mungbean in the summer planting apparently increased soil fertility. Thus, leguminous crops should be incorporated into multiple cropping systems in the tropics to sustain soil productivity.

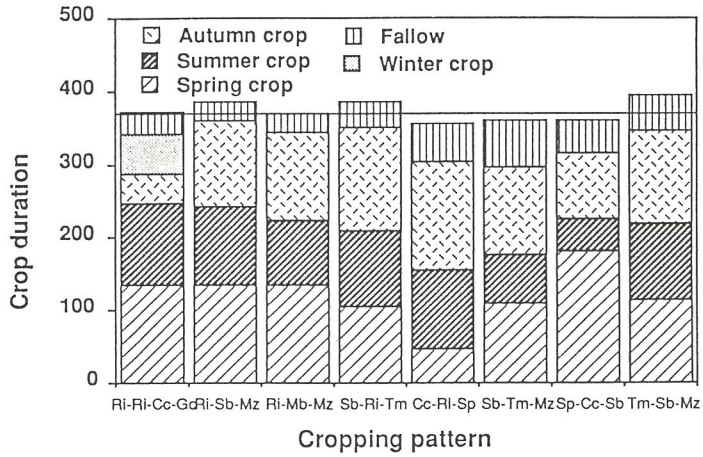


Fig. 6.
Total crop duration of different cropping patterns.

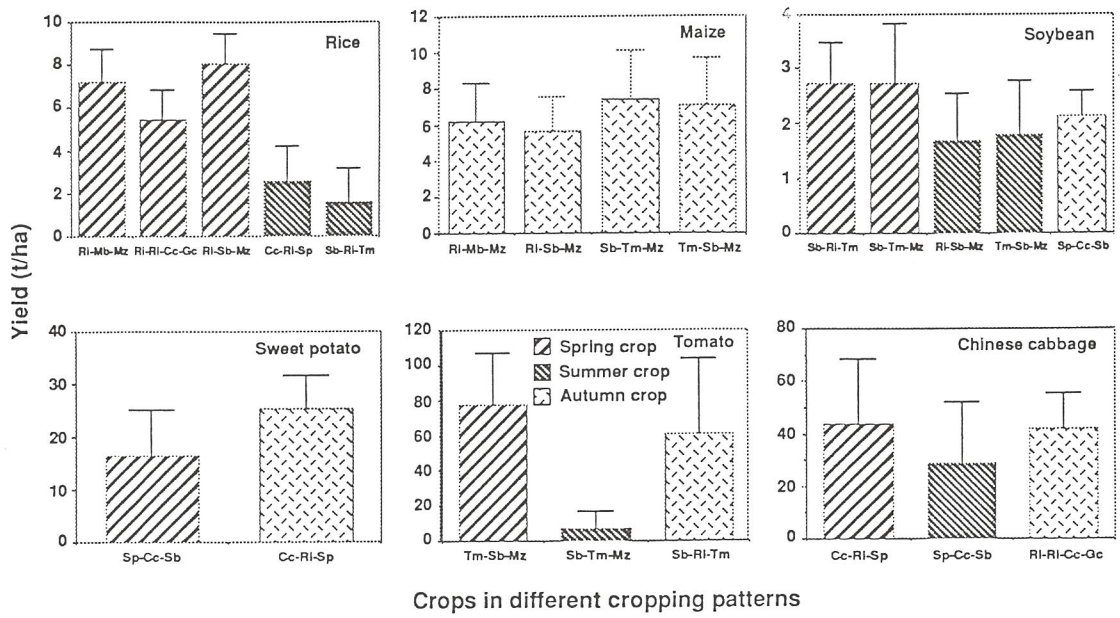


Fig. 7. Yield of crops in different cropping patterns.

Soil Science

Fertilizer Management for Sustainable Soybean Cultivation Under Continuous Cropping

Summary

Tropical soybeans (AGS 129, KS 8) have been cultivated 16 times successively on the same land to study fertilizer management for sustainable soybean production under continuous cropping.

No symptoms of the continuous cropping hazard have been observed even after 16 consecutive cultivations. The cumulative annual yields of AGS 129 and KS 8 reached 10.6 and 9.6 t/ha, respectively.

Compost application did not increase the yield of tropical soybean, but long-term application of compost minimized the yield loss due to charcoal rot (M.P.). Soil N and P increased gradually with successive compost applications but decreased in soils without compost as the frequency of cultivation increased.

Nutrient budgeting for P and K showed a positive value after two cultivations and then increased sharply. Without compost application, both nutrients also showed a positive value; P increased with the cultivation frequencies; but K did not show any cumulative effects.

In the N budgeting, compost application resulted in a negative budget up to the first four cultivations, but finally became positive. On the other hand, N budgeting was negative throughout the sixteen cultivations in the plots without compost. This implies that a large quantity of N is supplied by sources other than fertilizers and soil N, i.e., symbiotic N fixation.

There were no significant differences in the soybean yields between plots with and without compost over six years. Hence, a high rate of chemical fertilizer application alone can sustain reasonably high yields of soybean in the tropics for several years under continuous cropping without any hazardous effects. Compost application may ease the yield loss due to diseases.

Introduction

Under intensive farming, an adequate crop rotation should be adopted to avoid continuous cropping hazards, preserve soil organic matter, balance soil nutrients, and sustain high soil productivity. Soybean yield was reported to have decreased greatly after three successive cultivations on the same land in temperate regions. Previous reports indicated that cultivation of legumes increased soil N and K. Thus, generally, fertilizer recommendation for soybean is quite low. However, it is impossible to obtain high yield as well as to sustain high soil productivity for long periods under low input conditions. This project, initiated in 1983, was continued in successive years in an attempt to evaluate the effect of different cultural practices on soybean. It also aimed to determine the period in which soybean can be cultivated continuously on the same piece of land without great loss of yield. The goal is to maximize soybean yield, hence, high inputs of compost and fertilizer were applied. This report aimed to establish a fertilizer management regime for sustainable soybean production under continuous cropping based on data collected over the past six years, and trace the nutrient changes and balances in soils during prolonged cultivation.

Materials and Methods

Since 1983, soybean has been cultivated successively in the same experimental plots twice a year in spring and autumn. Summer planting also started in 1986, and the detailed cropping sequence is presented in Table 1. In spring 1988, soybean was infected by charcoal rot disease. The experimental field had been submerged and had lain fallow in summer 1988.

The experiment used a split plot design with two replications. The subplot consisted of cultivar Kaohsiung # 8 (KS 8) as a check (a broad-leaf, determinate cultivar) and AGS 129 (narrow-leaf type, indeterminate, high yielding cultivar). Details of the treatments are summarized in Table 2. Pests and diseases were controlled following recommended AVRDC cultural practices. Plant population was 400,000 plants/ha at sowing time, but actual population was determined at each harvest.

Yield and yield components were measured at R_8 stage. After harvest, soil samples were collected to determine the pH, electric conductivity (E.C.), total nitrogen, organic matter and available P and K. Plant samples were also collected and separated into root, stem, leaf, pod shell, and seed for analysis of major nutrients.

Table 1. Cropping sequence and growth duration in continuous cropping of soybean, 1983 to 1989.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1983									S	---------	93	---H
1984			S	----107	---------	H			S	---------	88	--H
1985		S	-------	116	--------	H			S	--------	89	---H
1986			S	-----117	----------	H		S---103	---------	H S	--109	----
1987	------	H S	---104	---------	H S	---------	119	-----	H S	------	97	-----
1988	-H	S	-------	119	--------	H	---submerged---		S	----------	97	--H
1989		S	-------	116	--------	H		S-----101	-------	H S	----	97-----
1990	---H											

S: Sowing date H:Harvest date *:Numbers between sowing and harvest date indicate the days of growth duration.

Table 2. Treatments used in continuous cropping of soybean since 1983.[a]

Year	Planting Season	Cropping Sequence	Main plots: Compost applied (t/ha)		Subplots: Cultivars		Fertilizer application: N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
1983	Autumn	1	0	20	AGS 129	---	60	60	90
1984	Spring	2	0	0	AGS 129	KS 8	40	60	80
1984	Autumn	3	20	20	AGS 129	---	40	60	80
1985	Spring	4	0	30	AGS 129	KS 8	100	60	80
1985	Autumn	5	0	30	AGS 129	KS 8	100	60	80
1986	Spring	6	0	50	AGS 129	KS 8	150	113	120
1986	Summer	7	0	50	AGS 129	KS 8	120	105	90
1986	Autumn	8	0	50	AGS 129	KS 8	120	105	90
1987	Spring	9	0	50	AGS 129	KS 8	120	105	90
1987	Summer	10	0	50	AGS 129	KS 8	120	105	90
1987	Autumn	11	0	50	AGS 129	KS 8	120	105	90
1988	Spring	12	0	50	AGS 129	KS 8	120	105	90
1988	Autumn	13	0	50	AGS 129	KS 8	120	105	90
1989	Spring	14	0	50	AGS 129	KS 8	120	105	90
1989	Autumn	16	0	50	AGS 129	KS 8	120	105	90

[a]The split plot design was used with compost application as main plot and cultivars as subplot.

Results and Discussion

Yields

Annual variation. The average yield of each cultivar with or without compost application is presented in Figs. 1 and 2. Soybean plants did not show any symptoms of continuous cropping hazards even after 16 successive cultivations. Yields in spring increased year after year reaching 4.7 t/ha in 1987. Total yield per annum of AGS 129 and KS 8 were 10.6 and 9.6 t/ha in 1987, respectively.

In autumn 1986 and 1989, sowing of soybean was delayed due to conditions which attended summer planting. Temperature and light intensity decreased in later growth stages, resulting in low yield of AGS 129. Since summer planting in 1986 was seriously damaged by typhoon and beanfly, the yield was relatively low in both cultivars.

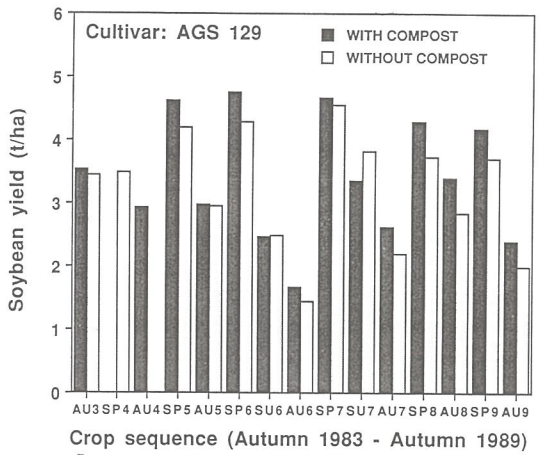


Fig. 1. Yield of soybean cultivar AGS 129 in continuous cropping.

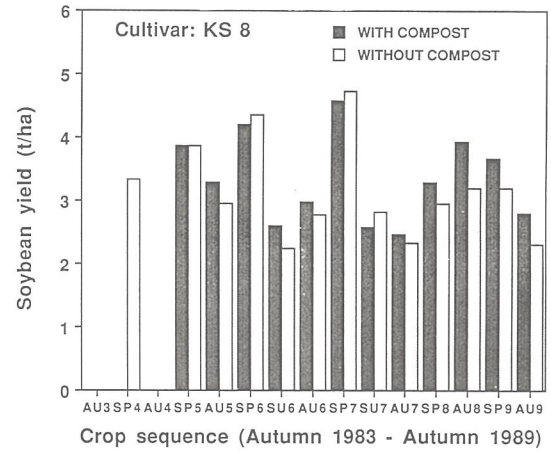


Fig. 2. Yield of soybean cultivar KS #8 in continuous cropping.

Seasonal variation. Seasonal variation in yield was greater than those in other treatments. Cultivation in spring resulted in significantly higher seed yield than that in autumn due to a long growth duration. From the pod-filling stage, daily air temperature and solar radiation gradually increased and resulted in prolonged pod-filling period and high pod-filling ratio. On the contrary, from the pod-filling stage of the summer cultivation, temperature and solar radiation started to decrease, and vigorous vegetative growth frequently caused a lodging problem in the pod-filling stage. As a result summer yields were slightly lower than those in autumn.

Effect of compost application. Compost application either increased soybean yield or greatly changed its yield components at the beginning of 10 consecutive cultivations (Figs.1-2). However, soybean yield already surpassed 4 t/ha with or without compost application. A sufficient amount of organic materials had been supplied even to the plots without compost through incorporation of the mulched rice straw and plant residues; this reduced the compost effects. The long-term effects of compost application became more visible starting autumn 1987 due to the gradual accumulation of organic matter and nutrient content in the soil.

Due to charcoal rot infection in spring 1988, yields of both cultivars dropped significantly. With compost application, yield of AGS 129 and KS 8 from spring 1987 to spring 1988 decreased from 4.7 to 4.3, and 4.6 to 3.3 t/ha, respectively. On the other hand in plots without compost, yield decreased from 4.6 to 3.7, and from 4.7 to 3.0 for AGS 129 and KS 8 (Table 3). Long-term application of compost eased the damages caused by the disease.

Table 3. Effect of long-term application of compost on yield loss due to charcoal rot (*Macrophomina phaseloina*).

Treatment	Yield (t/ha)		Pods/plant		100-seed wt.		Seeds/pot	
	SP7[a]	SP8[b]	SP7	SP8	SP7	SP8	SP7	SP8
AGS 129, w/compost	4.7	4.3	26.6	30.8	18.0	18.4	2.3	2.1
AGS 129, wo/compost	4.6	3.7	25.0	28.2	18.0	18.4	2.4	2.0
KS 8, w/compost	4.6	3.3	23.9	17.5	26.2	29.6	2.0	1.8
KS 8, wo/compost	4.7	3.0	21.9	16.9	27.2	26.1	2.0	1.8

[a]SP 7: spring 1987; SP 8: spring 1988. [b]Cultivation in spring 1988 was infected by charcoal rot disease.

Comparison in cultivars. Yield decrement due to charcoal rot was much greater in KS 8 than in AGS 129. The charcoal rot disease infected both cultivars at the pod-setting stage, which resulted in yellowing of leaves. KS 8 is a broad-leaf cultivar and its leaves are very sensitive to charcoal rot. The yellowish leaf areas were also much larger than those of AGS 129. These characteristics made KS 8 prone to charcoal rot which greatly reduced the number of pods. This, in turn, resulted in a yield loss higher than that of AGS 129. Judging from overall yield mean in 6 years, AGS is a better cultivar than KS 8.

In 1986 and 1989, delayed planting resulted in shortened growth duration of the autumn soybean, and caused the production of many immature pods in AGS 129. KS 8, however, produced nearly 3 t/ha of seeds because of the initial vigorous growth characterized by its broad-leaf and determinate genotype.

Variation in yield components. The yields of both cultivars increased with an increase in pod number, i.e. yield level ranging from 3 to 4.8 t/ha, pod number of AGS 129 ranging from 19 to 32, and from 17 to 24 in KS 8. This implied that AGS 129 is more dependent on pod numbers than KS 8 for high yields. Previous studies revealed that pod number of soybean is determined from flower initiation (R_1) to flowering (R_2) stage. Therefore, cultural practices that will accelerate its initial growth are essential to obtain high yield.

There was great seasonal variation in 100-seed weight in both cultivars. KS 8 had large seeds, with the 100-seed weight varying from 22-25 g in autumn and 26-34 g in spring; AGS 129 had an average 100-seed weight of 15-19 g in autumn and 18-23 g in spring. Top application of N fertilizer at R_4 stage was effective to produce large seeds, thus, active fixation of N at the later growth stage and its smooth translocation to the seeds should be ensured.

Seed number per pod seemed to be a genetically fixed yield component and was not greatly different between cultivars. Although it had some seasonal variation, the differences were minor. Since the other two yield components contributed more to soybean yield than this component, improving yield through it was more difficult.

Nutrient concentrations and partitioning to different plant parts. Soybean seeds contained about 6.0-7.0 %, 0.55-0.65 %, and 1.0-2.0 % of N, P and K, respectively. These nutrient concentrations in each plant part were not much influenced by application of compost and increased rate of fertilization. The difference in planting time was not significant either.

Nearly 80 %, 75-85 % and 55-60 % of the total uptake of N, P and K, respectively, were accumulated in soybean seeds. This indicated that plowing back of soybean residues does not greatly increase soil N, P and even K content as was commonly reported. These nutrition partitions in plant parts were almost the same in 6 years (Fig. 3).

Relation of nutrient uptake to yield and dry matter. Multiple regression analysis was applied to clarify factors affecting soybean yield and dry matter production. Nearly 90% of total dry matter production could be explained by total nitrogen uptake. Thus, to produce 4 t/ha of dry seed, 300 kg/ha of N should be absorbed by soybean plants. Soybean plants absorb much more N than the N applied. A large amount of N absorbed was supplied by symbiotic N fixation.

Changes in soil nutrient concentration. Changes in soil organic matter, total nitrogen and available P_2O_5 and K_2O were traced over 13 successive cultivations. Soil organic matter increased

gradually by year, and reached its peak in the last 2 years of cultivation (Fig. 4). In autumn 1984, all plots received 20 t/ha of compost. Thus, the organic matter content in plots with and without compost was almost the same. Deep plowing was used in plots applied with compost for several first cultivations; this caused the organic matter in the subsoils to increase. On the other hand, organic matter in soils without compost application showed a decreasing tendency after 16 successive cultivations of soybean.

A similar trend was observed in total nitrogen in soils with and without compost (Fig. 5). This indicated that N availability is closely related to total soil N which in turn is closely related to soil organic matter.

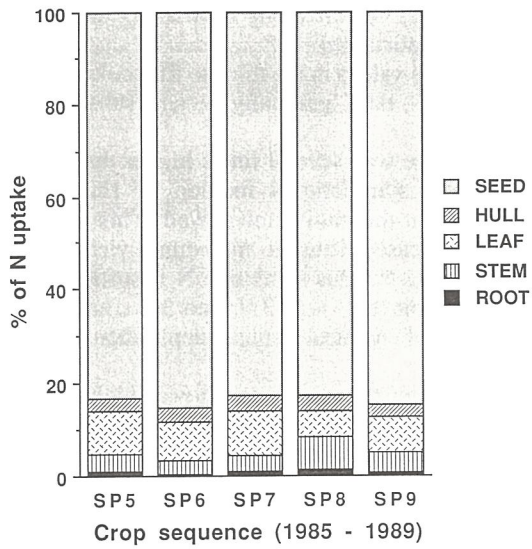


Fig. 3.
N partitions in different plant parts of AGS 129 (in spring with compost).

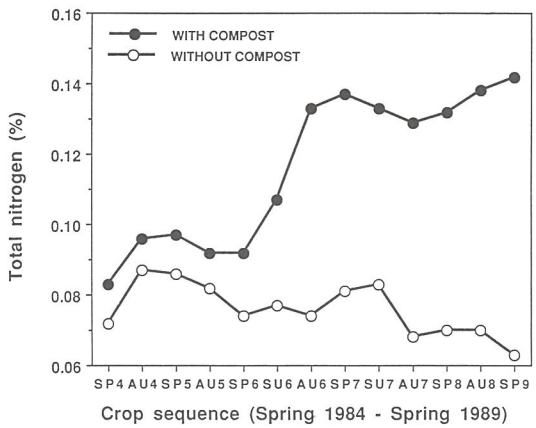


Fig. 4. Changes in soil organic matter in continuous cropping of soybean at AVRDC.

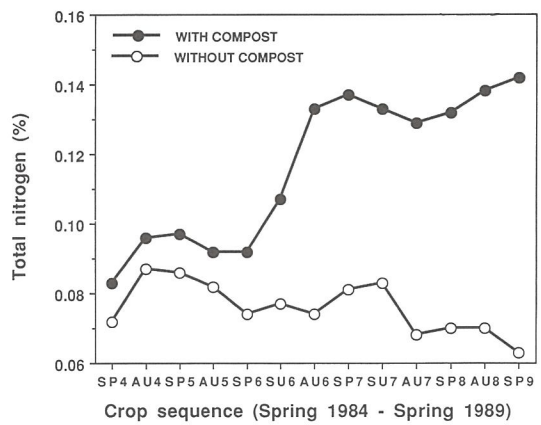


Fig. 5. Changes in soil total nitrogen in continuous cropping at AVRDC.

Compost application greatly increased soil phosphorus (P) which reached its peak at the seventh consecutive cropping. However, soils without compost showed a tendency to have less available P, even with the application of chemical fertilizer P. This indicated that a great amount of bioavailable P was converted into insoluble form, either held tightly on the active sites of the soil surface or precipitated as calcium phosphate complex, resulting in the decrease of available P.

Unlike P and N, soil potassium (K) slightly increased even in plots without compost and greatly increased in compost-applied plots. Fluctuation of K at different planting times was more

pronounced than that of other nutrients. K concentration in soils varied in reverse proportion to the amount of rainfall.

Soil pH varied only by one unit over the 16 successive cultivations, and remained in a desired range for soybean growth. Soil EC varied within the safe range of 0.1 to 0.7 mmho/cm for most crops. Planting time affected soil EC more than the amount of fertilizer applied. Autumn planting increased soil EC while spring planting decreased it greatly, because cation accumulation is always associated with rainfall.

Nutrient budgeting. Cumulative nutrient budgeting was calculated by subtracting the output (nutrient uptakes) from the input (fertilizer plus compost application).

The N budgeting in compost-applied plots showed negative values in the third to fifth cultivations. It was well-balanced during the sixth to the eighth cultivations, then, gradually became substantially positive at later cultivations.

In plots not applied with compost, however, the N uptake was several times higher than the N input. Hence, a sizable amount of N was supplied from symbiotic N fixation by rhizobium. Consequently, a large negative value was obtained throughout the cultivation period. This negative budgeting became greater as the number of cultivations increased. Thus, to maintain a yield of 2.5 t/ha or below, a low rate of N fertilization (i. e. 40-60 kg/ha N) plus symbiotic N is sufficient for soybean growth. However, if a maximum yield level is sought (e.g. 4.5, 3.0, and 3.5 t/ha of seed yield in spring, summer and autumn, respectively), a high rate of chemical fertilizer application (without compost) should be proposed.

Unlike N balance, both the P_2O_5 and K_2O balance in compost-applied plots showed high positive values which increased steeply as cultivations proceeded. Compost application greatly increased not only the available forms of P_2O_5 and K_2O in soil, but also the organic forms of these nutrients. These large accumulations of soil P and K in turn may bring on salt injuries under continuous cultivation in the future. Therefore, it is recommended to decrease the compost application.

Without compost, P_2O_5 and K_2O budgeting showed positive values throughout all cultivations. In the case of P_2O_5, the budgeting increased continuously as the number of cultivations increased. On the contrary, K_2O showed a decreasing trend. Even though P_2O_5 budgeting was positive, the available P in soil decreased. P fertilizer was supplied in adequate amounts. As a result, P was gradually deposited in soil as insoluble forms. On the other hand, the K uptake of soybean in plots without compost was slightly more than the K applied, and varied seasonally with the yield obtained. This implied that a small part of K was supplied from the irrigation water and soil organic matter. Soybean cultivation caused fluctuations of available K in soil.

Conclusions

From the results, the following conclusions can be drawn:

- Soybean is far more suitable for continuous cropping than mungbean. Continuous soybean cultivation is one of the promising cropping systems in the tropics.
- To obtain high soybean yield (more than 3.0 t/ha/season), choose the planting time properly and ensure proper duration.
- Pod number is a major yield component of AGS 129, while KS 8 is much more dependent on the 100-seed weight. To obtain high soybean yield in the tropics, proper cultivation and fertilizer management should be adopted.
- Organic matter, N and P_2O_5 gradually increased in soils continuously applied with compost. Without compost application nutrients in soils decreased gradually during continuous cropping. Soil K_2O slightly increased in plots without compost and greatly increased in plots applied with compost.
- With compost application, P_2O_5, and K_2O increased. But N budgeting showed a negative value up to the first four cultivations, and became positive in later cultivations. In plots without compost, budgeting of both P_2O_5 and K_2O also showed positive values, while N budgeting showed negative values throughout all cultivations.

- A high rate of chemical fertilizer application (N-P_2O_5-K_2O= 120-105-90 kg/ha) alone as base at R_1 and R_4 stages can be recommended to sustain a reasonably high yield of soybean in the tropics under continuous cropping without any hazardous effects.

Effect of Organic Fertilizer on Quality and Yield of Vegetable Soybean

Summary

Application of 120 t/ha of sugarcane compost (SCC) did not result in significantly higher graded and total pod yields compared to the control plots in both autumn and spring cultivations. Soil fertility in the experimental field was high and therefore fertilization was not a limiting factor in promoting vegetable soybean yield.

Applications of SCC and Taiwan organic fertilizer No. 1 greatly improved all nutrient concentration in soil before the first topdressing except soil pH which decreased as the amount of sugarcane compost increased. The increments of soil nutrients reflected the composition of organic fertilizer. Soil organic matter decomposed very fast, the effect on the soil lasting only up to the end of one successive cultivation.

Soil chemical properties were positively correlated with starch and fiber content, but negatively with protein content and hardness of vegetable soybean seeds. Since the relationship between the taste of vegetable soybean and the detectable chemical compositions has not been well established, it was difficult to determine the effect of soil nutrient concentration on the quality of vegetable soybean.

Introduction

This study was initiated in autumn 1988 to increase the production of high quality vegetable soybean using five kinds of organic fertilizers. Summarized results from three trials (autumn 1988 and spring and summer 1990) indicated that the effects of organic fertilizers were not obvious on both yield and selected quality properties. This might be due to insufficient of applications. Therefore, in the succeeding trials, the application amount was increased to 120 t. Two organic fertilizers, i.e., sugarcane compost (SCC) and Taiwan organic fertilizer, TF #1 were included. Experiments were continued in autumn 1989 and spring 1990. The relationships between soil properties and the quality of frozen vegetable soybean from these five experiments were examined.

Materials and Methods

Treatments used for the autumn 1989 and spring 1990 cultivations are listed in Tables 4 and 5, respectively. Both SCC and TF #1 were applied in the autumn trial, while only SCC was used in the spring experiment.

Vegetable soybean cultivar AGS 292 was sown on 5 October and harvested on 12 December for autumn cropping of 1989; sown on 14 March and harvested on 22 May for spring cropping of 1990.

Soil samples from each plot were collected before planting, at flowering stage and at harvest, and analyzed for soil pH, electric conductivity (EC), total nitrogen, total carbon, available P_2O_5, K_2O, Ca, and Mg. Vegetable soybean harvested at R_6 stage was analyzed for dry matter, protein, fat, sugar, starch, fiber contents, hardness, and pod color rating. Linear regressions were applied for those parameters.

Results and Discussion

Effect of application of organic fertilizer on yield. Application of a high amount of sugarcane compost (120 t/ha) did not produce significantly higher graded and total pod yields compared to those in the control plots in both cultivations (Table 1 and 2). Graded ratio of pod yield reached 70-75% in all treatments. This implied that soil fertility in the experimental field was high and that fertilization was not a limiting factor in promoting vegetable soybean yield.

Table 4. Effect of organic fertilizer application on yield of vegetable soybean (AGS 292), autumn 1989.

Treatment	Graded yield (t/ha)	Ungraded yield (t/ha)	Total yield (t/ha)	Graded ratio (%)
SCC 40 t/ha	8.2 a	3.1 a	11.3 a	72.79 a
SCC 80 t/ha	8.8 a	2.9 a	11.7 a	75.01 a
SCC120 t/ha	8.3 a	3.1 a	11.4 a	72.43 a
TF #1 15 t/ha	8.3 a	2.9 a	11.2 a	73.73 a
TF #1 30 t/ha	8.0 a	3.1 a	11.1 a	72.20 a
Control	8.3 a	2.6 a	11.0 a	75.95 a

SCC = sugarcane compost; TF = Taiwan Fertilizer.

Table 5. Effect of organic fertilizer application on yield of vegetable soybean (AGS 292), spring 1990.

Treatment	Graded yield (t/ha)	Ungraded yield (t/ha)	Total yield (t/ha)	Graded ratio (%)
SCC 40 t/ha	8.4 a	3.0 a	11.3 a	74.04 a
SCC 80 t/ha	7.8 a	3.3 a	11.1 a	69.84 a
SCC 120 t/ha	9.2 a	3.5 a	12.7 a	72.17a
Standard NPK	9.4 a	3.1 a	12.5 a	74.80 a
Double NPK	8.4 a	3.0 a	11.4 a	73.34 a
1/3 NPK	8.3 a	2.8 a	11.1 a	75.05 a

Standard NPK = 60 N: 82.5 P_2O_5, 60 K_2O kg/ha; Double NPK = 120-165-120; 1/3 NPK = 20-30-20

Changes of major soil chemical properties. In the autumn trial, a new field was selected. Soil properties before planting were uniform in all respects. Applications of SCC and TF #1 greatly improved all nutrient concentrations in soils before first topdressing except soil pH which decreased as the amount of sugarcane compost increased. The increments of soil nutrients revealed that organic fertilizer, TF #1, contained much higher P_2O_5, K_2O and Ca. It can be concluded that the application of 30 t/ha of TF#1 was more effective in raising the nutrient level than the application of 120 t/ha of SCC. These effects lasted until harvest. One harvest of vegetable soybean did not diminish soil nutrients.

In the spring trial, the same field and plot number was adopted, so that soil nutrient could be monitored for two cultivations. In treatments no. 4 to 6, only chemical fertilizer was applied, resulting in a significant drop in nutrient concentration from planting to flowering stage. At harvest, organic matter (total C) in the three treatments became almost the same. This suggested that the fluctuation of soil organic matter is strongly associated with application of organic fertilizer which decomposed quickly.

Selected quality properties. Chemical analysis of some quality related compositions of autumn and spring soybean are listed in Tables 6 and 7, respectively. In the autumn trial, TF #1 application decreased dry matter and protein content, but increased starch and crude fiber content in vegetable soybean seeds. However, most of the compositions were not significantly affected by organic fertilizer application.

Table 6. Selected quality properties of vegetable soybean (AGS 292) grown in autumn 1989.

Treatment	Pod color rating	Dry matter (%)	Protein (%)	Fat (%)	Sugar (%)	Starch (%)	Crude fiber (%)
SCC 40 t/ha	4.36 a	31.99 ab	40.15 a	16.98 a	13.68 a	9.48 ab	4.20 a
SCC 80 t/ha	4.43 a	31.86 ab	40.13 a	17.12 a	13.48 a	9.67 ab	4.23 a
SCC 120 t/ha	4.52 a	32.01 a	40.28 a	16.92 a	13.60 a	9.26 b	4.25 a
TF #1 15 t/ha	4.48 a	32.08 a	39.47 ab	17.38 a	13.34 a	9.61 ab	4.33 a
TF #1 30 t/ha	4.38 a	31.37 b	38.70 b	16.91 a	13.74 a	9.99 a	4.36 a
Control	4.43 a	32.27 a	40.27 a	17.13 a	13.57 a	9.25 b	4.28 a

SCC = sugarcane compost; TF = Taiwan Fertilizer.

Table 7. Selected quality properties of vegetable soybean cultivar AGS 292 grown in spring 1990.

Treatment	Pod color rating	Dry matter (%)	Protein (%)	Fat (%)	Sugar (%)	Starch (%)	Crude fiber (%)	Hardness (kg)	Free amino nitrogen (%)
SCC 40 t/ha	2.34 a	30.51 a	40.81 ab	19.02 ab	10.90 a	4.84 bc	8.34 bc	3.29 ab	0.125 a
SCC 80 t/ha	2.18 a	29.17 b	40.18 bc	18.61 ab	11.54 a	8.35 b	4.88 bc	3.09 ab	0.121 a
SCC 120 t/ha	2.37 a	29.47 ab	40.40 abc	18.49 b	11.10 a	8.52 b	4.81 bc	2.86 b	0.124 a
Standard NPK	2.30 a	30.45 ab	40.12 bc	19.20 a	11.04 a	8.62 ab	4.93ab	3.13 ab	0.125 a
Double NPK	2.38 a	29.94 a	39.66 bc	19.18 a	10.71 a	9.15 a	5.02 a	3.29 ab	0.125 a
1/3 NPK	29.76 ab	41.18 a	19.12 a	10.94 a	8.21 b	4.74 c	3.59 a	0.126 a	

Standard NPK = 60 N: 82.5 P_2O_5, 60 K_2O kg/ha; Double NPK = 120-165-120; 1/3 NPK = 20-30-20

In the spring trial, application of SCC was increased from 40 t/ha to 120 t/ha. No obvious effects were detected on most quality properties. However, increasing chemical fertilizer dosage from one third to double revealed the following trends: decrease in protein content and increase in starch and fiber content. These quality-related trends were found to be closely related to nutrient concentrations in the soil.

Linear regression was applied and correlation coefficients were computed. Negative correlations existed between soil properties and protein content and hardness. On the contrary, most positive coefficients were obtained between starch, fiber contents and soil nutrients. Similar results held true for five sequential trials, except that the correlation with starch became more negative.

Combined results of the five experiments showed that dry matter content and pod color rating were also negatively correlated with soil properties at significant levels. Since the relationship between the taste of vegetable soybean and the detectable chemical compositions were not well established in terms of eating quality, it was difficult to determine the effect of soil nutrient concentration on quality of vegetable soybean.

Cultural Practices for Sweet Pepper

Summary

Plastic sheet mulching produced significantly higher fruit yield and more fruit in sweet pepper than rice straw mulching and without mulching in autumn. High seedling pot kept the soil wet around the roots after transplanting, decreased transplanting shock and enhanced root establishment.

Improved high pot with painting or covering increased both marketable fruit number and weight. It protected plants from disease infection.

Cultivar PM-17 possessed a yield level similar to that of the cultivar Blue Star. However, the shape and color of this cultivar were less acceptable in the local market.

Sweet pepper was extremely sensitive to soil moisture status immediately after transplanting. Therefore, cultural practices to raise healthy seedlings, such as the use of plastic mulching, high seedling pot and irrigation of the field before transplanting are important to support active rooting during the growth period of sweet pepper.

Introduction

Experiments were conducted to develop cultural practices for improving the growth and yield of sweet pepper.

High temperature, flooding, insect damage and virus infection are the major constraints in sweet pepper production in the tropics. Compared with other vegetables, the development of plant roots required more abundant soil moisture, good aeration and heavy fertilization even in autumn season. A healthy root system strengthens the plant's resistance to disease infection. Many cultural practices developed previously for tomato and Chinese cabbage were found very effective for healthy rooting in sweet pepper.

Materials and Methods

Three experiments were conducted at the same time in autumn 1989. The first trial used split-split plot design with bed mulching as the treatment in the main plot, seedling pot in the subplot, and fertilization method in the sub-subplot. Seeds of the sweet pepper cultivar Blue Star were sown in seedling medium (soil:sugarcane compost:sand:rice husk=3:1:1:1) for both PE pot and high pot on 8 September, transplanted to the field on 13 October, and harvested on 7 and 27 December 1989 and 24 January 1990. Fertilization methods are presented in Table 1.

The second experiment adopted the split-plot design. The main treatments were application of lime, and comparative subplot studies of Blue Star (check) cultivars and the new cultivar, PM-17. Plastic mulching, PE pot seedling and first fertilization method were applied in this trial.

The third trial was carried out in a randomized complete block design with two replications. Different high pot seedling methods were compared with ordinary PE pot in the treatments. The high pots were either painted white on the outside or covered with aluminum foil. Cultivar Blue Star and plastic mulching were used.

Results and Discussion

In experiment 1, plastic sheet mulching produced significantly higher fruit yield, and larger fruits than the other two mulch treatments (Table 8). Rice straw mulch increased the marketable fruit number and total fruit yield slightly but not the fruit size. The plastic sheet preserved the soil moisture in

Table 8. Effect of mulching, seedling pot and fertilization on marketable fruit weight, marketable fruit number and yield (Autumn 1989).

Treatment	Marketable fruit number (no./m2)			Total fruit ($no./m^2$)	Marketable fruit size (g/fruit)			Marketable fruit yield (t/ha)			Total fruit ($no./m^2$)
	1st Harvest	2nd Harvest	3rd Harvest		1st Harvest	2nd Harvest	3rd Harvest	1st Harvest	2nd Harvest	3rd Harvest	
Main plot: Mulching											
Check	0.83 b	1.12 b	0.56 b	5.06 c	68.25 b	66.00 b	56.18 a	0.56 b	0.68 b	0.35 b	2.11 b
Plastic sheet	4.98 a	6.09 a	5.13 a	28.48 a	96.45 a	90.03 a	73.29 a	4.86 a	5.53 a	3.77 a	17.20 a
Rice straw	1.89 b	2.62 b	1.35 b	11.08 b	78.55 ab	70.94 ab	56.48 a	1.56 b	1.88 b	0.78 b	5.23 b
Sub-plot: Type of seedling pot											
High pot	3.23 a	3.29 a	2.35 a	14.68 a	83.08 a	72.89 b	58.19 b	2.98 a	2.64 a	1.63 a	8.60 a
PE pot	1.91 b	3.27 a	2.34 a	15.07 a	79.08 a	78.42 a	65.78 a	1.67 b	2.76 a	1.63 a	7.76 b
Sub-subplot: Fertilization											
Fertilization 1	2.36 a	2.88 a	2.19 a	12.96 a	75.94 a	80.67 a	65.75 a	2.09 a	2.39 a	1.53 a	7.26 a
Fertilization 2	2.80 a	3.23 a	2.36 a	16.29 a	84.13 a	72.50 b	63.00 a	2.58 a	2.59 a	1.62 a	8.58 a
Fertilization 3	2.53 a	3.72 a	2.48 a	15.38 a	83.17 a	73.80 b	57.20 a	2.31 a	3.11 a	1.75 a	8.70 a

[a] 1st, 2nd and 3rd harvest were carried out at 55, 75 and 103 days after transplanting, respectively.

[b] Sub-subplot treatment:

Fertilization	N	P^2O^5	K^2O
Basal	120	120	120
Top 1 (3 WAT)	50	12.5	25
Top 2 (6 WAT)	50	12.5	25
Top 3 (9 WAT)	50	12.5	25
Total	270	157.5	195
Basal	120	180	120
Top 1 (3 WAT)	60	30	45
Top 2 (6 WAT)	60	30	45
Top 3 (9 WAT)	60	30	45
Total	300	270	255
Basal	90	150	90
Top 1 (15 DAT)	30	0	0
Top 2 (30 DAT)	45	0	90
Top 3 (45 DAT)	45	0	0
Top 4 (9 WAT)	60	0	0
Total	270	150	180

the bed which helped the sweet pepper seedlings to get established after transplanting. On the other hand, the establishment of plants in both check and rice straw mulched beds were very poor even though irrigation followed immediately after transplanting. This indicated that the traditional method of transplanting tomato and Chinese cabbage may not be applicable to sweet pepper. Hence, the relationship among soil moisture and transplanting method to decrease transplanting shock and root development after transplanting has to be evaluated.

The high pot produced slightly higher marketable fruit number and yield at the first harvest, but it was not superior to others at the second and third harvests. It has a similar effect as plastic mulch, decreasing transplanting shock and enhancing root development after transplanting. Because this trial was conducted in autumn, the effect of high pot in decreasing disease infection was not shown.

Due to poor vegetative growth and serious infection by various viruses, the effect of fertilization was clearly seen.

Liming did not show any effect on the amount of yield and on the intensity of disease infection (Table 9). Cultivar PM-17 produced significantly more fruits at the second and third harvests, but it possessed smaller fruits. This resulted in similar fruit yield. PM-17 seemed more tolerant to some viruses; however, the long shape of the fruit and slightly green skin color may be less acceptable in the local market.

The high pot painted white outside or covered with aluminum foil kept insects away from the plants, making disease infection and virus transmission less likely. Results in Table 10 showed that the treatments grown in the high pot increased marketable fruit number and weight at first harvest. Total fruit yield was higher here than in the high pot without treatment and the PE pot, but the differences were not statistically significant.

Results suggested that cultural practices to keep roots active throughout the whole period of cultivation are very important in sweet pepper production. Mulching and improved high seedling pot are promising techniques for summer cultivation.

Effect of mulching and split fertilizer application on yield and internal rot incidence of Summer Chinese Cabbage

Summary

For summer Chinese cabbage, the effect of bed mulching treatments upon the yield and incidence of internal rot of four cultivars (two ordinary cultivars; ASVEG # 1 and Hybrid 82-156, one newly developed cultivar; Hybrid 86-181 and one local cultivar; Shang-Hsi (as a check)) was examined at different application rates of fertilizers.

Rice straw and double layer mulching treatments were confirmed to be very effective compared to plastic sheet mulching even under unfavorable weather circumstances such as typhoons and long periods of rainfall.

The new cultivar, Hybrid 86-181, was promising in terms of yield and resistance to internal rot.

A basal fertilizer treatment at higher application rates contributed more to production than low rates of application due to unusual weather conditions such as heavy rain and flooding. No differences were observed on the effects of fertilizer treatments on incidences of both internal and marginal rot under the present cultivation conditions.

Introduction

This experiment tried to confirm the cultural practices for Chinese cabbage cultivation and to determine the effects of mulching and split application of fertilizer on newly developed cultivars in summer.

Materials and Methods

The experiment was conducted in summer 1990 using a split-split design with two replications. The main plot adopted three-bed mulching treatments with 1) plastic film, 2) rice straw and 3) double-

Table 9. Effect of liming and cultivars on the marketable fruit yield and marketable fruit number of sweet pepper (autumn 1989).

Treatment	Marketable fruit number (no./m^2)			Total fruit (no./m^2)	Marketable fruit size (g/fruit)			Marketable fruit yield (t/ha)			Total fruit (no./m^2)
	1st Harvest	2nd Harvest	3rd Harvest		1st Harvest	2nd Harvest	3rd Harvest	1st Harvest	2nd Harvest	3rd Harvest	
Main plot: Mulching											
Lime application	9.7 a	11.6 a	6.3 a	45.6 a	78.4 a	71.1 a	53.9 a	6.6 a	7.6 a	3.2 a	20.55 a
Check	8.8 a	11.7 a	6.9 a	45.8 a	72.0 a	70.0 a	53.7 a	5.7 a	7.6 a	3.5 a	20.07 a
Sub-plot: Cultivars											
Blue Star	5.6 a	8.3 b	4.6 b	33.5 b	98.6 a	90.2 a	67.3 a	5.6 a	7.5 a	3.1 a	19.72 a
PM-17	12.9 a	15.0 a	8.6 a	57.8 a	51.8 b	50.9 b	40.4 b	6.7 a	7.6 a	3.5 a	20.90 a

1st, 2nd and 3rd harvests were carried out at 55, 75 and 103 days after transplanting, respectively.

	N	P_2O_5	K_2O
Basal	120	120	120
Top 1 (3 WAT)	50	12.5	25
Top 2 (6 WAT)	50	12.5	25
Top 3 (9 WAT)	50	12.5	25
Total	270	157.5	195

Table 10. Effect of high pot with white paint and with Al foil on the marketable fruit yield and marketable fruit number of sweet pepper (autumn 1989).

Treatment	Marketable fruit number (no./m^2)			Total fruit (no./m^2)	Marketable fruit size (g/fruit)			Marketable fruit yield (t/ha)			Total fruit (no./m2)
	1st Harvest	2nd Harvest	3rd Harvest		1st Harvest	2nd Harvest	3rd Harvest	1st Harvest	2nd Harvest	3rd Harvest	
High pot	5.8 ab	5.0 a	4.7 a	24.1 b	95.4 a	93.9 a	73.4 a	5.6 ab	4.7 a	3.4 a	16.1 a
High pot with aluminum foil	8.3 a	4.7 a	5.9 a	32.5 ab	105.0 a	91.3 a	76.3 a	8.7 a	4.3 a	4.5 a	20.8 a
High pot with paint	7.0 ab	7.4 a	4.6 a	35.6 a	104.2 a	91.6 a	72.8 a	7.3 ab	6.7 a	3.1 a	20.8 a
PE pot (check)	3.9 b	5.7 a	3.8 a	24.0 b	86.8 a	84.9 a	76.7 a	3.5 b	4.8 a	2.9 a	13.8 a

1st, 2nd and 3rd harvests were carried out at 55, 75 and 103 days after transplanting, respectively.

layer mulching with rice straw (inside). The subplot consisted of four Chinese cabbage cultivars: 1) ASVEG #1 (sensitive to internal rot, growth period: 35 days), 2) Hybrid 86-181, a new cultivar (sensitive to internal rot, growth period: 35 days), 3) Hybrid 82-156, i.e., Taoyuan ASVEG #2 (mildly sensitive to internal rot, growth period: 43 days) and Shang-hsi as a check (local variety, similar to Chang-puh, more resistant to internal rot, growth period: 35 days). The sub-subplot adopted two fertilizer treatments, F1 and F2, as shown in Table 11.

Table 11. Evaluation of cultural practices for summer Chinese cabbage — effect of mulching and split fertilization on yield and internal rot incidence (summer 1990).

Treatment	Head yield (t/ha)	Total yield (t/ha)	Harvest ratio (%)	Head plant no. ($no/7.2\ m^2$)	Internal rot index	Marginal rot index
Main plot: mulching						
Double layer mulch	9.32 a	18.79 a	75.52 ab	2.63 a	4.31 ab	3.19 a
Plastic sheet	5.69 b	13.66 b	59.38 b	3.38 a	1.38 b	2.00 a
Rice straw	9.22 a	18.19 a	84.90 a	2.06 a	5.88 a	2.38 a
Sub-plot: Cultivars						
ASVEG #1	7.87 ab	15.71 b	69.44 a	3.58 a	7.25 a	1.33 b
Hybrid 82-156	6.69 b	16.82 b	69.44 a	2.00 a	1.83 b	1.92 b
86-181	9.77 a	20.85 a	75.69 a	2.50 a	1.42 b	0.58 b
Shang-hsi	7.97 ab	14.14 b	78.47 a	2.67 a	4.92 ab	6.25 a
Sub-subplot: Fertilization ($N\text{-}P_2O_5\text{-}K_2O$)						
F1: 150-112.5-105	7.16 b	15.06 b	71.70 a	2.50 a	3.67 a	2.63 a
F2: 250-172.5-195	8.99 a	18.70 a	74.83 a	2.88 a	4.04 a	2.42 a

Size of the plot was 16 m^2 (1.5 m × 3 m × 3.6 m) with 48 plants/plot. There were 48 plots (3 × 4 × 2 × 2). The total experiment area was 777.6 m^2 (16.2 m × 48). Plant spacing was 45 cm between plants, two rows per bed with a width of 1.5 m.

Seedlings of the cultivars were transplanted on 31 July and harvested on 27 September 1990.

The harvested vegetables were measured for head and total yields and, at the same time, checked for internal rot incidence.

Results and Discussion

Mulching effect on head and total yield and incidences of internal rot and marginal rot. Both the double layer and rice straw mulchings proved to be very effective in Chinese cabbage production compared to the plastic sheet mulching (Table 11). Head yield and total yield showed no difference. The plastic sheet mulching, considered a useful mulching material widely used for this purpose, gave low head yield and total aerial parts.

This fact could be due to the increase in both air temperature and humidity inside the sheet covering under the unusual weather conditions (three typhoons and spells of rainy days) during the growth period.

All the three mulching treatments had almost the same effect on the incidence of marginal rot, but not upon the occurrence of internal rot.

The effectiveness of rice straw and double-layer mulching treatments was confirmed even under unfavorable weather conditions.

Head and total yields. The new cultivar, Hybrid 86-181, had the highest head and total yield and was more resistant to internal rot (and possibly to marginal rot) than ASVEG #1 and Shang-hsi, a local cultivar. This new cultivar is considered a promising one, based on its yield and resistance to internal rot.

Effect of fertilization upon the yield and the incidence of internal rot and marginal rot. Fertilizer treatment, F2, at higher application rates (N-P-K = 240-172.5-195 kg/ha) contributed more to Chinese cabbage production than F1 at low application rates (N-P-K = 150-112.5-105 kg/ha). No distinct effects were observed on the effects of fertilizer treatments on the occurrence of internal and marginal rot.

Under unusual weather conditions during the period of cultivation, plastic sheet mulching proved to be less effective than rice straw and double-layer mulching with rice straw (inside). It resulted in low yield due to increase in both air temperature and humidity inside the covering. Rice straw and double-layer mulchings were effective for increasing yield even under exceptional weather conditions, although, internal rot was observed to occur much more in the rice straw and double-layer mulching plots than in the plastic sheet mulching plot.

A new cultivar, Hybrid 86-182, was tested and compared with ASVEG #1 and Hybrid 82-156, and one local cultivar, Shang-hsi (check) for yield and resistance to internal rot. The new cultivar proved to be a promising.

A higher fertilizer application rate in basal dressing was shown to contribute greatly to production. No difference was observed among the fertilizer treatments in terms of incidence of internal rot and marginal rot under exceptional and adverse weather conditions.

Effect of cultural practices on minimization of internal rot and tipburn incidence on Chinese cabbage under typhoon conditions

Summary

This experiment determined the appropriate cultural practices for summer Chinese cabbage production; in particular, it looked into the minimizing effects of applying different practices on the incidence of internal and marginal rot and tipburn under unfavorable growing conditions of typhoons.

Among the practices applied under the same conditions of bed mulching with rice straw, PE pot cultivation, compared to high pot gave a higher head yield and total plant yield for ASVEG #1, Hybrid 82-156 (as a check) and Shang-hsi (with solar sterilization) at normal application rates of fertilizer. The increase in the head yield of ASVEG #1 was not so much due to increase in nitrogen application rate, indicating that the fertilizer applied was mostly lost in heavy rain and flood during the growing period.

Both PE and high pot practices showed no significant differences in minimizing the incidence of internal and marginal rot and tipburn in ASVEG #1 and Hybrid 82-156 at normal nitrogen application rates under the present conditions. The fertilizer treatments did not have any clear reducing effects on the rotting and tipburn occurrence. Except for netting, foliar spraying of Ca citrate, covering outer leaves with rice straw and solar sterilization, were shown to be effective even under unfavorable weather conditions.

Introduction

This experiment determined the effects of different cultural practices [(PE and high pots, fertilizer application rates, and others such as foliar spray (Ca citrate), netting (15 cm above the plant top), coverings (with rice straw leaf) and solar sterilization (with transparent sheet)] on the incidence of both internal and marginal rot and tipburn in summer under unfavorable weather conditions of heavy rain and typhoon.

Materials and Methods

This trial was carried out in summer 1990 using a randomized complete block design with four replications. Plot size was 16.2 m (1.5 m $\times$ 3 m $\times$ 3.6 m), with 48 plants/plot. There were 40 plots (10 $\times$ 4). The total experimental area was 648 m^2 (16.2 m $\times$ 40). Plant spacing was 45 cm between plants, with two rows per bed with a width of 1.5 m.

Three cultivars, ASVEG #1, Hybrid 82-156 as a check and Shang-hsi were used. Seedlings of each cultivar with PE or high pots were transplanted on 30 July and allowed to grow with bed mulchings of rice straw under the different treatments.

The plants were harvested on 18 September and examined for yield and incidence of internal and marginal rot and tipburn.

No irrigation was done during this cultivation period. There were three typhoons with heavy rains (1-4 August, immediately after transplanting, 18-19 August and 8-11 September).

Results and Discussion

The results obtained are summarized in Table 12.

Effect of PE and high pots

Yields of heads and total aerial parts. ASVEG #1 and Hybrid 82-156 (as check) had considerably higher head and total plant weights in the PE pot than those in the high pot plots at the same fertilizer application rates (F1).

Within the same PE pot plots with the same fertilizer application rates (F1), Hybrid 82-156 and Shang-hsi (with solar sterilization treatment) were also observed to have higher head and total plant weight than ASVEG #1. Hybrid 82-156 had the highest harvest ratio in this trial.

Incidence ratios of internal and marginal rot and tipburn. ASVEG #1 in both PE and high pot plots had an extremely higher and slightly higher incidence ratio of tipburn and marginal rot, respectively than Hybrid 82-156.

Within the same PE pot plots with the same fertilizer application rates (F1), Hybrid 82-156 and Shang-hsi yields were very low compared to ASVEG #1, suggesting the difficulty in finding out the differences in minimizing effect of rot and tipburn incidence between these pot practices under unfavorable growing circumstances.

No significant differences were noticed in the incidence ratio of internal rot between the PE and high pot plots.

Effect of increasing rates of fertilizer application.

Yields of the head and whole plant. ASVEG #1 cultivation in PE pot plots showed nearly the same yields in both head and total plant, irrespective of the fertilizer application rates (F1, F2 and F3) under unfavorable weather conditions with heavy rains accompanied by typhoons. Fertilizers could have been washed out by surface runoff and/or leaching as a result of the rain and the flood during this cultivation period.

Incidence ratios of internal and marginal rot and tipburn. ASVEG #1 plants grown within the PE pot plots showed higher incidence ratios for tipburn than for marginal rot, irrespective of the fertilizer application rates. The highest ratios of tipburn (41.2%) and marginal rot (26.4%) were observed in plots applied with higher rates of N fertilizer F3 and F2 respectively.

No statistical difference was shown among the fertilizer treatments in occurrence ratio of internal rot.

Effects of foliar spray, netting, covering with rice straw leaf and solar sterilization

Yields of the head and total plant. ASVEG #1 plants grown in PE pot plots at the same N application rate (F2) had nearly the same head and total plant yield as the different treatments using foliar spray of Ca citrate, covering (with rice straw leaves) and solar sterilization (with transparent sheet at F1 fertilization rate), including the control plots except for netting treatment (30 cm apart from the top of plant).

Incidence ratios of internal and marginal rot and tipburn. The netting plot showed almost the same high incidence ratios of marginal rot and tipburn as the control plot, while the foliar spraying and covering and solar sterilization plots had slightly low and lower ratios, respectively. No significant differences were observed in incidence ratio of internal rot amongst these treatments.

Among the hybrids applied with rice straw bed mulch, ASVEG #1 and Hybrid 82-156 plants in PE pot cultivation yielded the highest in terms of head and total plants. The relationship between

Table 12. Evaluation of the cultural practices for summer Chinese cabbage production under typhoons and their effect on internal rot and tipburn incidence (summer 1990).

Treatment					Head yield (t/ha)	Total yield (t/ha)	Harvest ratio (%)	Dead plant no.	Internal rot ratio (%)	Marginal rot ratio (%)	Tipburn ratio (%)
Cultivar	Mulching	Seedling pot type	Fertilizer amount	Other							
ASVEG #1	Rice straw	PE pot	F1	–	10.6 ab	19.9 bc	86.46 a-c	1.5 a-d	3.7 a	12.2 ab	33.3 ab
H 82-156	Check	PE pot	F1	–	10.9 ab	27.7 a	97.92 a	0.0 d	3.2 a	5.2 ab	4.2 d
ASVEG #1	Rice straw	High pot	F1	–	5.9 cd	14.7 d	76.04 bc	0.2 cd	14.8 a	7.9 ab	40.6 a
H 82-156	Rice straw	High pot	F1	–	4.9 d	14.8 d	70.83 c	0.0 d	2.8 a	3.1 b	5.7 cd
ASVEG #1	Rice straw	PE pot	F2	–	9.4 ab	17.6 cd	81.25 a-c	3.7 ab	4.9 a	26.4 a	25.0 a-c
ASVEG #1	Rice straw	PE pot	F2	Foliar spray	10.1 ab	18.5 b-c	79.17 a-c	3.2 a-c	6.45 a	15.35 ab	18.7 b-d
ASVEG #1	Rice straw	PE pot	F2	Netting	8.3 bc	16.1 cd	73.96 bc	4.5 a	13.8 a	23.2 ab	26.0 ab
ASVEG #1	Rice straw	PE pot	F2	Cover O-leaf	9.3 ab	18.3 b-d	85.42 a-c	2.2 a-d	7.5 a	5.9 ab	20.8 b-d
ASVEG #1	Rice straw	PE pot	F3	–	12.4 a	22.6 b	91.67 ab	1.2 b-d	10.24 a	8.0 ab	41.1 a
Shang-hsi	Rice straw	PE pot	F1	Sun sterilization	11.5 a	18.6 b-d	89.58 a-c	1.7 a-d	5.9 a	7.3 ab	5.7 cd

yield increase and increasing rate of nitrogen application was not clear because of the considerable loss of applied nutrients during the typhoons with heavy rains, but higher head yield was observed in plots with higher N application rates and solar sterilization.

No distinct differences were shown by PE and high pot practices in minimizing the occurrence of internal and marginal rot and tipburn in ASVEG #1 and Hybrid 82-156 at conventional fertilizer application rates. No clear effects on the incidence of internal and marginal pot and tipburn were found on ASVEG #1 using the different fertilizer treatments. Foliar spray of Ca citrate solution, covering outer leaves with rice straw and solar sterilization with transparent sheet, except for netting, were shown to be effective even under unfavorable growing conditions.

International Cooperation Program

Training

Enrollment

During the year under review, 61 training participants from 17 countries were enrolled under six training categories: research fellows, research scholars, research interns, production trainees, special purpose trainees, and undergraduate student trainees.

The 61 participants contributed an aggregate training time of 172.25 man-months or 13 man-years (Table 1). The participants were distributed into the three major programs of the Center: Crop Improvement Program, Production Systems Program, and International Cooperation Program (Table 2). Thirty-six scholars (60%) were enrolled in four disciplines under the Crop Improvement Program while 22 (36%) were enrolled in four programs under the Production Systems Program.

Training Sponsors

In 1990 11 other sponsors besides AVRDC (Table 3) provided financial support to 61 participants. The Japan Shipbuilding Industry Foundation (Table 4) sponsored four participants from three countries for a total of 13.5 man-months while AVRDC, collaborating with four other sponsors, provided scholarships to 25 of the scholars for a total of 48.5 man-months. AVRDC alone provided scholarships to 24 scholars for a total of 88 man-months.

Table 1. Distribution of trainees by country and period of scholarship.

Countries	RF	RI	SPT	UST	Total	MM
Ethiopia11			1		1	1
Germany			1		1	2
India	1		1		2	13
Indonesia		3	2		5	18.75
Japan		1		1	2	6
Korea	1	2	1		4	35.25
Malawi		1			1	4
Malaysia			2		2	4
Nigeria			1		1	1
Philippines	2		4		6	27.75
Senegal			1		1	1
Singapore			1		1	1
Sri Lanka			1		1	1
Taiwan		2	8	16	26	45.75
Tanzania			1		1	1
Thailand		1	4		5	7.75
Vietnam			1		1	1
Total	3	10	30	17	61	170.25

RF = Research Fellow RS = Research Scholar RI = Research Intern PT = Production Trainee SPT = Special Purpose Trainee UST = Undergraduate Student Trainee MM = Man-months

Other Activities

– The 447-page Vegetable Production Training Manual came off the press in 1990. It is intended to be a guide to the vegetable production training course for developing country specialists, and as

Table 2. Distribution of trainees by program/discipline and training period.

Program/Discipline	RF	RI	SPT	UST	Total	MM
Crop Improvement Program						
Plant Breeding		1	2	3	6	13.75
Plant Pathology	1	1	13[a]	3	18	47.5
Plant Physiology		5			5	29
Entomology		2	1	4	7	20
Subtotal	1	9	16	10	36	110.25
Production Systems Program						
Ag. Chemistry			13[b]	5	18	18.5
Soil Science				2	2	3
Crop Management		1			1	4
Home Garden	1				1	12
Subtotal	1	1	13	7	22	37.5
International Cooperation Program						
Publication & Documentation	2				2	24
Training			1			0.5
Subtotal	2		1		3	24.5
Grand Total	**4**	**10**	**30**	**17**	**60**	**172.25**

[a]Vegetable Virology Workshop. [b]Electrophoresis Course.

Table 3. Distribution of grantees by sponsors.

Sponsor	RF	RI	SPT	UST	Total	MM
JSIF		2	2		4	13.5
AVRDC	3	3	1	17	24	88
BBA			10		10	25
COA		2	1		3	12
IDRC/GTZ			12		12	11.5
EWSC			1		1	1
GAES			1		1	2
GTZ	1				1	24
IDRC			1		1	0.75
JTI		1			1	5
PPD			1		1	2
WUAEP		1			1	6
USAID/Malawi		1			1	4
Total	**4**	**10**	**30**	**17**	**61**	**172.25**

JSIF-Japan Shipbuilding Industry Foundation AVRDC-Asian Vegetable Research and Development Center BBA-Federal Research Institute for Plant Protein in Agriculture and Forestry COA-Council of Agriculture, Republic of China IDRC-International Development Research Center, Canada GTZ-German Agency for Technical Cooperation EWSC-East-West Seed Company GAES-German Academic Exchange Services JTI-Japan Tobacco Inc. PPD-Primary Production Department, Ministry of National Development, Singapore WUAEP-Western Universities Agricultural Education Project USAID-US Agency for International Development

Table 4. Distribution of grantees by country/Japan Shipbuilding Industry Foundation.

Country	RI	SPT	Total	Percent	MM
Korea	2		2	50	11
Philippines		1	1	25	2
Thailand		1	1	25	0.5
Total	**2**	**2**	**4**	**100**	**13.5**

a resource book for extension subject matter specialists and vocational agriculture teachers. The production and distribution of this manual is supported by the Japan Shipbuilding Industry Foundation.

– A survey of 250 AVRDC training alumni was conducted using a questionnaire sent to 455 participants in five countries namely, Indonesia, Korea, Malaysia, Philippines, and Thailand. The alumni rated AVRDC training and services/backstop as very useful. More and more trainees expressed interest in receiving AVRDC publications, slides and videos.

– A Special Research Skills Training Course for vegetable research leaders from the Collaborative Network for Vegetable Research and Development in Southern Africa (CONVERDS) and the South Asian Vegetable Research Network (SAVERNET) was designed.

Library, Information and Documentation

Summary

In 1990, a total of 2,272 titles of books and crop documents were catalogued. Thirty-two new titles of serial publications obtained through exchange and as gifts were added to the library collection. Library holdings increased to 13,463 books, 1,214 journal titles, bound volumes of 11,752 journals and 30,397 crop document titles. The bibliographic database also grew by 2,340 records.

Information Collection

Acquisition. In 1990, Library, Information and Documentation (LID) received 785 requests for books and photocopies and received 476 titles of books and 482 titles of serial publications through exchange and as gifts (Table 1).

Table 1. Acquisitions in 1990.

	Request for order (title)	Ordered (title)	Received/ Paid (title)	Received/ Exchange (title)
Books	119	69	55[a]	476
Photocopy	666	609	351	85
Serial publication		482		
Journal subscription for 1990/91		110	110	
CD-ROM		1	1	
Back issues		30. (vols)	30. (vols)[b]	

[a]Twenty-three titles were charged to Sasagawa Fund. [b]Thirty volumes of Review of Applied Entomology were charged to COA Fund.

Literature searching. Literature searching on AVRDC principal crops from newly received journals and books was regularly conducted. Some searching on specific topics was done in-house and from external databases.

Documentation and database development. A total of 2,272 titles of book and crop documents were catalogued. Thirty-two new titles of serial publications obtained through exchanges and as gifts, and 453 back volumes of journals were added to the library collection. The status of the library collections and retrieval system is given in Table 2.

Information Dissemination and Readers' Service

Information dissemination. During 1990, LID published seven issues of the new acquisition list and 22 issues of the SDI Bulletin on Chinese cabbage, diamondback moth, garlic, mungbean, peppers, soybean, sweet potato and tomato (Table 3).

Reader's service. LID conducted 54 literature searches from in-house database for staff, trainees and external users and attended to five queries through the telephone for external users. A total of 2,788 titles of books and documents were loaned out. Some 721 titles totaling 4,926 pages of documents on various topics were provided for external users in eight countries (Table 4).

Table 2. Status of library collection and retrieval system during 1990.

Items	Additions	Total Holdings	Retrieval System	
			card-catalog	online DB
Books (title)	619	13,463	9,655	3,808
Journals (title)	32	1,214		1,214
Bound volumes	453.(vol)	11,752.(vol)		
Maps		77	77	
Slides		878		
Cassettes		52	52	
Microforms		11		11
Documents	(title)	(title)	(title)	(title)
Chinese cabbage	43	1,451		1,451
Diamondback moth	47	564	340	224
Garlic	130	132		132
Mungbean	139	4,397		4,397
Onion	117	372		372
Peppers	210	844		844
Shallot	26	26		26
Soybean	220	9,956	7,631	2,325
Soybean rust	59	405		405
Sweet potato	146	3,899	2,566	1,333
Tomato	366	7,068	5,257	1,811
Others	150	1,283		1,283

Table 3. Current awareness service in 1990.

Topics	No. of issues	Records (title)
Library List (new acquisition)	7	510
SDI Bulletin		
Chinese cabbage	3	203
Diamondback moth	2	150
Garlic	1	57
Mungbean	4	299
Pepper	3	271
Soybean	4	323
Sweet potato	2	149
Tomato	3	307

Table 4. Readers' service in 1990.

Type of Service	Frequency
In-house database searching	
Internal users	40
External users	14
Question and answer	
External user	5
Library loan	
Internal users – staff	1,289.(titles)
– training scholars	1,439.(titles)
Interlibrary loan	
Internal users	3.(titles)
External users	60.(titles)
Document delivery	
India	16.(titles)
Japan	15
Kenya	38
Malawi	2
Sweden	1
Taiwan	692
Thailand	20
USA	37

Networking. The annual meeting of the Science and Technology Library Network of ROC was held at the National Tsing Hua University, Hsinchu in November 1990. The main theme for discussion was 'copyright'. The network will be re-organized in early 1991.

LID contributed an updated list of journal holdings with 1,000 titles to the 1990 edition of the Union List of Non-Chinese Sci-Tech. Serials in ROC.

LID also contributed 760 titles of journal holdings to the Union Catalog of Serials Holdings in IARCs, a project of the CGIAR Documentation and Information Service. This project produced a Micro CDS/ISIS database and hard copy of the Union Catalog, which should greatly increase the flow of information among the IARCs and NARS.

Office of Publications and Communications

The Office of Information Services (now OPC) was established to expedite the flow of vegetable crop research information from the Center to an international audience of scientists, policymakers, educators and extension specialists.

AVRDC's research outputs have been disseminated through various mechanisms, such as bilateral projects, informal collaboration among scientists, training, international symposia, the media, and publications.

OPC's responsibilities include the production of research publications, public relations, general communication services (e.g. photo, art, printing, etc.).

Specifically, its objectives are (1) to assist in increasing the level of communication between AVRDC scientists and their colleagues working in national programs; (2) assist in the popularization of the Center's new varieties, management practices and training programs; (3) serve as a link between the Center, its donors and other audiences interested in AVRDC activities.

Publications produced are Centerpoint, Technical Bulletins, Proceedings, Journal Papers, Progress Report Summaries, and Progress Report.

The latter two publications are aimed at the following: donors, politicians, research administrators, scientists, extension people and the general public.

The Office of Information Services went through a number of changes in 1990, including a name change (Office of Publications and Communications), and the appointment of a new Head.

Future style and methods of reporting are under active consideration within the Center. There is a perceived need to more clearly define the reporting requirements of the Center: the need to have a detailed annual record of progress and results in all of the research areas; how much and in what form some of this information needs to be prepared for outside use; to more clearly define audiences including the international donor agencies, the international research community, the national groups, other international centers, etc.

Publications

In 1990 AVRDC published 12 books and newsletters with a total print run of 19,800 copies. The total number of printed pages was 3,309. A list of new publications is included in this report.

Journal Publication/Symposium Presentations

During the year a number of journal papers by AVRDC scientists were published and articles were prepared for submission to international journals and for presentation at international symposia. These are listed at the end of this report.

Special Training Publication

An important new Center publication appeared in 1990: 'Vegetable Research Training Manual.' This 447-page book is the result of one of the most effective collaborative efforts of this kind undertaken by the Center. Special promotion is being considered and there is already wide interest in this book throughout the world.

Public Awareness

Only one issue of the Center's newsletter (Centerpoint) was issued in 1990 because of staff changes. Another issue is in production for publication in early 1991. The plan is to regularly publish two issues per year. Five press releases were issued during the year. Work has started on the revision of the Center's slide/sound show, and the preparation of a video story. The Center receives well over 100 groups of visitors, and many individual international scientists, and the slide show and in formation kits are the main tools used in briefings. The AVRDC information leaflet is also undergoing revision. The Center actively encourages journalists from many countries to visit the Center and to write articles about its research and training activities.

Other Communication Services

The Office of Publications and Communications provides a range of services to researchers at AVRDC, including photography, graphics, printing, a publication distribution service, slide preparation, a mailing list data base, and editing and writing services.

Publications

A list of publications for 1990 is contained in the Appendices.

AVNET

Summary

The Collaborative Vegetable Research Program in Southeast Asia (AVNET) was realized through technical assistance funds provided by the Asian Development Bank (ADB). The technical assistance agreement was signed on 26 May 1989.

AVRDC appointed an AVNET coordinator to take charge of the implementation of the project. The four countries, Indonesia, Malaysia, the Philippines, and Thailand designated their respective policy and technical coordinators. The AVNET coordinator and the technical coordinators constitute the Program Coordinating Committee (PCC). AVRDC entered into an agreement with each of the four countries for the implementation of AVNET. Malaysia, the Philippines and Thailand have already signed the Memorandum of Understanding.

AVNET has two main subnetworks, namely, the germplasm improvement subnetwork and the integrated pest management subnetwork. The major objectives of the networks are: 1) to exchange germplasm of priority vegetables, namely tomato, pepper, garlic, yar dlong bean, shallot (onion), and cucumber, 2) to strengthen the research capability of participating country scientists through research skills training, 3) to exchange and share valuable research information and 4) to transfer mature technologies generated by research to farmers in the network member countries.

Lack of diverse germplasm has been reported as one of the major constraints limiting vegetable production. Exchange of germplasm between collaborating countries is expected to alleviate these countries of this constraint. In the Germplasm Subnetwork , cucumber, tomato (determinate and indeterminate types) and yardlong bean germplasm so far have been successfully multiplied and distributed to all the country collaborators for evaluation.

Hot pepper germplasm is being multiplied. Initial trials in Malaysia with yardlong bean suggested the superiority of germplasm introduced from the Philippines and Thailand, thus providing proof that sharing of promising germplasm from one country can have a significant impact in vegetable production in other countries in the region.

Garlics are usually 100% infected with viruses and yield losses due to viral infection can rise to as much as 50%. This is exacerbated by the fact that it is asexually propagated. One way of producing virus-free planting materials is through in vitro meristem culture. The AVNET collaborator in the Philippines has successfully installed an in vitro culture propagation system for both garlic and shallot.

Bacterial wilt is the most serious disease of tomatoes in the tropics. However, bacterial wilt resistant tomato varieties do not behave consistently in all locations due to differences in pathogens and in environmental conditions. Bacterial wilt surveys in the Philippines and Thailand confirmed that indeed there are different biovars of *Pseudomonas solanacearum*, with different virulence levels. This could explain the different behavior of resistant varieties in different countries. In fact, using different isolates, varietal resistance varied significantly, confirming the assumption. Moreover, International Bacterial Wilt Disease Nursery (IBWDN) results demonstrated that environmental differences further complicate differential resistance. Under high temperature conditions in Indonesia bacterial wilt resistance broke down.

Anthracnose disease infects pepper fruits making them unsuitable for market. The disease can be caused by different species of *Colletotrichum*. Which of these species is the causal organism needs to be identified and better described to effectively control them. Three species of anthracnose pathogen, *C. capsici*, *C. gloeosporioides* and *C. acutatum*, were identified during a survey for anthracnose of chilies in Malaysia, whereas in the Philippines only the first two species were observed. Moreover,

in the Philippines *C. capsici* and *C. gloeosporioides* appear to be location-specific. In the anthracnose resistance screening trials in Malaysia, varieties C2, C3 and C5 from Thailand had no diseased plants while the susceptible varieties registered up to 96% disease.

Losses due to viruses are very high in tropical peppers. A survey of pepper viruses in all four countries suggested the widespread prevalence of chili veinal mottle virus (CVMV), cucumber mosaic virus (CMV), potato virus Y (PVY), tobacco etch virus (TEV), alfalfa mosaic virus (AMV), tobacco mosaic virus (TMV), and tomato mosaic virus (ToMV). Among them, CMV and CVMV were predominant suggesting that the screening for resistance should be focused on these two viruses. Efforts on resistance screening showed that chili variety LV-2411 was immune to CVMV giving hope to the possibility of developing productive chili varieties with immunity to CVMV. To intensify the virus resistance screening studies, supplemental screenhouses have been constructed in Malaysia and Thailand utilizing AVNET funds.

Farmers use excessive amounts of pesticides to control the diamondback moth (DBM), a serious pest of cruciferous vegetables. As a result the danger of pesticide residue in cruciferous vegetables (cabbage group) has become real. A special group of insects, parasitoids, has been identified to attack DBM thereby, considerably reducing their damage to crucifers. Supplemented with nonchemical pesticides such as *Bacillus thuringiensis* in an integrated pest management (IPM) approach, DBM can be effectively managed without the danger of pesticide residue. This way, high quality vegetables can be profitably produced. The construction of IPM-DBM parasite-rearing facilities have been completed in Indonesia, Malaysia, Philippines and Thailand with the help of AVNET funds. Substantial number of parasitoids are produced from the newly developed facilities in all the AVNET countries for release in cruciferous vegetable-growing areas in the highlands. Malaysia, Philippines and Indonesia have been highly successful in the use and establishment of parasitoids in the highlands. In fact, parasitoids have become so well established in the Cameron Highlands in Malaysia that DBM is no longer a serious problem there. Farmers can now save the money they used to spend on pesticides. Moreover, cruciferous vegetables relatively free of toxic pesticide residues are now available to consumers.

To expand this technology to other areas, MARDI has conducted in-country IPM-DBM training and has trained 30 staff members. In addition, MARDI, the Department of Agriculture and the Malaysian Plant Protection Society organized a seminar on 'DBM-management in Malaysia: Perspectives and Strategies'. Two-hundred participants attended and eight papers were presented and discussed.

More and more cruciferous vegetables are being cultivated in the lowlands with introduction and use of KK and KY cabbage hybrids and other heat-tolerant cruciferous crops. DBM is a problem in the lowlands as well. But rearing of parasitoids, which are adapted to highland cool environments, in the lowlands is underway.

Germplasm Subnetwork

The objective of the germplasm subnetwork is to strengthen the vegetable research capability of the NARS and accelerate the development of improved cultivars in Southeast Asia through special skills training of its personnel, provision of a wide diversity of germplasm, improvement in understanding of major diseases, and identification of new sources of disease resistance.

Germplasm Exchange for Evaluation

The objectives of this activity are:

- To assemble, multiply, maintain, distribute and evaluate elite local cultivars (land races, improved cultivars, and breeding lines) of the approved network commodities, such as tomato, pepper, garlic, shallot, yardlong bean and cucumber; • To develop a set of potentially useful varieties of the above crops, based on the proposed germplasm activities, for further evaluation, potential use in breeding, and/or immediate release by the participating NARS of AVNET;

- To enhance the capability of the NARS personnel in carrying out the planned germplasm activities through training;
- To establish a regional gene bank, if applicable and possible, in which the elite and indigenous germplasm of the network commodities collected from the participating NARS are kept and maintained for communal use.

Training

In the Germplasm Subnetwork planning meeting on 31 May to 1 June 1989 the countries agreed to share the specific crop responsibility depending upon their strengths and weaknesses. In a collaborative spirit, the germplasm multiplication and distribution was assigned as follows:

Country/Inst.	Crop responsibility	Crop Coordinator(s)
Indonesia	Peppers	Dr. Anggoro Permadi Hadi Mr. Sudjoko Sahat
Malaysia	Yardlong bean	Dr. Yap Thoo Chai Dr. B.H. Chew
Philippines	Shallot and Garlic	Dr. Eufemio T. Rasco, Jr. Mr. Benjamin Legaspi
Thailand	Cucumbers	Dr. Kasem Piluek Dr. Chairerg Sagwansupyakorn
AVRDC	Tomato	Dr. R.T. Opeña Dr. L. Engle

A training workshop for germplasm evaluation was held at Lembang Horticultural Research Institute, Lembang, Indonesia. Sixteen researchers from four collaborating countries actively discussed and came up with a uniform procedure for varietal trials on hot pepper, yardlong bean, cucumber, tomato and sweet pepper.

Progress

AVRDC Tomato has been a principal crop of AVRDC since its inception. Therefore, all the four collaborating countries suggested that they be given diverse promising tomato germplasm. AVRDC put together and distributed two sets of tomato varieties for the AVNET trials. One set has 22 determinate entries while the other set comprised of 14 indeterminate entries. The sets included available promising entries from each partner country and were jointly selected and agreed upon by the collaborating country members during the germplasm training workshop in Indonesia. The cooperators were also provided with AVRDC's International Cooperator's Guide Sheets, AVRDC 78-101 and AVRDC 79-127, for collecting data uniformly so that they can be shared and compared among the countries.

Indonesia. 1) The responsibility of Indonesia is to collect, multiply and distribute hot pepper varieties to all the other collaborating countries. Seeds of three cultivars each from Malaysia and the Philippines were received. All six varieties had very low germination. 2) Seeds of five hot pepper cultivars, namely, Tit, Jatilaba, Keriting, MC-4, and MC-5 have been multiplied for distribution to the collaborating countries.

The countries concerned provided their respective cultivars as follows:

Thailand — Huey Siton, Mun, Luang, Yuak

Philippines – Matikas, Bontai, Kawit
Malaysia – Kudai

Yardlong bean Seeds are yet to arrive from Malaysia.

The cucumber variety trial commenced on October 15, 1990 in the lowland experimental field at Subang (100 m.a.s.l.) and is in progress.

Malaysia. Promising yardlong bean varieties agreed upon by Thailand, Malaysia and the Philippines have been sent to Malaysia. Malaysia successfully multiplied and promptly distributed 130 g of seeds of each variety in October 1990 to three collaborating member countries. The sixteen entries from the Philippines, Indonesia, Malaysia and Thailand which were multiplied and distributed are given below:

Variety	Source	Variety	Source
KP1 1018	Indonesia	CSD 4	Philippines
KP2 1019	Indonesia	CSD 5	Philippines
USUD Hijau	Indonesia	CSL 19	Philippines
LV 801 (Sugar Cisadane)	Indonesia	PS 1	Philippines
MKP 5	Malaysia	Rajpuri	Thailand
MKP 4	Malaysia	KU #7	Thailand
Taiwan White	Malaysia	KU #8	Thailand
ML 30	Malaysia	RW #24	Thailand

Five entries among these 16 cultivars gave a higher yield of 403 to 467 g/plant compared to the local check's yield of 302 g/plant.

Philippines. Garlic and shallot are both asexually propagated – clones for garlic and bulblets for shallot; occasionally, seeds are used for shallots. Garlic is obligate apomictic and therefore, sterile. Vegetative propagation results in the danger of rapidly transmitting viruses and other diseases. Therefore, the collaborating countries agreed to support the proposal that instead of focusing on varietal evaluation, full attention will be given to in vitro culture techniques as a tool for rapid mass propagation and as an instrument for the elimination of virus disease, for the preservation of the germplasm. The Philippines has trained personnel in in vitro culture techniques for garlic and shallot.

Seven accessions of shallot and 12 accessions of garlic have been received primarily from Indonesia, Thailand and Cambodia. Initial observations demonstrated that germplasm from Thailand (Varieties Sri-Saket 1 and Sri-Saket 2) and Indonesia (Variety Bangkok) could produce bigger shallot bulbs in the Philippines compared to the native ones.

Among the garlic accessions received, only LV 1020 from Indonesia was preserved while all the others rotted enroute. New samples have to be obtained. Eleven strains of garlic and 18 strains of shallot have been successfully cultured in vitro. The plants were subcultured at three-week intervals. To date, the cultures have undergone three successive subcultures.

In vitro meristem culture of garlic and shallot is eventually expected to produce virus-free planting materials, and this technology could be easily shared for mass production of virus-free planting materials.

Thailand. Thailand is responsible for the multiplication and distribution of cucumber seeds. The seeds of elite local cultivars received from the participating countries were multiplied and simultaneously evaluated at Kamphaeng Saen campus, Kasetsart University, Nakhon Pathom. Seeds for multiplication were sufficient except for one variety from Malaysia (Tangkak) which did not germinate. The multiplied seeds were distributed to all the three collaborating countries.

The first varietal evaluation was completed. Cucumber varieties from Thailand were distinctly small and oblong ellipsoid; but cucumbers from Malaysia, Philippines, and Indonesia all had large,

ellipsoid-elongated fruit. All varieties had white flesh and were not bitter. The Philippine varieties had distinctly dark green fruit which did not show skin mottling whereas the other varieties had light green fruits with skin mottling.

Bacterial Wilt Screening

Bacterial wilt (BW) is the most damaging disease of tomato in the lowland tropics and subtropics. It is a soil-borne disease. Resistant varieties developed at AVRDC were later noted to be susceptible in some locations. Apparently, variety reaction to the pathogen is influenced by the presence of different pathogenic races as well as local environmental conditions. It is important that screening procedures be standardized so that the results obtained in each country could be useful to others. The objective of the International Bacterial Wilt Disease Nursery (IBWDN) study is to understand the variability in the host, pathogen and their interaction with the environment. By using selected resistant lines and planting them in IBWDN with a known local, resistant, and susceptible check varieties using a commonly agreed screening procedure, the collaborating countries hope to have a better understanding of the host-pathogen-environment relationships. To accomplish the above objective, a uniform BW screening procedure was agreed upon by the collaborating countries. An international bacterial wilt disease nursery using 22 varieties was proposed.

Training

Thailand organized the bacterial wilt training at Kasetsart University for a 10-day period. Topics for training included the following practical aspects of research: 1) isolation and preservation of bacteria; inoculation procedures and biovar typing, and 2) the establishment and management of the international bacterial wilt nursery (IBWN).

Progress

Indonesia. In Indonesia, 100% economic loss due to BW is very common. Most of the commercial tomato cultivars are susceptible to BW. To identify a reliable source of resistance to bacterial wilt, 19 test entries were planted in a randomized complete block design (RCBD) with four replications from January to June 1990. Screening and disease rating procedures agreed upon were followed. Average disease occurrence in the IBWDN ranged from 63-100%. Initial mild symptoms of the disease were followed by permanent wilting after one week. Except for variety BL 333, which had a moderate susceptible reaction (64% of the plants wilted), all other 18 varieties were highly susceptible. Minimum and maximum temperatures during the IBWDN trial period were 23.7°C and 32.6°C, respectively; relative humidity was 83.7% and the average rainfall was 17.7 mm during the trial period. It was reported that under high temperature (30 to 33°C). The resistance of BW easily breaks down.

Based on this observation it is likely that under the high temperature in Indonesia the resistance of BW will have broken down. Based on fruit characteristics, the following varieties from the trial were found acceptable to the local market: CL 5915-206-D4-2-2-0, BL 323, BL 342, CL 9-0-0-1-3, CL 143-0-10-3-0-1-10, and BL 333.

Malaysia. An IBWDN was conducted at MARDI, Serdang. Eight AVRDC tomato entries plus two local checks and one AVRDC susceptible check were planted on June 25 and 26, 1990 in a RCBD with three replications.

Two weeks after planting the AVRDC susceptible check L 390 had 98% wilted plants, indicating the high inoculum potential in the trial plots. Three weeks after planting the average number of wilted plants of all AVRDC entries was 1% suggesting a very high level of resistance to bacterial wilt. The local checks MT 1 and MT 11 had 1.5 and 9.2% wilted plants, respectively.

The IBWDN is currently being repeated to confirm the resistance observed in earlier trials.

Philippines. The reported yield loss in tomato due to bacterial wilt in the Philippines range from 80 to 95%. In pepper, the yield loss range from 10 to 40%.

Six tomato-growing areas in five municipalities of three provinces in Southern and Central Luzon were surveyed for bacterial wilt. Wilted tomato and pepper plant samples were collected and carefully examined using recognized isolation procedures and conducting pathogenicity tests. Seventeen isolates were biochemically classified into biovar groups. Fifteen isolates belonged to biovar III and two belonged to biovar IV using Hayward's (1964) method. The presence of different biovars partially explains the differences in resistance of cultivars in different locations within the Philippines. The training provided by AVNET and the interest of the researchers contributed in obtaining the new findings.

Twenty-six tomato accessions were screened for resistance to bacterial wilt in the greenhouse. Virulent biovar III and IV isolates of *Pseudomonas solanacearum* were used.

Differential host resistance was observed for biovar III and IV. Accessions GH Tm1 114-47 and F7-80-378-N V/P were resistant to both biovar III and IV. Three accessions were resistant to biovar IV but were only moderately resistant to biovar III . Two entries were moderately resistant to both biovar III and IV (Tm L 114-56-20 and F7-80-465-10 Pink). Seven accessions were moderately resistant to biovar IV but were moderately susceptible to biovar III. Among the two biovars, biovar III appears to be more virulent than biovar IV based on the number of accessions susceptible and resistant to each biovar. Based on these results, it is possible to identify varieties with stable resistance. The role of the environment needs to be clarified.

IBWDN has been established in a 1100 m^2 field. A bacterial suspension of the virulent biovar III isolate of *P. solanacearum* was used as the inoculum in the nursery. Twenty-six tomato accessions from AVRDC and four accessions from the Philippines wer e used to determine relative resistance. Susceptible L 390 and resistant L 285 were planted for comparative evaluation. An evaluation procedure agreed upon was followed. Of the 30 entries screened, 11 were resistant, 15 moderately resistant and 4 moderately susceptible.

Thailand. Samples of tomato and pepper plants with BW from the north, northeast, west and central parts of Thailand were collected.

Bacteria were isolated from each of the collected samples. Strains with positive pathogenicity on their corresponding hosts were used for serological characterizations by dot-blot immunosorbent assay (DIBA). Antisera were produced against either membrane protein complex (MPC) or formalized cells of *P. solanacearum* SR 21. All newly isolated strains with positive pathogenicity were grouped as serologically indistinct. Some of the strains were either less or more virulent than strain SR 21, since these strains showed variation in their ability to induce disease on tomato seedlings. As in the Philippines, the observed variation in the pathogen partially explains the variability in disease expression on host in different locations.

The IBWDN planted in March failed because of poor soil texture, high temperature and low soil moisture. Seedling growth was very poor.

The soil texture has since been improved with the application of well-decomposed green manure. A water storage tank has been constructed to supply water as required. Soil has been infested with bacteria by adopting the procedures agreed upon.

Anthracnose of Pepper

Anthracnose of pepper, caused by *Colletotrichum* spp., occurs throughout the pepper production areas in Indonesia, Malaysia, Philippines and Thailand. There is a need to conduct a disease survey to understand the severity of the disease and variability in the pathogen in different pepper-growing areas in each of the countries.

In all countries, primary losses are due to fruit infection; plant die-back has also occurred in Indonesia. Estimates of yield losses in Java vary from 40 to 60% in both lowland and highland production areas. In Thailand and Malaysia, the estimated overall losses were 50% and up to 60%, respectively. Furthermore, postharvest losses due to anthracnose disease could be as high as 25%.

The pathogen species varied between locations within a country and between countries. The general control procedure involves the application of fungicides, which increases the cost of production and

the risk of pesticide residue. Screening and identifying varieties resistant to the disease will result in savings to the farmers and greater safety to consumers.

Training

Since anthracnose is caused by different species of *Colletotrichum*, staff members were trained to undertake disease surveys and disease resistance screening. An anthracnose training workshop organized at AVRDC trained one scientist from each country in 1989.

Progress

Malaysia. A survey of the incidence and severity of anthracnose of chili in Kelantan and Terengganu was conducted. The following three species of *Colletotrichum* pathogenic on chili were identified: *C. capsici*, *C. gloeosporioides* and *C. acutatum*.

Thirteen chili lines from AVRDC and five from Thailand were observed for anthracnose incidence and severity while they were planted for seed multiplication at Jalan Kebun (Table 1). Observations showed that varieties C1, C2, C3, C4 and C5 from Thailand had very high resistance to anthracnose. In fact entries C2, C3 and C5 had no diseased plants. This clearly demonstrates the value and usefulness of a network approach in exchanging promising germplasm from one country to another country to help introduce disease resistance, which in turn will help the farmers to reduce cost of production and will offer quality vegetables to consumers. Entries from AVRDC had an anthracnose incidence of 10.4 to 96%.

Table 1. Anthracnose incidence and severity of 18 lines of hot peppers in in-country testing.

Source	Line No.	Common Name	Reaction type	Origin	No. fruits	No. anthracnosse infected	% Anthracnose
AVRDC	C 00632	Tenkostenna Zitawska	R	Hungary	179	144	80.5%
AVRDC	C 00708	Povazka	R	Czechoslovakia	208	115	55.3%
AVRDC	C 00918	P. 256/77	R	Turkey	466	227	48.7%
AVRDC	C 01172	C. Pendalum baccatum	R	France	1816	189	10.4%
AVRDC	C 01227	–	S	Italy	51	49	96.1%
AVRDC	C 01676	NAM CJU	R	Korea	643	160	24.9%
AVRDC	C 01768	MG 200858	R	Egypt	197	116	58.9%
AVRDC	C 01777	Chili	R	Malaysia	486	240	49.4%
AVRDC	C 01780	PI 102883	R	CN	861	85	9.9%
AVRDC	C 01807	PI 125804	R	AF	256	143	55.9%
AVRDC	C 01826	PI 138560	R	Iran	152	122	80.3%
AVRDC	C 02220	PI 187315	R	GT	78	55	70.5%
AVRDC	C 02676	PI 241646	S	Peru	209	132	63.2%
Thailand	C1	Banglen	R	Thailand	12353	279	2.3%
Thailand	C2	Lublae	R	Thailand	469	0	0.0%
Thailand	C3	Pechabun	R	Thailand	344	0	0.0%
Thailand	C4	Prapadaeng	R	Thailand	5787	76	1.3%
Thailand	C5	Sanurksong Karm	R	Thailand	1798	0	0.0%

Twelve of the above 18 lines were selected. A replicated trial has been planted to further determine anthracnose resistance and to study other horticultural characteristics under local conditions.

Philippines. A survey of anthracnose of pepper fruits in the field and in the market in Luzon Island showed a 1-80% incidence of anthracnose. The following two *Colletotrichum* species were identified from the samples: *C. capsici* and *C. gloeosporioides*. A total of 19 isolates of *Colletotrichum* spp. are being maintained, of which 11 are *C. capsici* and 8 are *C. gloeosporioides*. Among them nine *C. capsici* and five *C. gloeosporioides* were tested for their pathogenicity on hot pepper cultivar Matik as. SR #9 of *C. capsici* and Lipa #5 of *C. gloeosporioides* were found to be the most pathogenic.

C. capsici and *C. gloeosporioides* were predominantly location-specific except in Lipa City where both species were observed. Furthermore all the samples observed in the market had only *C. capsici*.

To screen for anthracnose resistance a total of 14 pepper varieties (introduced and local varieties) were grown either in the greenhouse or in the field and the fruits were harvested and artificially inoculated with *C. capsici* and *C. gloeosporioides* using the plastic box moist chamber technique. Of the 14 entries tested, one entry, C 01172, had the lowest percent of anthracnose infection with both species of *Colletotrichum* suggesting the possibility of selecting for resistance to different species of the anthracnose pathogen.

Thailand. AVRDC pepper lines were planted to obtain fruits for evaluation for anthracnose resistance. Fruits were of poor quality due to insect infestation and virus infection and therefore were unsuitable for testing. The planting had been repeated at Kamphaeng Saen campus and in the greenhouse. The research results on anthracnose disease of peppers to date are encouraging.

Pepper Viruses

The yield and quality losses due to viruses in tropical peppers are very high. In the tropics pepper plants are infected by a complex group of viruses. Very little information is available on the identity of these viruses. The techniques to identify these viruses are also not well developed.

The major objectives of the pepper viruses research are: (1) collection and sharing of germplasm, land races, most important cultivars and resistant sources to screen for resistance to major viruses of pepper; (2) identification of viruses to survey the pepper-growing areas and use available modern techniques to control them; (3) production of antisera which could be shared by different countries and AVRDC; (4) identification of strains using serological methods, differential hosts or by using resistant germplasm; (5) screening for pepper viruses resistance by using standardized screening methodology and rating method; and (6) exchange of resistant lines between the collaborating countries so that their usefulness in different countries for different viruses can be established.

Training

Two researchers each from Malaysia, Philippines, and Thailand and one from Indonesia were trained at AVRDC. Practical training was given on the following: 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. Samples collected by the trainees in farmers' fields in central Taiwan were tested with different ELISA methods and detected for seedand soil-transmitted virus.

The trainees were provided with PVY antiserum to use in their own country survey. A plan of an insect-proof screenhouse similar to those in use at AVRDC was also supplied as a model for setting up screenhouses in their respective countries.

The following antisera were supplied to all the virology cooperators in the four NARS: CMV, TEV, TMV, PeMV, and CVMV. At the request of the participants DAEA cellulose was also provided. A pepper virus abstract database covering the period 1983 to 1988 was sent to keep the participants informed of the ongoing research.

The trainees upon their return agreed to carry out a pepper virus survey. The antisera provided by AVRDC is highly valuable in identifying the viruses in the samples.

Although the virus diseases of pepper are caused by a complex group of viruses, from the initial survey in all the four collaborating countries it was apparent that the major viruses are chili veinal mottle virus (CVMV), cucumber mosaic virus (CMV) and potato virus Y (PVY).

Progress

Indonesia. A number of unidentified viruses infect hot pepper in Indonesia. A survey of pepper viruses was conducted in West and Central Java.

The estimated yield loss due to viruses from a greenhouse study was 74%. Pepper growing areas in Brebes, Subang, Lembang and Segunung were surveyed from July 1989 to August 1990. A total of 1,011 hot pepper leaf samples were collected and tested with the indirect ELISA technique for the presence of the most common pepper viruses.

In the seedling nursery the most common symptoms observed were mosaic mottle, curling, malformation, sinuosity, necrosis, and rugosity. In the early growth stage of the seedling, chlorosis, leaf malformation, and yellowing were absent. Based on indirect ELISA the viruses were identified as CMV, CVMV, PVY, TEV, AMV and ToMV. Some samples did not react with any antiserum and some reacted with more than one antiserum, suggesting that there may be viruses other than the ones already identified. In all pepper-growing areas viruses were observed. In most of the crops there was almost 100% infection with one or more viral diseases.

The CMV obtained from samples were grouped into 12 isolates. Based on the intensity, symptomatology and incubation period the 12 CMV isolates were grouped into six types, namely: CMV-1, CMV-2, CMV-4, CMV-5, CMV-11 and CMV-12.

Information on sources of resistance to some of the major pepper viruses such as CMV, PVY and CVMV are lacking in Indonesia. By using artificial inoculation in one experiment, 50 accessions/cultivars were screened for resistance to CMV and PVY. In another experiment 88 accessions/cultivars were screened for resistance to CVMV in experiments conducted in a greenhouse. Out of the 50 accessions/cultivars screened, none were resistant to CMV and PVY.

Among the 88 accessions/cultivars screened for resistance to CVMV, LV-2411 was immune, whereas LV-1559, LV-2320, Kariting Hitam, and Genjah-1 were resistant. The seeds from resistant accessions were collected and stored.

Malaysia. An insect-proof semipermanent screenhouse was constructed at MARDI HQ, Serdang, for virus isolation and resistance screening.

Twelve virus surveys were conducted in seven states: Kelantan, Terengganu, Pahang, Selangor, Malacca, and Johore. Double antibody sandwich ELISA tests were used by selecting seven polyclonal antibodies against alfalfa mosaic virus (AMV), CMV, chili veinal mottle virus (CVMV), tobacco etch virus (TEV), tomato mosaic virus (ToMV), TMV, and TSWV. CVMV was the most common virus on chilies in peninsular Malaysia. The other viruses, in the order of prevalence, are CMV, TSWV, TEV, TMV, ToMV, and AMV.

CVMV was predominant in Kelantan, Pahang, Penang, and Johore. In Terengganu and Selangor CMV was the most abundant followed by CVMV. In Malacca CVMV and CMV were equally abundant. In addition to CVMV and CMV, TMV, TEV, ToMV and AMV were also detected in Kelantan. In Terengganu, besides the high incidence of CMV and CVMV, TEV, TSWV, TMV and ToMV also occurred in that order of importance. ToMV was also detected in Johore. Mixed infection of different virus combinations, particularly CVMV and C MV, were also detected in the samples. This is possibly due to the active transmission of aphids in a nonpersistent manner.

The number of viruses of peppers identified and the extent of their prevalence is overwhelming. The yield and quality loss due to virus diseases appeared to be very high indeed. Therefore, it is essential to identify sources of resistance to at least the major viruses such as CMV and CVMV to minimize the yield loss and provide quality peppers to the consumers.

Philippines. A survey for pepper viruses was conducted in seven provinces in Luzon. DAS and DAC indirect ELISA techniques were used to identify the following viruses in decreasing order of occurrence: ToMV, CMV, TEV, CVMV and PVY. Nitrocellulose membrane-ELISA procedure detected PVY.

A tobamovirus isolate from hot pepper which induced yellow mosaic on pepper and tomato caused severe systemic yellow mosaic on *Nicotiana sylvestris* suggesting that it belonged to the TMV group and not ToMV.

Thirty hot pepper and 10 sweet pepper varieties both locally collected and introduced were grown in clay pots in the greenhouse to screen for resistance to pepper virus. Three-week-old plants were artificially and mechanically inoculated with each virus inoculum. Inoculated plants were kept in

the greenhouse for 2 months and were rated on a 0 to 5 scale as resistant to highly susceptible. Resistant materials were confirmed by serology. *N. sylvestris* was the indicator host.

Of the 30 hot pepper lines, 6 were rated as resistant while 2 were rated moderately resistant to TMV. Among the 10 sweet pepper lines, only Delray Bell was moderately resistant. All the resistant cultivars showed hypersensitive types of reaction. The seeds of all the resistant cultivars are being multiplied for further confirmation of their resistance.

Thailand. From November 1989 to January 1990, a pepper virus disease survey was conducted. Collected samples were tested for the viruses by DAS-ELISA using antisera against AMV, CMV, CVMV, PVY, TEV, TMV and ToMV.

CVMV, CMV and PVY were the three major viruses observed in that order of importance. Among the five provinces surveyed ToMV was observed only in Chiang Mai and Lamphun. TMV was not observed in Chiang Mai, and PVY was not detected in Ratchaburi. The result of the survey suggests that the focus of further intensive research should be on CVMV, CMV and PVY. Some isolates of CMV and CVMV have been purified.

To screen for resistance to pepper viruses, seven hot pepper lines tolerant to virus have been collected from the field. Three resistant lines A2-3, 7/2-3, and 5/1-6, were received from Mrs. Siriwipa Satgapong, a plant pathologist at the Si Sa Ket Horticultural Crops Research Center, Horticultural Crops Research Institute, Department of Agriculture, Thailand. The above three resistant lines were derived from a screening for virus resistance in 'Huey Siton' pepper in 1988. The tolerant germplasm included: 'Yuak' and 'Huey Siton' from Central plain; 'Hua Rua' and 'Si Som' from the Northeast; and 'Noom', 'Mun Dang' and 'Duey Kai' from the North. All the above lines will be sent to AVRDC and other collaborating countries for evaluation.

Two screenhouses, 5 × 2.5 m and 6 × 2.5 m were constructed. The smaller one is at the Plant Virology Section, Department of Agriculture and the larger one is at the Scientific Equipment Center, Kasetsart University, Bangkhen Campus. Provision of these two screenhouses through AVNET/ADB funds will facilitate efficient virus isolation and characterization.

Integrated Pest Management of Diamondback Moth in Crucifers Subnetwork

Cruciferous vegetables such as cabbage, cauliflower, broccoli, and radish are economically important to many countries. In recent years, however, crucifer production has been seriously affected by a steady increase in infestation by insect pests, es pecially the diamondback moth (DBM), *Plutella xylostella*. Farmers in Southeast Asia use large quantities of chemical insecticides to control DBM. As a result of injudicious use of pesticides, DBM has developed resistance to practically all chemicals now being used. Since no other practical control measures are yet available, farmers are using ever-increasing quantities of insecticides. Indiscriminate use of pesticides not only gives poor control of DBM, but also kills the natural enemies of DBM such as predators and parasites which otherwise help check the natural population of DBM and other pests.

Scientists have found a bacteria, *Bacillus thuringiensis*, which kills DBM but is not harmful to parasites, predators and humans. A synthetic sex pheromone which attracts DBM males has also been developed. More recently, the chemical industry has developed selective chemicals which are safe for the natural enemies of DBM. AVRDC has also worked with several parasites on DBM.

The NARS of Southeast Asia have unanimously agreed during the Strategy Planning Workshop to accord high priority to the transfer of IPM technology.

The goal of the IPM-DBM subnetwork is to transfer the concept and the technology of IPM to cruciferous vegetable scientists in Southeast Asia with particular emphasis on DBM.

Training

Rearing parasites for release in the pilot areas and a follow-up monitoring of the effectiveness of parasites in controlling the DBM were the subjects of the training course organized at AVRDC. Two scientists from each of the four collaborating countries were trained.

Pilot project areas were identified in both highlands and lowlands in each of the countries. Malaysia and the Philippines completed their construction of the parasite rearing facilities in record time. Initial success was quickly observed in the Cameron Highlands in Malaysia where the establishment of parasitoids was excellent, the farmers cooperation in refraining to use the chemical pesticides was remarkable, and as a result DBM were hard to find. The quality of cruciferous vegetables produced in the Cameron Highlands was excellent and they were free from chemical pesticide residue.

Progress

Indonesia. The construction of a permanent greenhouse (10 m × 5 m) equipped with A.C. and incubator was finished by the end of 1990. The new greenhouse will be used for mass production of *Diadegma semiclausum*, *Cotesia plutellae* and *Trichogrammatoidea bactrae*.[1] At Segunung, a screenhouse (10 m × 6 m) was constructed for mass production of *C. plutellae* and *Diadromus* collaris (pupal parasitoid of DBM).

Cabbages and cruciferous crops are commonly grown in the highlands of Indonesia. However, with the advent of KK and KY-cross cabbages, the crop has become popular in the lowlands as well. DBM is an important pest in both the highlands and the lowlands. The parasite *D. semiclausum* has established very well in most of the highland vegetable-growing areas in Indonesia. As part of the AVNET activities different parasitoid populations are being introduced and established to control DBM effectivel y. As a result the cost of control of DBM will be minimal for the farmers resulting in increased profit and quality pesticide-free vegetables for consumers.

From February to May, 1990, in the following three lowland areas, cocoons of *D. semiclausum* and *C. plutellae* were released when the DBM larval population surpassed 0.3 larva/plant, the threshold level: Sumedang (West Java), Jember (East Java), and Jogyakarta (Central Java). About 400 to 600 cocoons of parasitoid were released in 5 weeks after planting (WAP), 7 WAP and 8 WAP in Sumedang; 5 WAP and 7 WAP in Jember. *Bacillus thuringiensis* was used only when necessary.

In Sumedang the rate of emergence of parasitoids was 31% for *D. semiclausum* and 40% for *C. plutellae* which was rather low. The rate of parasitism of *D. semiclausum* was only 5.7-8.2% at 7 WAP. Neither cocoons of *C. plutellae* nor parasitized DBM larvae were observed in this study. The population of DBM was low. Furthermore, due to high temperature at the lowlands, the survival and efficiency of parasitoids were not as good as in the highlands. Nevertheless, the effectiveness of parasitoid or parasitoid plus minimal sprays of *B. thuringiensis* gave better yield than the control.

In Jember, although parasitoid cocoons were not observed, many adults of *C. plutellae* were observed, suggesting that *C. plutellae* could survive and get established at temperatures between 20° to 35°C. However, parasitism of DBM could not be detected. The following may be the possible reasons for the lack of parasitism: 1) change of sex ratios, 2) lack of natural food for the adult parasitoid, 3) the population of DBM larvae was too low to be parasitized by *C. plutellae* which is density-dependent. The cabbages were also badly damaged by soft rot (caused by *Erwinia carotovora*) and common cutworm (*Spodoptera litura*).

In Yogyakarta, some *C. plutellae* cocoons were noted suggesting that there is a possibility for the parasitoid to get established by itself. It is likely that the environmental factors in Yogyakarta are favorable for the establishment of the parasitoid.

Other studies on the effect of competition between *D. semiclausum* and *C. plutellae* on parasitism of DBM larvae and the effect of space (size of cage) on parasitism of *C. plutellae* on DBM larvae are in progress. In addition to the selectivity of representative microbial insecticides, synthetic pyrethroids and organophosphoric insecticides were being evaluated against *C. plutellae*.

Malaysia. Ms. Siti Asmah Dhiauddin (MARDI) and Mr. Razlan Abdul Ghani (Department of Agriculture) trained at AVRDC and are now actively involved in the mass rearing of *Trichogrammatoidea bactrae* (lowlands) and *D. semiclausum* (highlands), respectively.

MARDI and the Department of Agriculture have successfully organized a 10-day in-country training course on IPM of DBM at Serdang, Malaysia. A total of 30 participants from both agencies were

[1]The parasites, *Diadegma eucerophaga* and *Apanteles plutellae* have been renamed *Diadegma semiclausum* and *Cotesia plutellae*, respectively.

trained. The training emphasized mass rearing techniques of parasitoids of DBM and field assessment of DBM damage.

The mass rearing of *D. semiclausum* was expanded to 200 cages (40 cm × 40 cm × 40 cm) with the production capacity of 5,000 to 8,000 pupae/week. Experimental results revealed that a four-day exposure of second instar larvae of DBM to *D. semiclausum* resulted in the highest level of parasitization.

At present about 500 *D. collaris* are produced per week. After the installation of a heater, *D. collaris* production increased by 50%.

Corcyra cephalonica are used to rear *Trichogrammatoidea bactrae*, an egg parasite of DBM. Currently it is being reared in a temporary laboratory room kept at 28-32°C at 70-100 % RH.

The egg production of *C. cephalonica* peaked in May 1990. Thereafter, egg production progressively decreased to the lowest level in October 1990. *Bracon* spp., a parasite of *C. cephalonica*, and mites reduced the *C. cephalonica* egg production. A change in growing medium might have also been responsible for the reduced egg number.

The mass rearing of *T. bactrae* failed because the egg collections from those brought in from Taiwan in four generations were insufficient for parasitization. The percentage of parasitization was also very low.

A national seminar entitled, 'DBM Management in Malaysia: Perspectives and Strategies' was held in Kuala Lumpur. The seminar was jointly organized by MARDI, Department of Agriculture, and Malaysian Plant Protection Society (MAPPS). Two hundred participants attended and eight papers were presented and discussed. AVRDC was represented by Dr. N.S. Talekar as one of the panel discussants. The seminar concluded that DBM in highland areas is well controlled by the adoption of IPM by more than 50% of the vegetable farmers. However, IPM of DBM needs to be intensified in the lowlands.

Philippines. In Benguet three farmers' fields were chosen for release of *D. semiclausum* and *C. plutellae*. In the first field release (site A) chemical insecticides were not applied. In another (site B) chemical insecticide was kept to a minimum. Cabbages were planted on a staggered basis. During the second set of field releases, site A was planted with cabbage and site B was planted with broccoli on a staggered basis.

D. semiclausum imported from Taiwan was successfully reared under ordinary greenhouse conditions. Parasitization was absent where farmers used heavy chemical insecticide application emphasizing the need to educate the farmers on the usefulness of IPM technology. *D. semiclausum* had 19-30% parasitism during the dry season (March-May) and 8-21% during the rainy season (May-July). Frequent rainfall appears to hinder the parasite activity. However, when the field was enclosed by a plastic house the parasitism remained as high as 37% even during the rainy season. The quality and yield of broccoli harvested was very good under such high parasitism. *D. semiclausum* had an almost similar level of parasitism as *C. plutellae*. However, during rainy season *C. plutellae* had higher parasitism than *D. semiclausum* possibly because *C. plutellae* is an indigenous parasitoid.

It appears that there may be other pathogenic natural enemies of DBM since a number of dead DBM without parasitism was observed in the release area. High DBM populations were observed in March-April. Frequent rainfall caused waterlogging and poor growth of host plants. DBM had been infected with a disease. The parasite rearing house was severely damaged by the July 16 earthquake which temporarily hampered the IPM-DBM activity. The AVRDC entomologist and the AVNET coordinator readily agreed to support the repair of the facilities which have been promptly completed, thus reviving the IPM-DBM activities.

D. semiclausum, *C. plutellae* and *T. bactrae* (imported from AVRDC) were mass-reared in the laboratory at 23-37°C from February-April and 21-27°C from May-June 1990. *T. bactrae* was mass-produced in rice moth eggs. Parasitism was 100% in UV-treated eggs but low in eggs not treated with UV. From egg to adult it took 7-8 days and the longevity of adults was 3-4 days. *T. bactrae* is very sensitive to refrigeration. AVNET gave two strips (1,000 parasitoids) to the National Crop Protection Center (NC PC). From this modest beginning the NCPC is planning to expand the parasitoid mass production and supply to farmers.

C. plutellae was mass-produced in the second instar larvae of DBM. Parasitism in the laboratory increased from 60% in December 1989 to 87% in May 1990. From egg to cocoon it took 6-9 days and the longevity of the adult was 8-12 days. The cocoons could be stored for 15-25 days in the refrigerator. Weekly production of cocoons significantly increased from 500 to 1000 in May 1990. *D. semiclausum* was also mass-reared in the second instar larvae of DBM. Initially, rearing of this parasitoid was unsuccessful and the reasons were unknown. Beginning in June 1990 about 20-30% emergence has been observed.

One-thousand-square meters of field were planted with Chinese cabbage and other varieties of cabbage on a staggered basis. *C. plutellae* was released seven times. *D. semiclausum* was released five times and *T. bactrae* three times. A total of 5,000 cocoons of *C. plutellae*, 3,800 cocoons of *D. semiclausum* and 60,000 parasitoids of *T. bactrae* were released. Three weeks after first planting DBM larvae + pupae and parasitoid cocoons were assessed in the released area and in the farmers' field. Parasitism and population build-up of parasitoids were monitored at 10to 15-day intervals.

C. plutellae was first released on 9 November 1989 and after 12 days showed 4% parasitism. The parasitoid was observed 2 months after the first release in farmers' field (3 January 1990). The highest parasitism recorded in the released area and farmer's field, despite application of insecticides by the farmers, was 55 and 43% respectively. The population of *C. plutellae* increased from 19% in December 1989 to 69% by May 1990.

T. bactrae was released twice in the release area but showed only 14.5% egg parasitism. The parasite could not be recovered in the nearby farmers' fields. The release of this parasitoid was discontinued during the wet season.

D. semiclausum was first introduced in the release area in February 1990 and was recovered from the same field after 20 days with 12% parasitism. However, as of May 1990 the population and parasitism of this parasitoid were still low.

Thailand. The highlands at Ampur Sarapee in Chiang Mai Province have been selected for pilot field release of parasitoids. A contract with a farmer has been signed. For the lowlands Ampur Thamuang in Kanchamepuri Province has been selected as the place for the pilot release. It was proposed to start releasing 375,000 *T. bactrae* eggs/ha at 10-day intervals beginning 10 days after planting. Monitoring of parasitism and population establishment of parasitoid was also planned.

AVRDC-ROC Cooperative Program

Summary

Promising AVRDC vegetable lines and selected varieties of the new vegetable, snap bean, were tested under different environments in Taiwan as part of the ROC national on Regional Yield Trials (RYT).

Fresh market tomato, FMTT 3 was released as Hualien Asveg No. 5 through this process in 1990. Vegetable soybean AGS 292, which was released as Kaohsiung Selection No. 1 in 1987, was planted into 4,202 ha of land, which constitutes 83% of the total vegetable soybean area in spring 1990, in Taiwan. Entries which outperformed the check entries in RYT and advanced trials in 1989 and 1990 were: GC 83008-16 (in yield) and GC83006-7 (in yield and quality) for vegetable soybean; VC3901 A and VC 3737 A, for mungbean; PT 4121, PT 4225, and PT 4287, for processing tomato; CN 1489-89, C 74-357, and C 74-443, for sweet potato; AVRDC 86-187, 86-181 and 86-182 for Chinese cabbage; Sentry and Slenderette, for snap bean; Prize Head, Green Wave, Green Rapid, Grand Rapid Nacional, Red Fire and Simpson's Curled for leaf lettuce, White Boston and Margarita, for butter head lettuce; and Great Wall, Sunny Lakes, Sunny Gold, Georgia, Alper and Mikado Great 4304, for crisp head lettuce.

Introduction

Promising AVRDC vegetable lines and selected varieties of the new vegetable, snap bean were tested under different environments in Taiwan as part of the ROC national Regional Yield Trials (RYT). These trials are mainly conducted in farmers' fields and fully funded and implemented by the ROC national program. The advanced trials on lettuce, one of the new vegetables in AVRDC's 'Development Basket', has been supported by the ROC national program since 1988 to evaluate lettuce cultivars under tropical conditions. These trials on lettuce were conducted and supervised at AVRDC.

Materials and Methods

All trials were conducted in a randomized complete block design (RCBD) with four replications. A total of 71 regional yield trials in 1989-90 are included in this report.

Nine advanced trials for three types of lettuce in three planting seasons from summer 1989 to spring 1990 were conducted. An RCB design with four replications was used.

Results and Discussion

Release of AVRDC breeding lines in Taiwan in 1990

A fresh market tomato F_1 hybrid, FMTT 3, was released as 'Hualien Asveg No. 5' by Hualien District Agricultural Improvement Station in June 1990. This is an F_1 hybrid similar to FMTT 22, with heat tolerance and resistance to bacterial wilt (*Pseudomonas solanacearum*) and tomato mosaic virus (ToMV). Its fruits are also firm and resistant to cracking. It can therefore be grown during the humid hot summer in the lowlands. Its fruits, however, have light green shoulders, a characteristic not preferred by consumers. It was released and introduced to a particular cropping system in the northeast region of Taiwan to produce tomatoes for the Taipei market during off-season, the period with the highest market price in the year.

Performance of released AVRDC lines in Taiwan

An AVRDC introduced vegetable soybean line, AGS 292 (Taishoshiroge) was released in Taiwan as Kaohsiung Selection 1 (KS 1) in April 1987, after its outstanding performance in RYT. Its hectarage in spring and autumn 1989 plantings in Taiwan were 2,321 and 2,620 ha, respectively. They represent 71.9% and 65.1% of the total hectarage for vegetable soybean, respectively in spring and autumn 1989. The area planted to AGS 292 increased to 4,202 ha in the spring 1990 planting which constitutes 83% of the total area in the spring.

Seed production and distribution of AVRDC promising lines for testing in Taiwan

To demonstrate the yield potential of released and promising AVRDC lines in farmers' fields in Taiwan, AVRDC multiplied and distributed a substantial amount (4864 kg) of propagating materials in 1990. Among them were seeds of Chinese cabbage (1.8 kg) and fresh market tomato (11.3 kg).

Regional yield trials and advanced trials

Soybean. Although the development of yield potential is the priority for soybean improvement in Taiwan, there is need for a soybean variety which is of the early maturing type (about 90 to 95 days), with reasonably high yield (2.5 t/ha) and with large seeds (the 100-seed weight is more than 14 g) for the 'Rice Soybean Maize' cropping pattern in summer planting in Chianan areas. Two AVRDC lines, AGS 253 and AGS 301, were evaluated for the second time along with 10 other entries in RYTs in spring, summer and autumn 1989. There was a total of 23 trials. Kaohsiung No. 8 (KS 8), KSS 10 (AGS 129), KS 1745, KS 1625, HL 74-48 and G4 performed better than the other entries across all trials in three seasons in 1989 as well as in the average of two years. KSS 10 had a slightly lower yield in autumn 1989. The protein and oil contents were comparable with other entries in the different seasons, except that autumn soybeans had a low oil content. Protein and oil content were also comparable among entries, though KSS 10 and G4 had a significantly high level of oil content in spring.

Vegetable soybean. Released AVRDC vegetable soybean line, AGS 292 (KS 1), has been recognized to have maintained a competitive level in the Taiwan vegetable soybean industry. Further improvement of vegetable soybean variety in Taiwan should be based on quality, characteristics for mechanical harvest, and yield potential. Two AVRDC promising lines, GC 83006-7 and GC 83008-16, and four from Kaohsiung DAIS with three check cultivars were included in a vegetable soybean RYT which started in autumn 1988.

The mean yields of entries across locations in each cropping season were not significantly different. The average size of marketable pods, however, was significantly different among entries. GC 83006-7 and the high quality check, '305' (Ryokkoh), had the largest pods in all three seasons among entries. Results of the average performance of entries in all trials for 2 years showed that KSV 124 had the highest yield among entries, but it was the most sensitive to environment. Entries showed significant differences for all quality components. GC 83006-7 had good quality in terms of hardness, color and sugar, while protein and fiber contents were better than or similar to the high quality check cultivar '305'.

Mungbean. Mungbean breeding program in Taiwan is aimed to develop high and stable yielding genotypes with a) dull seeds with a size of more than 6 g/100 seeds, b) uniform maturity for mechanical harvest, c) resistance to pests, and d) early maturity. Mungbean has to be harvested by machinery to reduce production cost in Taiwan because of shortage of labor and high wages. Uniform maturing lines developed by AVRDC were particularly suitable for mechanical harvest in Taiwan.

Eight dull type AVRDC mungbean lines with two check varieties were included in an RYT which started in summer 1988. The mean yield across locations in the summer 1989 and spring 1990 trials 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), except VC 3888 A, and VC 3853 A in spring 1990. These two yielded lower. Analysis of the average performance of entries in 11 trials in two years showed that VC 3737 A and VC 3901 A consistently yielded well in all seasons. Stability analysis

showed all entries had a stable performance, being close to the mean response of all entries to environments (locations, seasons and years).

Results of the study on 1000-seed weight, an important mungbean quality component in Taiwan, indicated that VC 3885 A, VC 3901 A and VC 3907 A had big seeds and 1000-seed weight greater than the 60 g 1000-seed weight of check cultivars, TN No. 5 and TN S No. 3.

In conclusion, VC 3885 A, VC 3901 A and VC 3907 A were better than the checks in terms of yield and seed size.

Processing tomato. One of the main objectives of the program on processing tomato in Taiwan is to develop high and stable yielding genotypes with heat tolerance to extended production period and high quality. Three RYTs were conducted in late summer, autumn and winter plantings in 1989-90. These trials, including four AVRDC F_1 hybrid processing tomato trials, were evaluated mainly for mechanical harvest in Chianan area.

In the late summer planting, all entries yielded as high as the heat tolerant check F_1 hybrid, TN 3 (PT 3027), except SEN 49, and UC 82 B which yielded low. In the autumn trial, AVRDC F_1 hybrids PT 4121, PT 4225, and PT 4287 yielded significantly higher than or similar to the check variety, TN 3. PT 4225 had the highest yield (107 t/ha) among entries in the winter planting.

PT 4287, T 8243, SEN 51 and CXD 105 had a significantly bigger fruit than check varieties TN 3 and P 933 in all three trials. Their maturity periods were all similar. The shortest maturity period (118 days) among three plantings occurred in winter planting. Qualities in terms of color and soluble solid contents were similar to that of checks, TN 3 and P 933, except that CXD 105 had a poorer color.

In conclusion, PT 4287 and PT 4225 outyielded check varieties in a total of 21 RYTs during 2 years and their responses to environments did not significantly differ from the average response of entries. They are similar in maturities, fruit quality in terms of size, pH, soluble solids and color as the checks, except that PT 4287 had larger fruits.

Sweet potato. Hectarage of sweet potato in Taiwan has decreased dramatically in the last 20 years. Therefore, the main objectives of the sweet potato breeding in Taiwan is to improve various characteristics to meet the requirements for particular products, e.g. soluble fiber food, sweet potato ice cream, and traditional food. Two sets of entries in the sweet potato RYT, one in summer planting and the other in autumn, were used.

Average yields across five locations for entries in summer 1989 RYT are discussed. The extraordinarily low yield at AVRDC was attributed to the flooding of the fields caused by a typhoon. CN 1489-89, Taoyuan No. 1, and Taoyuan No. 2 performed as well as the check cultivar, TN 66. They also had similar sensitivities to environmental conditions. CN 1489-89 had higher dry matter and starch content, but lower fiber content than TN 66. However, the protein and sugar content was lower in the first than in the second. CN 1489-89 had the highest mean yield among all summer RYTs in 1988-89. For autumn RYT, C 74-443 was the best yielder among entries at all locations except Si-Kou in 1989. It had higher protein content but lower dry matter content than the check cultivar, Tainan 18. C 74-357, C 74-443, and the check cultivar, Tainan 18, had the highest mean yields among entries in a total of 10 RYTs in 1988-89. Both C 74-357 and C 74-443 had higher protein and sugar content but a lower dry matter content than the check cultivar, Tainan 18.

Chinese cabbage. Three AVRDC F_1 hybrids in Chinese cabbage RYTs were planted in summer 1989. Compared to the summer RYT there were less variations in yield among locations than in the autumn RYT. There was no significant difference in yield among entries, except KP No. 2 which had a lower yield than others. All AVRDC F_1 hybrids had bigger heads than the check cultivar, TYASVEG No. 2. AVRDC F_1 hybrid, 82-156, was less sensitive to environments than the other entries. This might be attributed to its tolerance to heavy rain.

Snap bean. A total of eight snap bean entries were studied in six RYT trials, at three locations in autumn 1989 and spring 1990. All entries had higher yield as well as larger pods, in terms of mean pod weight, in spring than in autumn. They did not differ significantly in yield within the same season.

Sentry tended to yield highest in autumn, and Slenderette tended to have the highest yield and the biggest pods in spring.

Lettuce. A total of 34 entries (including 10 leaf, 8 butter head, and 15 crisp head type lettuce), were evaluated in advanced trials in three planting seasons (summer and autumn 1989, and spring 1990). Yields of all three types of lettuce in summer trial varied from 0.7 to 7.2 t/ha. These yields were low compared to those in the previous two summers. The yields in autumn and spring trials were 26.0-44.9 and 0-42.9 t/ha in autumn and spring trials, respectively. These results again indicated that the growth of lettuce under summer conditions in Taiwan is unstable and heat-tolerant varieties are needed.

The growth of leaf lettuce was poor in summer with the highest yield of 2.83 t/ha from Grand Rapid. A substantial variation in maturity existed among entries (23-48 days). However, entries with a later maturity did not yield better than the others. During autumn, the leaf lettuce grew well with a yield level that varied from 26.0 to 40.3 t/ha. Prize Head, Green Wave, Green Rapid, Grand Rapids Nacional, Red Fire, and Simpson's Curled were better yielders than the other entries. The variation in maturity among entries was not great (33-39 days) in this trial. There was no significant difference in yield among entries which varied from 13.8 to 26.3 t/ha, in the spring trial. Entries took 24-33 days to mature in spring. Laksa showed its early maturity consistently in all three seasons.

The butter head type lettuce tended to yield higher than the other two types in spring and summer. In summer 1989, it also had a low yield level of 0.9-27.2 t/ha. This yield level was lower than that observed (1.0-11.3 t/ha) in summer 1988. On the other hand, number of days of maturity (46 days) of most entries in 1989 was about 10 days longer than that in 1988. White Boston and Margarita were the best yielders among entries in autumn 1989 and all entries had similar maturities (44-48 days) except Ueahedu which matured in 86 days. In spring 1990, the yield of entries did not differ significantly. It varied from 32.6 to 42.9 t/ha. Brasil 221, which had the lowest yield, matured about 1 week earlier than the other entries.

The crisp head lettuce did not form any head in the summer trials. Its growth was also poor with the highest plant weight of 5 t/ha in 77 days. This group is the most sensitive to tropical conditions among three lettuce groups tested. It had the highest yield in the autumn trial among the three season trials. Great Wall, Sunny Lakes, Sunny Gold, Georgia, Alper, and Mikado Great 4304 yielded higher than the other entries. They matured in 54-57 days. Great Wall also had the biggest head among entries. The crisp head lettuce did not perform well in the spring trial though it matured earlier than in the autumn trial. Early S-25 was the best yielder among entries, with a yield of 10.5 t/ha. It appeared that transplanting in April in the lowland in southern Taiwan might have been too late for this group of lettuce.

AVRDC-Philipines Outreach Program

Vegetable Soybean Preliminary Yield Trial

Summary

Ten AVRDC vegetable soybean accessions were evaluated under the preliminary yield trial (PYT) in December 1989 (dry season) and July 1990 (wet season) to determine their yield potential, eating qualities and reactions to pests and diseases under local climatic conditions.

Grand mean of fresh pod yield of the 10 entries during the dry season was 4.7 t/ha. The highest yielding entry was AGS 186. All yield components measured showed significant differences among entries.

Introduction

There is an increasing demand among farmers to produce vegetable soybean for domestic consumption and for export. Because of its high nutritional value and ease of production techniques even in backyard gardens, vegetable soybean has been included as one of the priority crops in the nutrition program of the municipal governments. To support this program, promising lines of vegetable soybean from AVRDC are being evaluated for yield potential, eating quality, and reaction to pests and diseases under local climatic conditions.

Materials and Methods

Ten entries were evaluated during the dry season (December 1989). Each entry was sown in four-row 5 m long subplots. The rows were spaced 50-60 cm apart for dry and wet seasons, respectively. AVRDC standard cultural practices for soybean were followed in raising the crop.

Results and Discussion

The grand mean yield of fresh pods evaluated during the dry season was 4.7 t/ha. The highest yielding entry was AGS 186 with fresh pod yield of 5.1 t/ha. Line F 10142 gave the highest 100-seed weight of 52.3 g. The seed size ranged from 35.7 to 52.3 g/100 seeds with a grand mean of 44.8 g/100 seeds.

All the entries were rated resistant to moderately resistant to soybean rust infection.

Accessions AGS 186, AGS 190 and AGS 191 were rated most acceptable in terms of palatability of the green boiled pods and usefulness of the shelled green beans as substitutes for green peas.

Mungbean

Summary

- From the 2 years of GYT data, four promising AVRDC lines (VC 3901, VC 3827, VC 2890 and VC 3758) will be included in the RYT in 1991. These lines outyielded the check BPI-Mg7 by 5 to 24% during the DS and by 8 to 11% during the WS.

- Line VC 2768 b was released by the Philippine Seedboard in 1989 as BPI-Mg9 and commonly known as Taiwan Green. In the PCARRD Mungbean Pilot Project for 1989-90, Taiwan Green was planted in 403 ha by 942 farmer-cooperators of Regions 1 to 4. Bean yields of 1.5-2.0 t/ha were reported by some cooperators and Taiwan Green is fast becoming popular among farmers.

Future Plans

- Continue the collection of lines/accessions from AVRDC and other sources.
- Continue the selection, purification and evaluation of lines/accessions for high bean yield potential; early and uniform maturity; tolerance/resistance to major pests and diseases; desirable agronomic characters; and acceptable eating and processing qualities.
- Continue production of breeder seeds of seed board varieties (particularly Taiwan Green) to support production programs like the Mungbean Commercialization Project of PCARRD.

General Yield Trial

Summary

Fifty-two mungbean lines selected from PYT were evaluated in GYT in two sets of trials during the dry and wet seasons of 1989-90.

The results of the dry season trial were not validated due to severe moisture stress. The average bean yields of the entries ranged only from 193 to 298 kg/ha. In the wet season trial in Set I, VC 3831-2B-1 with 770 kg/ha outyielded the check variet y BPI-Mg9 (769 kg/ha) but the difference was not significant. In Set II, seven test lines outyielded the check BPI-Mg9 but only VC 4083-2B-B-1-B showed statistical significance.

Based on the previous two years GYT data, four entries (VC 3901, VC 3827, VC 3890 and VC 3758) will be elevated to the RYT in 1991. They outyielded the check BPI-Mg7 by an average of 5 to 24% during the dry season and from 8 to 11% during the wet season.

Introduction

Selected material from the PYT was further tested in the GYT to get more information on their adaptability under local agroclimatic conditions and reaction to common pests and diseases. Results obtained from this trial served as the basis for further evaluation in the RYT of the National Cooperative Test.

Materials and Methods

A total of 52 test entries and three check varieties were evaluated during the dry and wet seasons. These were planted in two sets of experiments conducted in a Randomized Complete Block Design with four replications. The dry season was planted in October 1989 and the wet season in June 1990.

The cultural management and data collection were based on the standard procedure suggested in the AVRDC International Cooperators' Guide.

Results and Discussion

Results from the dry season trial were not statistically analyzed due to the poor performance of the entries caused by severe drought. Total precipitation during the crop season was 58 mm. The average bean yield of the 40 entries ranged from 193 to 298 kg/ha and plant stature from 16 to 26 cm.

The wet season trial was exposed to frequent typhoons resulting in yield losses. In Set I, the 12 entries produced an average bean yield of 671 kg/ha with no significant differences between entries. Line VC 3831-2B-1 (770 kg/ha) gave a higher yield than the check BPI-Mg7 with 769 kg/ha; line

VC 3988-B-4 produced the largest seeds (6.4 g/100 seeds). In Set II, with 24 entries, seven test entries outyielded the check BPI-Mg9 (665 kg/ha) but only VC 4083-2B-B-1-B with 823 kg/ha was statistically significant. The mean bean yield was 581 kg/ha. The highest seed weight of 6.6 g/100 seeds was recorded for line VC 3039-B-4-B.

Slight infection from CLS and virus were observed from both sets of trials. The entries matured in 52-73 days after germination.

Regional Yield Trial

Summary

Regional yield trial is a cooperative endeavor among research institutions/agencies involved in mungbean varietal improvement. For 1989-90 dry season, four AVRDC lines, namely EGM 2778, EGM 3102, EGM 3121 and EGM 3541, produced comparable yields to the check BPI-Mg7 (1273 kg/ha). Average yield of the test entries ranged from 1031 kg/ha (EGM 3541) to 1225 kg/ha (EGM 3102) in five locations. All the entries were rated moderately resistant to CLS, mungbean rust and virus.

Introduction

The RYT for mungbean under upland monoculture conditions was conducted in cooperation with 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 the promising strains/varieties of mungbean in different regions of the country. The results from the RYT were used as the basis for recommending to the Philippine Seedboard varietal releases for regional or national production.

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. Accepted entries were evaluated for four to six seasons in the different cooperating s tations. The performance of the varieties was reviewed by the Technical Committee each year. The entries that consistently surpassed the yield or other characteristics of the standard checks were submitted to the Philippine Seed Board for approval while those inferior to the checks were dropped from the trial after four seasons.

For 1989-90, 8 and 10 entries were evaluated during the dry and wet season, respectively, in five locations. The test entries were composed of four AVRDC lines, four IPB lines and three checks (BPI-Mg9 and Pag-asa 7 as national check and MG50-10A as regional check). Each entry was planted in a 10 m^2 four-row subplot distributed in RCBD and replicated four times. The cultural management and data collection were based on the guidelines of the Upland Crop National Cooperative Trial (UCNCT) of the Philippine Seedboard.

Only the dry season data are reported here; the wet season trial is still in progress.

Results and Discussion

Four of the five promising test entries in the RYT were AVRDC lines. Bean yields of the test entries during the 1989-90 dry season across five locations ranged from 1031 kg/ha for EGM 3121 to 1225 kg/ha for EGM 3102 (Table 3). However, all were outyielded by the national check BPI-Mg 7 (1273 kg/ha), an AVRDC line. All the entries were rated moderately resistant to CLS, mungbean rust and virus infections.

17th International Mungbean Nursery

Summary

Twenty AVRDC elite lines together with two local checks were evaluated for their performance under Philippine conditions.

The average yield of the 22 entries was 487 kg/ha in the dry season. Nine AVRDC breeding lines produced bean yields higher than the check BPI MG 9 (441 kg/ha). The highest yielding line, VC 3300 A (964 kg/ha), was the tallest (21 cm) and it matured at 53 days after germination.

Introduction

The IMN is an International Cooperative trial coordinated by AVRDC. The entries are elite mungbean cultivars/accessions from different countries of origin assembled by AVRDC and sent to cooperating stations for evaluation. The study aims to provide information on the range of adaptation of the crop, specific adaptation of individual cultivars and the characteristics of the mungbean plant influencing adaptation. The test also serves as a means of disseminating superior cultivars to mungbean workers.

Materials and Methods

Twenty elite accessions selected/developed at AVRDC together with two local checks were planted on 10 January 1990 (DS) in a Randomized Complete Block Design with three replications. Each entry was planted in 5 m long, four-row subplots. The rows were set 0.5 m apart.

The cultural management and data collection were based on the standard procedure suggested by the AVRDC International Cooperators' Guide for mungbean evaluation trial.

Results and Discussion

The trial was affected by severe drought; the data were not validated. However, the mean bean yield among the 22 entries was 487 kg/ha. Nine AVRDC lines outyielded the check BPI-Mg9 (441 kg/ha). Four AVRDC mungbean breeding lines (VC 3300 A, VC 4111 A, VC 3301 A and VC 3738 A) gave 50% higher yield than the check. They appear to be good materials for moisture stress studies.

Tomato

Single-Seed Descent Materials

Summary

Thirty-seven new tomato lines were tested during dry season (DS) 1989-90 and 38 during wet season 1990. Eight of 12 AVRDC fresh market indeterminate type lines outyielded the checks, Pope and Marikit, but the yield differences were not significant during DS 1989-90. Twenty-three open-pollinated tomato varieties from the station's germplasm collection were field-tested under the SSD during the late wet season (transplanted in October 1989). Low yields were obtained due to the high incidence of southern blight brought about by high precipitation and temperature during the vegetative stage of the plants.

In another set of SSD trials transplanted in July 1990, all four AVRDC open-pollinated fresh market lines and 3 F1 hybrids from Mainland China succumbed to bacterial wilt. Three more sets of SSD trials composed of three entries of open-pollinated BC_1F2, BC_3F_2 and FMTT F_1 lines were transplanted in September 1990.

Introduction

New lines of fresh market tomatoes from AVRDC, Mainland China, and the United States were field tested under the single seed descent trial to evaluate their yield performance under local conditions. Screening was based on yield, resistance/tolerance to tropical pests and diseases, and physiological disorders.

Materials and Methods

Fourteen F1 indeterminate and 23 open-pollinated fresh market tomatoes were tested during the 1989-90 dry season (transplanted January 1990 and October 1989, respectively) and 38 open-pollinated lines and F1 hybrids during the 1990 wet season (transplanted September 1990).

In both seasons, each entry was planted in one-row 5-m long subplots distributed in RCBD and replicated twice. The rows were set 1 m apart and 12 plants were maintained per row. The plants were raised following the AVRDC recommended cultural guide for tomatoes. Rice straw was used as mulch. The indeterminate types were provided with trellis.

Data on yield, horticultural characteristics and observations on pests, diseases and physiological disorders were recorded and analyzed.

Results and Discussion

Dry Season 1989-90

The yield performance of the 23 American varieties transplanted in October 1989 was very low, ranging from 0.31 to 4.36 t/ha. Poor performance was due to excessive rain (265 mm) after field setting and severe outbreak of Fusarium wilt, southern blight, bacterial leaf spot and bacterial wilt.

Fourteen fresh market indeterminate tomato lines transplanted in January 1990 gave marketable yields comparable to the checks which ranged from 18 to 28 t/ha. FMTT-109 had the highest yield. The mean number of days to flower and mature was recorded at 21.5 and 69.5 days, respectively, from transplanting. The checks matured earliest, and FMTT-70, latest. Fruit set rating was comparable to the checks while fruit size significantly varied. The largest fruits (77.7 g) came from FMTT-33.

The effects of southern blight varied significantly among the entries with the highest score of 3.3 recorded on FMTT-13. The checks were the most susceptible to TMV.

Preliminary Yield Trial

Summary

The 21 F1 processing tomatoes tested during DS 1989-90 gave yields comparable to variety Mapula. However, for the fresh market type, six out of 23 open-pollinated lines outyielded the checks.

Introduction

Selections from the SSD were advanced to the preliminary yield trial to identify lines with heat tolerance, built-in resistance to tropical pests and diseases and desirable agronomic, eating and processing qualities.

Materials and Methods

Twenty-four F1 processing hybrids and 33 open-pollinated fresh market lines were evaluated during dry season 198990 and 38 open-pollinated fresh market lines for wet season 1990. The checks were Mapula for processing tomatoes and Pope and Marikit for the fresh market type. Twelve seedlings of each entry were transplanted in 5 m^2 raised subplots distributed in RCBD and replicated three times.

The crops were raised using AVRDC tomato culture practices. Rice straw was used for mulching and the indeterminate types were provided with trellis.

Data on marketable and nonmarketable yields, horticultural characteristics and ratings on pests, diseases and physiological disorders were recorded and statistically analyzed.

Results and Discussion

Dry Season 1989-90

Processing Tomato. Most of the test hybrids produced yields comparable to or higher than the check variety Mapula, but the differences were not significant. The highest yielding entries were PT-4067 with 27.4 t/ha and PT-4064 with 26.8 t/ha.

There were significant differences among entries on nonmarketable yields with PT-4165 producing the highest (4.48 t/ha) followed by PT-4057 (3.41 t/ha). This was a high incidence of blossom end rot (BER), cracked fruits, and fruitworm damage.

After transplanting, the entries flowered in 25-28 days and matured in 63-75 days. Fruit setting varied in a score of three to four which was insignificant among entries. The largest fruits were produced by PT-4062 (71 g/fruit) and PT-4151 (60 g/fruit). The incidences of TMV, BW and sunscald were uniform among entries.

Fresh market tomato. Preliminary results showed that out of 33 open-pollinated lines evaluated, the most promising lines in terms of yield were CLN 698 BC1 F4-512-0-12-6, CLN 475 BC1 F4-265-9-0 and CLN 657 BC1 F5-206-0-0-0.

All entries flowered in 21-28 days and matured in 72-81 days after transplanting. Fruit size varied significantly among entries with the largest produced by CLN 657 BC1 F5-267-0-0 (70.7 g/fruit).

There was a high incidence of BER among the entries with CLN 229 F5-12-5-3-12-10 as the most susceptible with a mean score of 4.7.

Line CLN 475 BC1 F4-265-12-1-20 was most susceptible to fruitworm. Sunscalding, TMV and fruit cracks were observed on all lines but their effects did not show significant differences.

Line CLN 475 BC1 F4-265-12-1-20 was most susceptible to fruitworm. Sunscalding, TMV and fruit cracks were observed on all lines but their effects did not show significant differences.

General Yield Trial

Summary

PT-1599, PT-1600 and PT-778 significantly outyielded the check Mapula by 46%, 37%, and 21%, respectively, during DS 1989-90 trial. Mapula gave the lowest yield average of 17 t/ha. For the fresh market tomatoes, four lines showed better yields than the checks but the differences were insignificant. They were CL 5915-222 (G) D4-0 (22.54 t/ha), CL 5915-204 (G) D4-1 (20.64 t/ha), CL 1131-0-0-43-4-12 (19.5 t/ha), and CL 5915-153 D 4-3-3-0 (18.9 t/ha). Pope and Marikit produced 17.2 and 17.9 t/ha yields, respectively.

The continuous rain and high night temperature during the wet season did not favor crop development. Therefore, data from three sets of trials were discarded.

Introduction

Lines found promising after four seasons in the PYT were evaluated in the GYT to screen further entries with high marketable yield potential, desirable fruit characteristics, and resistance to tropical diseases. Outstanding entries from the GYT were then entered in the regional testing before they were released for regional or national recommendations.

Materials and Methods

Seven F1 processing tomatoes were compared to Mapula and 12 open-pollinated fresh market lines to Pope and Marikit during DS 1989-90. During wet season 1990, 22 open-pollinated and seven F1 hybrids of fresh market type were evaluated in the GYT.

Each entry was transplanted in 6.5 m^2 subplots distributed in RCBD with four replications.

The AVRDC recommended guide for tomatoes was followed in conducting the trial. Rice straw was used as mulch and the indeterminate types were provided with trellis.

Data on yield, horticultural characteristics and observations on pests, diseases and physiological disorders were recorded and statistically analyzed.

Results and Discussion

Dry Season 1989-90

Processing tomatoes. Three test lines produced marketable yields significantly different to the check, Mapula. These were PT-1599 (25.0 t/ha), Pt-1600 (23.5 t/ha) and PT-776 (21.8 t/ha). Mapula produced a mean yield of 17.2 t/ha. The nonmarketable yield produced by the test lines were comparable to the check. Flowering was from 26 to 28 days while maturity from 64 to 72 days from transplanting. Fruit size varied significantly among entries; largest fruits were recorded for TM-103 (50.5 g). The effects of TMV, blossom end rot (BER), and fruit cracks varied significantly. TM-103 and Mapula were susceptible to TMV with scores of 5.0. Highest BER rating of 4.25 was recorded on PT-1017, PT-1599, and TM-103. PT-778 was most susceptible to fruit cracks.

Fresh market tomato. Four lines outyielded the checks on marketable yields but the differences were insignificant. Yield ranged from 10.4 to 22.5 t/ha, with the highest produced by CL 5915-222 (G) D4-0. Largest fruits of 89 g were produced by Cl 591 5-93 D4-1-0. Flowering was 30.5 days and maturity was 75 days from transplanting. Differences on flowering and maturity among the entries were significant.

The incidence of TMV varied significantly with least infection on CL 5915-222 (G) D4-0. The effect of Southern blight, fruit cracks, sunscalding and BER on test lines were comparable to the checks. The infestation of fruit worms was highest on CL 1131-0-0-43-4-12.

Regional Yield Trial of Fresh Market Tomato

Summary

Twelve fresh market tomato lines/varieties were evaluated in the RYT during the dry season 1989-90. Results from the BPI-POP showed that three entries with marketable yields of 27-33 t/ha significantly outyielded the check Maigaya (20.7 t/ha). The highest yielder was CES I-8225. This result was confirmed when CES I-8225 again produced the highest mean yield of 33.4 t/ha across 13 cooperating stations. The two AVRDC selections from POP did not perform well in the trial.

Introduction

The RYT on fresh market tomato was resumed during dry season 1989-90. Conducted in 13 cooperating stations, the trial aimed to evaluate the field performance of promising tomato lines/varieties in the different regions of the country and to identify those that can be released through the Philippine Seedboard for national and/or regional recommendations.

Materials and Methods

Twelve test entries from UPLB/IPB, DA-Claveria Experiment Station, BPI-POP and the East/West Seed Co. were evaluated against the check Maigaya in 13 cooperating stations.

Each entry was transplanted in four-row 4 m long subplots distributed in RCBD and replicated four times. The rows were spaced 1 m apart.

Application of 55-55-55 kg/ha N, P_2O_5 and K_2O, respectively, was made at planting. Three side dressings of 32-24-90 kg/ha were done at 10, 20 and 30 days after transplanting.

The plants were mulched with rice straw. Irrigation, cultivation, weeding and control of pests and diseases were done whenever needed.

Data on yield and other horticultural characteristics were recorded from the two center rows and statistically analyzed.

Results and Discussion

BPI-POP

The RYT from POP showed significant differences among entries in yield and other horticultural characteristics measured. The marketable yield ranged from 19.4 t/ha for Bonanza to 33.4 t/ha for CES I-8225 or a grand mean of 25.3 t/ha for the 13 entries. Three test entries significantly outyielded the check Maigaya. Yields of the two POP entries (CL 5915-222 (G) 4D-0 and -2), which ranked fourth and fifth in the trial, were not significantly different from the checks. While variety Bonanza produced the largest fruit size of 49.2 g/fruit, it was also rated most susceptible to blossom end rot. The high mean on nonmarketable yield was 5.2 kg/ha.

RYT Across Location

The computed mean marketable yield of the fresh market tomato entries across location further showed that CES I-8225 with 36.3 t/ha ranked the highest and Bonanza with 24.2 t/ha the lowest among the test entries. The grand mean yield was 30 t/ha. Like Bonanza, the two POP entries produced yields (26-27 t/ha), lower than the check Maigaya (29 t/ha). All the entries will be tested for another season in the 13 cooperating stations.

Chinese Cabbage

Summary

Of the six Chinese cabbage open-pollinated lines and one hybrid evaluated during the dry season, hybrid CAT 80-33 produced the highest marketable head yield of 22.2 t/ha which was significantly higher over all the entries.

Introduction

Since the scaling down of the Chinese cabbage improvement program at AVRDC, few entries have been received at POP for evaluation. Only one preliminary yield trial was conducted during dry season 1989-90 (transplanted 6 December 1989). Six OP lines and one hybrid were compared to the check variety, Reyna Elena.

Materials and Methods

Each entry was planted in 1 m × 4.8 m raised subplots distributed in RCBD and replicated three times. Two furrows 50 cm apart were set in each subplot. One seedling was planted 40 cm between hills within the furrows. Application of 60-60-60 kg/ha N, P_2O_5 and K_2O respectively, was made at planting. Side dressings with 30-75-15 kg/ha of N, P_2O_5 and K_2O were done 10 and 20 days after transplanting, respectively.

Results and Discussion

Dry Season 1989-90

Only hybrid CAT 80-33 with 22.2 t/ha significantly outyielded the check Reyna Elena (17.0 t/ha). The yield ranged from 10.3 t/ha for 77M (3)-26 to 22.2 t/ha for CAT 80-33 or an average of 16.1 t/ha for all entries. Heaviest head of 767 g was produced by 77M (2/3)-43 which also gave the second highest marketable yield of 20.4 t/ha. All the entries showed comparable head solidity which ranged from 0.31 to 0.52 g/cc. The incidence of soft rot infection was low for all the entries.

The mean temperature during the dry season trial was 33.1°C maximum and 21.3°C minimum. Total precipitation during the crop cycle was only 35 mm.

Pepper

Preliminary Observation on the AVRDC Hot and Sweet Pepper Lines and Accessions

Summary

One-hundred lines/accessions from AVRDC were received in June 1989 for evaluation and selection under the local agroclimatic conditions. Observational trial was conducted in pots to characterize and group the different collections in terms of type, maturity, growth and fruiting habits.

Field evaluation was done in the 1990 wet season and harvesting of the different entries is in progress. Preliminary results as of October 1990 showed that irrespective of classification, a wide variation on yield existed among varieties ranging from 88.9 kg/ha for Unknown 1 to 10.4 kg/ha for Kradee Kao.

Introduction

One-hundred pepper lines/accessions from AVRDC were evaluated to select lines that were high yielding, resistant to pest and diseases, tolerant to heat, with desirable horticultural characteristics and with acceptable eating and processing qualities.

Materials and Methods

Some 100 AVRDC pepper accessions were transplanted in pots (three pots per accession) on 15 August 1989 for characterization in terms of type, maturity, growth and fruiting habits. Yield per plants and reaction of the different collections to natural incidence of pests and diseases were also recorded.

Based on the characterization obtained in the observational trial in the pots, the entries were grouped along with 13 previous collections and were field evaluated in June 1990. Each entry was transplanted in a nonreplicated single row 3 m long plot spaces 0.75 m between furrows. Proper cultural management practices such as periodic spraying of pesticides, fertilizer application, weed control and cultivation were done.

Data on yield, yield components, horticultural characteristics, and disease rating were recorded.

Results and Discussion

The 1989 set of 100 AVRDC pepper lines/accessions were grouped as follows:

Group	No. of Lines/Accessions
Sweet Pepper	13
F1 Hot Pepper	11
Perennial Siling Pasiti Type (similar to native varieties)	8
Perennial, Upright, Prolific Hot Pepper	11
Pendant, Medium to Long	
Hot Pepper (Anaheim Types)	42
Conical, Semi-Upright to Upright Hot Pepper	15
TOTAL	100

Natural viral infection at first harvest was not apparent in but seven entries.

For the 1990 wet season field evaluation, harvesting of the different accessions in each grouping is still in progress. The following lines/accessions appeared to be promising for each group:

Group	Promising Lines
Sweet Pepper	Heart Shaped
F1 Hot Pepper	Hot Beauty
Perennial Siling Pasiti Type (similar to native varieties)	Perennial HDV and Hot Pepper
Perennial, Upright, Prolific Hot Pepper	Unknown 14, Unknown 16 and Unknown 19
Pendant, Medium to Long Hot Pepper (Anaheim Types)	Kradae Kao, MC4, Unknown 6 A. T. 1 and K1
Conical, Semi-Upright to Upright Hot Pepper	HDA 248
Other Hot Pepper Collections	HP 87

Due to variability within lines, plant selections were made on segregating accessions for further screening.

Irrespective of groupings, 47 collections were rated moderately resistant to natural virus infection. Twenty-seven entries, particularly the sweet pepper lines, were found to be moderately to highly susceptible to the disease. Three accessions totally succumbed to bacterial wilt prior to harvest.

Sweet Potato

Germplasm Collection and Maintenance on Sweet Potato

Summary

A total of 110 sweet potato lines/accessions from AVRDC and other sources are maintained in the station. This germplasm pool cateres to the needs of researchers in government institutions and the private sector.

Introduction

A germplasm collection on sweet potato is being maintained at POP to serve as a source of material for public and private researchers engaged in varietal improvement of the crop.

Materials and Methods

Each line and accession collected from foreign and local sources are maintained at POP in 6 m^2 nursery plots.

Results and Discussion

At present, there are 110 sweet potato lines/accessions in the collection. Planting materials have been provided to sweet potato researchers.

Preliminary Yield Trial

Summary

The study on 24 sweet potato entries evaluated against the check BPI-Sp2 during the 1990 dry season (DS) did not produce valid results due to severe drought.

From the previous three wet season (WS) trials (1987-89), lines CN 1232-9 and CN 1424-3 with mean marketable root yields of 20.4 and 18.2 t/ha, respectively, consistently outyielded BPI-Sp2 (17.7 t/ha), but the difference was not significant. However, lines CN 1232-9 and 1424-3 produced higher dry matter contents of 29.6% and 31.7%, respectively, than BPI-Sp2 (27%).

During the DS trial in 1989, none of the test entries outyielded the BPI-Sp2 (42.0 t/ha). The promising line CN 1232-9 produced 33.1 t/ha.

Introduction

From 1987-89, three wet seasons and one dry season PYTs were conducted on 24 AVRDC sweet potato lines/accessions against the check BPI-Sp2. The study aimed to evaluate the tuber yield potential, dry matter content, desirable agronomic characteristics and eating and processing qualities of the test entries.

Materials and Methods

Twenty-four entries of sweet potato lines/accessions were evaluated against BPI-Sp2 (check). Each entry was planted in a double row 6 m^2 subplots distributed in RCBD with three replications. Planting distance was 75 cm × 25 cm between rows and hills , respectively. The cultural management and data collection procedures were according to the AVRDC procedures on sweet potato evaluation.

Results and Discussion

Of the 20 entries evaluated from 1987-89, lines CN 1232-9 and CN 1424-3 with average marketable root yields of 20.4 and 18.4 t/ha, respectively, consistently outyielded BPI-Sp2 (17.8 t/ha) in three wet season trials. These two promising accessions have dry matter contents (29.6% for CN 1232-9 and 31.7% for CN 1424-3), higher than BPI-Sp2 (27%).

However, during DS 1989, none of the test entries outyielded the check variety BPI-Sp2 which produced a marketable root yield of 42.0 t/ha. Line CN 1232-9, which was promising during the WS trial (based on yield and dry matter content) produced marketable root yield of 33.1 t/ha.

The results of the 1990 dry season trial were not validated due to the severe drought experienced during that season.

The same set of entries, planted in July 1990 for wet season, is still in progress.

General Yield Trial

Summary

No valid results were obtained from the 17 sweet potato entries evaluated during the 1989-90 trial due to drought. The 1990 WS trial is still in progress.

Consolidation of the past two WS and DS data showed none of the test entries in the GYT significantly outyielding the check, BPI-Sp2.

Introduction

Seventeen sweet potato lines/accessions were evaluated in the GYT during the dry season of 1989-90. This activity was done to reconfirm the root yield performance and other desirable characteristics of the test entries.

Materials and Methods

Each of the 17 AVRDC sweet potato lines/accessions were planted in double-row 6 m^2 sub-plots distributed in RCBD with four replications. Cultural management and data collection were based on

the AVRDC recommendations in conducting the trial. Data on marketable and nonmarketable tuber yields and other horticultural characteristics were recorded.

Results and Discussion

The trial during the 1989-90 DS did not produce valid results due to drought. The WS trial is still in progress.

The consolidated data obtained from the two WS and DS trials of 1987-89 showed none of the test entries significantly outyielded the check BPI-Sp2.

Pheromone Trial for the Control of Sweet Potato Weevil

Summary

Initial results on the use of sex pheromone against sweet potato weevil reduced weevil damage by 82% on the tubers of BPI-Sp2 from a 515 m^2 field trial conducted during the dry season of 198889. A total of 2,527 male weevil adults were caught from the three traps set in the field during the course of the study.

Introduction

Screening studies on sweet potato weevil showed that all the sweet potato varieties and accessions were susceptible to weevil infestation. An integrated approach on the control of weevil through the use of sex pheromones was devised by AVRDC with very promising results. This technique has been evaluated using sex pheromones in controlling sweet potato weevil under local conditions.

Materials and Methods

Sweet potato variety BPI-Sp2 was used in the trial. The sex pheromone-impregnated capsules were supplied by AVRDC. The weevil-infested field was cleared of sweet potato debris and alternate hosts of the pest prior to land preparation. The field was then divided into 12 sampling subplots of 5 m × 6 m distributed in RCBD with three replications. Each subplot contained 10 rows set 50 cm apart. The BPI-Sp2 cuttings, presoaked overnight in an insecticide solution, were planted at one cutting per 20 cm within the row. Three sex pheromone traps were placed strategically in the field 20 m apart and facing the wind. Daily counts of the trapped weevils were made and the traps were moved around the experimental field once a week until the completion of the study. Root sampling for weevil counts and other field observations were made from the four center rows of each subplot. An adjacent field planted with BPI-Sp2 in a like manner, but lacking the sex pheromone treatment, was used as the control.

Results and Discussion

Initial results from the 1988-89 trial showed that a total of 2,527 male adult weevils were caught from the three traps set in the 515 m^2 plot of BPI-Sp2. The number of weevils trapped during the first 2 weeks was high and progressively declined towards the later part of the trial. At harvest, weevil damage was 18% in the treated plots compared to 100% in the control plots.

AVRDC-Indonesia Vegetable Research Program

Biological Control of Diamondback Moth in Lowland Farmers' Fields

Summary

Diamondback moth (DBM, *Plutella xylostella* L.) is an important cabbage pest in the lowlands and mid-elevation areas. Attempts were made to control DBM in Sumedang (West Java), Yogyakarta (Central Java) and Jember (East Java) in 1989 by the introduction of two larval parasitoids, *Diadegma eucerophaga* Horstm. and *Apanteles plutellae* Kurdj. Promising results were obtained only from Yogyakarta. Most of the parasitoids did not emerge because of the hot climate. The dispersal capability of parasitoids could have been hampered by lack of continuity of host (DBM) and habitat (cabbage) in the area, thus preventing effective biological control of DBM.

Introduction

Cabbage is commonly commercially grown in the highlands. However, some cabbage varieties such as KK-Cross and KY-Cross can also be grown in the lowlands. The area devoted to cabbage growing in the lowlands and in medium elevations is increasing every year.

DBM is an important pest of cabbage in the highlands and the lowlands. At present, *Diadegma eucerophaga* Horstm. has established itself very well in most highland vegetable growing areas of Indonesia. This has encouraged researchers to develop a biological control program for DBM using *D. eucerophaga* and *A. plutellae* which has been reported adaptable to warmer areas.

This study aimed to develop a biological control method for DBM with *D. eucerophaga* and *A. plutellae* in the lowlands.

Materials and Methods

Cabbage variety KK-Cross or KY-Cross was grown in a rice-based system in the lowlands of Sumedang (West Java), Yogyakarta (Central Java) and Jember (East Java), from February to May. All agronomical aspects followed local recommendations. A microbial insecticide, *Bacillus thuringiensis*, (Dipel WP 0.1% formulated concentration) was used only when necessary, as when the larval population surpassed control threshold (0.3 larva/plant).

In Sumedang, 400 cocoons each of *D. eucerophaga* and *A. plutellae* were released 5 weeks after planting (WAP), 7 WAP and 8 WAP. In Jember, 600 cocoons of each parasitoid were released 5 WAP and about 7 WAP, while in Yogyakarta, 500 cocoons of *A. plutellae* were used.

Sample plants were selected systematically: 50 plants in Sumedang and 10 plants in Jember and Yogyakarta. The number of DBM larvae and pupae and parasitoid cocoons on each sample plant were recorded. The percentage of parasitism was calculated. At harvest, all cabbages were harvested and the weight of marketable crops in each plot was recorded. Observations were also made for other important pests and diseases.

Results and Discussions

Experiment in Sumedang. The rate of emergence of both parasitoids were relatively low, about 31% for *D-eucerophaga* and 40% for *A. plutellae*. The rate of parasitism by *D. eucerophaga*

was very low, from 5.7-8.2% at 7 WAP. No cocoons of *A. plutellae* and parasitized larvae were found.

This could be due to the hot climate and low population of the host (*P. xylostella*). Cabbage was grown in rotation with rice. Since there was no continuation of host (DBM) and habitat (cabbage), the parasitoid population may have been too little for effective biological control. The use of *B. thuringiensis* effectively suppressed the population of DBM and therefore maintained the cabbage yield.

Experiment in Jember. No parasitoid cocoons were found in this area. However, many adults of *A. plutellae* were observed. This meant that *A. plutellae* can survive and become active at high temperatures (between 20 and 35°C) This parasitoid can be established at relatively high temperatures of the lowland. However, results from five samplings of DBM larva showed that no larvae was parasitized. Some possible reasons for this are: (1) changing of sex ratio; (2) lack of natural food for the adult parasitoid; (3) the population of DBM larvae was too low to be parasitized by *A. plutellae* which is density-dependent.

The cabbage yield was very low due to serious infection by soft rot (*Erwinia carotovora*) and common cutworm (*Spodoptera litura* F.).

Experiment in Yogyakarta. Results of the biological control of DBM experiment in Yogyakarta were not so different from those of Sumedang and Jember. The environmental condition and constraints in this location were almost similar to those of the other two locations. Some *A. plutellae* cocoons were found in this place but were left in the field to give *A. plutellae* the opportunity to establish itself. The average yield was about 1.0 kg/plant.

Biological Study

To support the biological control and integrated control program of DBM in Indonesia, several biological studies on *D. eucerophaga* and *A. plutellae* had been undertaken. Ongoing research along this line includes:

- Effect of competition between *D. eucerophaga* and *A. plutellae* on parasitism of DBM larvae.
- Effect of space (size of cage) on the parasitism of *A. plutellae* on DBM larvae.

Toxicological Study

One of the basic components of DBM-IPM (diamondback moth integrated pest management) is the use of selective insecticides. Synthetic pyrethroids and organo-phosphoric insecticides representative of microbial insecticides are being tested to determine their selectivity against *A. plutellae*.

Parasitoid Rearing Facilities

To support the biological control and IPM of the DBM program, two old screenhouses have been renovated. The Asian Development Project (AVNET) funded this construction (US$ 28,000).

A permanent greenhouse (10 m × 5 m) equipped with air conditioner and incubator was constructed at Lembang. This greenhouse will be used for mass production of *D. eucerophaga*, *A. plutellae* and *Trichogrammatoidea bactrae*. While at Segunung, a screenhouse (10 m × 6 m) was also constructed for mass production of *A. plutellae* and *Diadromus collaris* (pupal parasitoid of DBM).

Future Activities

Studies for 1991:

- Development of biological control of DBM in farmers' field:
  - Highland: at Lembang (*A. plutellae* and *T. bactrae*) and at Segunung (*A. plutellae* and *D. collaris*).
  - Lowland/mid elevation: at Majalengka (West Java) or Magelang (Central Java).

- Verification trial of DBM-IPM in a farmer's field at Pangalengan (West Java). This study will be carried out in cooperation with CIBA-GEIGY Cisarua, Lembang.
- Mass production of parasitoids:
  Lembang: *D. eucerophaga*, *A. plutellae* and *T. bactrae*.
  Segunung: *A. plutellae* and *D. collaris*.
- Development of biological control of DBM with *D. eucerophaga* in new areas: During the recent meetings with the Extension Service staffs from the provinces of Irian Jaya, North Sulawesi, South Sulawesi, West Nusa Tenggara, East Nusa Tenggara, etc., several requests have been received for the development of biological control in the respective areas. For this purpose, samples of *D. eucerophaga* will be supplied from Lembang.

Problems

Problems encountered in the development of biological control program for DBM in Indonesia

- lack of budget for equipment (cages, glasswares, etc.) and operational costs for continuity of the program;
- lack of trained staff to support the program in Indonesia;
- little coordination among research institute, extension service and related organizations; and
- lack of farmers' knowledge on judicious use of pesticides.

Screening of Pepper Accessions/Cultivars for Resistance to Viruses

Summary

Resistance of peppers to viruses, mainly CMV, PVY and CVMV, was studied in two tests. Results indicated that none of the 50 accession/cultivars tested showed resistance to CMV or PVY. Accession LV-2411 was immune, while LV-1559, LV2320, Keriting Hitam and Genjah-1 showed resistance to CVMV.

Introduction

Peppers are subject to attacks of many fungal, bacterial and viral diseases. Among the major virus diseases on peppers, CMV, PVY and CVMV are very important. No information on source of virus resistance for peppers so far exists in Indonesia. This study therefore determined sources of resistance to major viruses in peppers.

Materials and Methods

Two screening experiments were carried out in a greenhouse. In one experiment, 50 accessions were screened for resistance to CMV and PVY. In another, 88 accessions were screened for resistance to CVMV. Screening was done by artificial inoculation.

Classification of disease resistance

Reaction	Appearance
Immune	– Plant population does not show symptom, and plant does not contain virus. Intensity of disease is 0%.
Resistant	– Plant population shows disease intensity between 0.1-10.0%
Moderately resistant	– Plant population shows disease intensity between 10.1-30%
Moderately susceptible	— Plant population shows disease intensity between 30.1-50%
Susceptible	– Plant population shows disease intensity of more than 50%.

Intensity of disease was obtained using the formula:

$$I = [S(n \times v)/NV] \times 100\ \%$$

where: n = number of plants showing certain symptoms
v = score of symptoms of each plant
N = total number of plants observed
V = highest score of symptoms (3).

Score levels	Score
No symptom, where the individual plant looks healthy.	0
Very mild symptoms, symptoms exist but are unclear.	1
Moderate, symptoms can be seen clearly, but no malformation of leaves or part of the plant can be observed.	2
Severe, worst symptoms, very distinct, combined with stunting, malformation or defoliation.	3

The level of symptom expression may differ depending on the initial symptoms, such as mosaic, curling, necrosis, etc.

Results

Screening for CMV and PVY resistance. The results of the screening for virus resistance in pepper are presented in Table 1.

Table 1. Development and incidence of virus symptoms in pepper seedlings.

Suspected	Number	Development of symptom after one month		Virus incidence	
		Diseased	Healthy	Diseased	Healthy
Healthy	9	1	8	1 PVY + CMV + AMV	8
Chlor. Malf.	17	6	11	4AMV, 3PVY 2CMV, 1CVMV, 1 ToMV	5-,1CMV, 3 PVY, 1CMVM, 1ToMV
Mos., sin.	6	4	2	3PVY,2CMV, 2AMV	1-,1AMV
Yellowing	2	1	1	1TEV + CVMV + ToMV	1

Out of 50 accessions/cultivars screened, none showed resistance to CMV and PVY. Seeds from resistant accessions were collected and stored. More detailed studies will be done by Mr. R. Sutarya in AVRDC.

Screening of AVRDC Tomato Lines for Resistance to Bacterial Wilt

Summary

Bacterial wilt caused by *Pseudomonas solanacearum* is an endemic disease that causes severe yield losses in tomato in the tropics and subtropics. In general, very few resistant accessions and lines have been identified. Varieties and lines resistant at one location were not always resistant in other locations. These differences were due to variations in bacterial pathogenicity and environmental conditions. Screening for resistance was conducted at Subang Horticultural Research Station (110 masl). None of the 21 AVRDC lines tested was resistant to bacterial wilt. Only one accession, BL 333 was moderately susceptible. The quality of the fruits of accessions CL 5915-206-D4-2-2-0, BL 323,

BL 342, CL 9-0-0-1-3, CL 143-0-10-3-0-10 and BL 333 seemed to be acceptable in local market conditions.

Introduction

Bacterial wilt causes severe yield losses in tomato and potato in tropical and subtropical regions. There are no economic control measures for the disease yet and 100% crop loss is very common in Indonesia. Most of the commercial tomato cultivars are susceptible to bacterial wilt.

Research on bacterial wilt resistance in Indonesia has been carried out since 1970, but efforts were mainly concentrated in the highlands. Sahat (1987) crossed Intan (VC-33) with high quality tomato varieties such as Monalbo, Gondol, etc. Several lines with resistance to bacterial wilt with a better quality than Intan were developed.

This study screened promising AVRDC tomato accessions which have a high degree of resistance to bacterial wilt and are commercially acceptable.

Materials and Methods

The study was conducted at Subang Horticultural Research Station (110 masl) from January to June 1990. A randomized complete block design with four replications was used. The treatments used 21 accessions of tomato received from AVRDC.

Screening for bacterial wilt resistance was conducted in the disease nursery. Thirteen-day old seedlings (DAS) of susceptible tomato variety L 390 were planted in beds. The distance between rows was 20 cm. At 30 DAS, all uppermost leaves were cut with a pair of scissors dipped in a suspension of bacteria (1 × 108 cfu/ml). Land was rototilled 15 days after plant infection.

The tested tomato accessions were seeded and transplanted to the disease nursery at 21 days old. All tomato accessions were planted next to the susceptible (L 390) and resistant (L 285) checks using a distance of 20 × 30 cm. Observations on bacterial wilt were made every week. For the classification of resistance, the Thaveechai et al. (1989)[1] rating scale was used:

80-100 % Survival = Resistant (Rs)
60-79 % Survival = Moderately resistant (MR)
30-59 % Survival = Moderately susceptible (MS)
0-29 % Survival = Susceptible (Ss)

Results and Discussion

P. solanacearum attacked all the tomato accessions tested. The average disease occurrence on these plants ranged from 63 to 100 %. Early symptoms of attack were characterized by mild wilting of the plant, followed by permanent wilting after 1 week.

None of the lines tested was resistant to *P. solanacearum*. The only exception was BL 33 with a moderately susceptible reaction. All of these accessions were resistant to *P. solanacearum* in Taiwan (Hartman et al., 1989)[2]. It has been reported that the degree of resistance of tomato to bacterial wilt was controlled by polygenes. Hence, the resistance will easily be broken down by the effects of temperature (30-33°C) (Thurston cited in Hutagalung, 1980)[3]. High temperature may have been the reason for susceptible reactions in the experiments. At the experimental site, air temperature, relative humidity and rainfall were, respectively, 24 to 33°C, 84% and 18 mm.

Differences in resistance may also be due to the pathogenicity of bacterial wilt as determined by its races. French, in Hutagalung (1980); Buddenhagen and Kelman (1964)[4] reported that three

[1]Thaveechai, N, W. Kositratana and G.L. Hartman. 1989. Bacterial wilt resistance screening. In: Laboratory Course on Bacterial Wilt of Tomato. Kasetsart University, Thailand: p. 40-44.

[2]Hartman, G.L., N. Thaveechai and W. Kositratana. 1989. International Bacterial wilt disease nursery for tomato. In: Laboratory course on bacterial wilt of tomato. Kasetsart University, Thailand: p. 40-44.

[3]Hutagalung, L. 1980. *Pseudomonas solanacearum*. In: Bakteriologi, Bahan Pelajaran Latihan Karantina Pertanian. IPLPP, Ciawi-Bagian Hama Penyakit LPH, Pacet: 8 hal. (in Indonesian).

[4]Buddenhagen, I. and A. Kelman. 1964. Biological and Physiological Aspects of Bacterial Wilt Caused by *Pseudomonas solanacearum*. Ann. Rev. of Phytopathology (1964) 2:202-230.

races have been designated at present. Race-1 attacks solanaceous and other plants living in the lowland tropics. Race 2 effectively attacks bananas and heliconias and Race 3 attacks potato.

Aside from resistance, fruit performance was also observed in this experiment. Accessions CL 5915-206-D4-2-2-0, BL 323, BL 342, CL 9-0-0-1-3, CL 143-0-10-3-0-1-10 and BL 333 seemed to be acceptable for the local market. Fruits of accession CL 5915-2-06-D4-2-2-0 and CL 143-0-10-3-0-1-10 were plum shaped; BL 342, CL 9-0-0-1-3 and BL 333 were high-round and BL 323 was of the apple type.

Conclusions

Varieties and lines resistant to bacterial wilt in AVRDC (Taiwan) were susceptible under Indonesian conditions.

Accession CL 5915-206-D4-2-2-0, BL 323, BL 342, CL 9-0-0-1-3, CL 143-0-1-3-0-1-10 and BL 333 produced fruits that may be suitable for the local market.

Evaluation of Some Tomato Genotypes in the Lowlands

Introduction

Tomato is one of the world's most popular vegetables. They are grown both in home gardens and on a commercial scale. They can be eaten as table tomato (fresh fruit) or processed into tomato sauce, juice, etc. Data from the Agricultural Statistical Department mentioned that Indonesians consume + 1 kg tomato fruits/capita/year. On the other hand, the Department of Health reports that a person needs 98.5 kg vegetables and fruits per year. This asserts the importance of growing tomatoes along with other vegetables. Since only a few varieties are adapted to lowland areas, this trial evaluated the yield potential of tomato and its resistance to important pests and diseases in the lowlands.

Materials and Methods

The materials originated from AVRDC and were compared with Ratna and Mutiara as checks. A randomized complete block design with 33 materials, two replications and 12 plants per plot were used for field evaluation. The materials tested are presented in Table 2.

Table 2. Tomato materials evaluated in 1990.

No. Accession, Clone, Variety	No. Accession, Clone, Variety
CL 143-0-10-3-0-1-10	CLN 657-BC^1F^2-274-0-15-4
CL 1131-0-0-13-0-6	CLN 657-BC^1F^2-285-0-20-0-24
CL 5915-93 D^4-1-0-3	CLN 657-BC^1F^2-285-0-20-0
CL 5915-93 D^4-0-12	CLN 6046-BC^3F^2-51-0-20-5-15-14-1
CL 5915-93 D^4-1-0-C-1	CLN 6046-BC^3F^2-51-1-1-20-5-10-13
CL 5915-223 D^4-1-0-0	FMTT 95
CLN 65-349 D^5-2-0	FMTT 105
CLN 475-BC^1F^2-265-4-19	FMTT 114
CLN 475-BC^1F^2-265-9-0	FMTT 115
CLN 475-BC^1F^2-265-12-9-1	FMTT 138
CLN 657-BC^1F^2-267-0-3-1-4	FMTT 260
CLN 698-BC^1F^2-358-4-13	FMTT 264
CL 5915-206 D^4-2-2-0	FMTT 265
CL 5915-206 D^4-2-5-0	FMTT 22
CL 5915-206 D^4-2-2-0-4	Ratna (Control)
CLN 657-BC^1F^2-274-0-15-0	Mutiara (Control)

The following parameters were observed: plant characteristics, flowering date, harvesting date, number of productive plant, weight of marketable yield per plant, weight of unmarketable yield per plant, number of plants attacked by important pest and diseases and screening of pest/disease damage.

Tomato seeds were sown 17 November and planted 3 December.

Future Activity

Evaluation of tomato germplasm (AVNET) will be done after the sample of tomato seeds are received by LEHRI from AVRDC.

Development Program

Training

- Ir. Nani Sumarni MS attended the 4-month International Agricultural Centre (IAC) Vegetable Growing Course in the Netherlands.
- Ir. Hanudin has been trained in bacteriology in the Institute for Plant Protection Research (IPO), the Netherlands.
- Ir. Asih K. has attended the 4-month Agricultural Biotechnology Training in Bogor.
- Ir. Sudjoko Sahat to AVRDC for a short training (about 10 days) on vegetable germplasm.

Workshop

- Dr. Farid A. Bahar and Dr. Sudarwohadi Sastrosiswojo attended the Regional Workshop on Pest Management of Vegetables in Cameron Highlands, Malaysia, 8-12 October.
- The National Workshop on Vegetables was held at Lembang (22-24 November). This workshop was supported by AVRDC and ATA-395, and attended by about 120 participants from several institutes, universities and the private sector.

Collaborative Vegetable Research Network (AVNET)

AVNET activities made up the major research program during the year. The details of these activities are reported under the head AVNET in the International Cooperation Program part of this publication.

AVRDC-Korea Outreach Program

Legumes and Sweet Potato Development

Development of the Semi-Dwarf, High Density-Adaptable and High Yielding Soybean Variety 'Suwon 144'

Suwon 144 was grown at AVRDC as an F_3 generation in spring 1985. The major agronomic characteristics of Suwon 144 are presented in Table 1. Table 2 summarizes the yield potential of this new variety.

Table 1. Major agronomic characteristics of Suwon 144.

Variety	Growth habit	Flowering date	Maturing date	Plant ht. (cm)	Lodging	Virus		Leaf shape	Flower color	Hilum color
						SMV-N	SMV			
Suwon 144	Det.	7/04	9/26	57	R	R	MR	Round	White	Dark
Hwangkeum-Kong (check)	Det.	7/17	9/28	79	MR	MR	R	Round	Purple	Yellow

[a]Seeding date: 15 May.

Table 2. Results of yield test for Suwon 144 on farmers' fields in 1990.[a]

Location	Variety	Maturing date	Plant ht (cm)	Yield (T/ha)	Yield index
Pyoungtaek	Suwon 144	9/26	50	3.7	127
	Paldalkong (check)	9/22	66	2.9	100
Taean	Suwon 144	9/25	47	2.9	116
	Paldalkong (check)	9/21	46	2.5	100

[a]Seeding date:Pyoungtaik – 17 May Taian – 25 May.

Mungbean Accessions Introduced from AVRDC

Seeds of 50 mungbean accessions received from AVRDC were sown in June in single 4-m rows without replication. Distance between rows was 50 cm and between plants within rows, 10 cm. Three seeds per hill were planted and later thinned out to two seedlings. Yield data were collected from the full untrimmed row at each end.

Basic statistics on major agronomic characteristics for 50 mungbean accessions are presented in the following table.

Characteristics	Mean	S.D.	Maximum		Minimum		Range
			Value	Variety	Value	Variety	
Plant height (cm)	43.4	9.1	58	VC 3012A	21	VC 1163D	37
Days to flower	51.3	6.3	61	VC 2802A	38	V 3746	23
Days to first pod maturity	73.7	7.0	82	VC 3199A	57	V 3746	25
Pods per plant	12.5	5.3	30	VC 3199A	4.8	VC 2527A	25
1000-seed wt. (g.)	54.1	8.8	72	VC 2651A	26	V 1807	46
Yield (kg/ha)	986	415	1837	VC 3907A	233	VC 2564A	1604

Sweet Potato

Ten tissue-cultured clones were received from AVRDC and multiplied in vitro. Each clone showed a different growth rate. The clones used in the study are presented in Table 3.

Table 3. Tissue-cultured clones of sweet potatoes introduced from AVRDC in 1990.

AVRDC cross no.	Plant type	Skin color	Dry matter (%)
CN 1028-15	Semi-prostrate	Red	24
CN 1510-25	Semi-prostrate	Pale red	29
CN 1656-37	Prostrate	Pale red	
CN 1448-49	Semi-prostrate	Red	32
CN 1489-89	Prostrate	Yellow	32
CN 1108-13	Semi-erect	Light orange	25
CN 1232-9	Semi-erect	Yellow	26
CN 1517-142[a]	Prostrate	Pale orange	31
I 157 (Tainung 57)	Prostrate	Yellow	25
I 423 (Tainan 17)	Prostrate	Pink	26

[a]Contaminated by fungi and died when imported.

Chinese Cabbage

Breeding of TuMV Resistant Populations

To investigate the distribution of turnip mosaic (TuMV) strains in Korea, 290 samples from 130 locations were collected in 1989. As the first step in the breeding program for TuMV resistance, 11 crosses were made between Korean inbreds and the 0-2 cultivar which had been found resistant to all the five known strains of virus by AVRDC virologists in 1989. In 1990, 7 F_2 and three combinations (3 commercial F1 hybreed × 0-2) were sowed in August 20, and inoculated with virus by carborandum method. Among 156 plants, those without virus infection symptoms were selected

Table 4. Characteristics of lines used to make combinations for lowland summer cultivation in 1989 and 1990.

Line	Characteristic	Remarksa
SSD 31	Resistant to high soil moisture	Bred by SSD, '89, '90
SSD 139	Resistant to high soil moisture	Bred by SSD, '89, '90
Cheongbang	Resistant to virus	HES inbred, '90
Shimoyama Chitose	Resistant to virus	HES inbred, '89
Naebyung 60 Days	Resistant to viurs	HES, '90
0-2	Resistant to virus	AVRDC, '90
An 6	Resistant to virus	Bred by AC, '89
An 111	Good performance	Bred by, '89
An 619	Good performance	Bred by, '89
76M(2)	High heading ability under high temp	AVRDC, '90
77M(3)	High heading ability under high temp	AVRDC, '90
B-18	High heading ability under high temp	AVRDC, '90

[a]SSD: Single Seed Descent Method. HES: Horticultural Experiment Station. AC: Anther culture.

and transplanted in the green house. The plants that survived were selfed in spring and tested for resistance to virus in autumn.

Breeding of Heat Tolerant Varieties

To breed heat-tolerant varieties, 9 and 17 combinations crossed with 6 and 8 lines were tested in the field at two different seed times. The characteristics of lines used to make combinations in both years are shown in Table 4. Two lines bred through single-seed descent method (coded SSD) seemed to be resistant to high soil moisture, 5 lines, including 0-2 which were induced from AVRDC virus resistant line and 2 lines derived from another culture performed considerably well under high temperature. Three lines from AVRDC showed high heading ability under high temperature.

In 1989 all combinations were infected with soft rot after 60 days from the first seed time (June 24). In the second seed time (July 15) virus and downy mildew severely infected almost all entries. In 1990, harvest was possible in all entries in the first seed time (June 25), but in the second seed time (July 15) nothing was harvested of all the entries because they were infected with virus and soft rot in the second seed time (July 15).

Project for Cytoplasmic Male Sterility

In 1989, six CMS lines, derived from *Raphanus* and *B. juncea*, were open-pollinated instead of back-crossed. Seeds of 13 plants which bred enough seeds were sowed in September. Only 11 entries were tested because one entry, Raphanus did not germinate and another one turned out to be fertile male. In November, leaf color of 35 plants were almost the same as that of the ordinary Chinese cabbage. But the leaf color of 273 out of 387 plants ranged from yellow-green and whitish yellow. Some 114 plants were selected by their leaf color and were transplanted in the green house. The seeds were harvested from only 48 plants. Those seeds were intended for sowing in 1990 winter and pollination after selection by leaf color.

Pepper Breeding

Improvement of breeding methods for resistance to bacterial leaf spot

Race distribution of the pathogenic bacterium. Leaf tissues diseased with *Xanthomonas campestris* var. *vesicatoria*, were collected from major pepper growing areas of the country. One hundred and thirty-two pepper isolates obtained were inoculated on the host set which consisted of pepper genotypes with race-specific responses to leaf spot; ECW, ECW-10R, ECW-30R, and 3-25-27.

Races 1 and 3 were distributed throughout the country with almost an equal frequency (Table 5). Race 2 was not found from any diseased tissues. Race 3 appeared more frequently than Race 1 in the Northern and Central provinces (Kyonggi and Kangwon) than in the Southern provinces, while Race 3 arises more frequently in the latter areas. Those regional differences have yet to be confirmed through more extensive surveys.

Cross protection between Races 1 and 3. The presence of Races 1 and 3 in Korea is confirmed. In the course of resistance breeding, different host plants with distinct reactions to either or both races were inoculated with the disease on the same or separate leaves of the same plants through the infiltration method. Intervals between inoculations with the first and the second races were 24 hours. Single race inoculations were also done for the sake of comparison.

Table 5. Number of isolates of *X. campestris* var. *vesicatoria* collected from different provinces of Korea and classified into different races.

Collection Site	No. of isolates	Race 1	Race 3
Total	132	57	75
Kyonggi-Do	22	8	14
Kangwon-Do	33	7	26
Chungchong-Do	21	12	9
Cholla-Do	29	13	16
Kyongsang-Do	19	13	6
Cheju-Do	8	4	4

Varietal reaction of the host plants was completely without cross protection and did not show any sign of the existence of cross protection between the two races. Therefore, it maybe concluded that Races 1 and 3 can be mixed when being inoculated for resistance screening.

Simultaneous detection of vertical and horizontal resistance in vitro. Two different types of genetic resistance to bacterial leaf spot diseases had been reported; vertical resistance controlled by three-independent single-dominant genes and vertical resistance (originally named partial resistance) conferred by polygenes. Although it is simpler to use the first type in resistance breeding, it is limited by its race-specific reaction and therefore would be easily broken by newly emerging races. It is recommended to combine both types of resistance in the cultivated varieties.

Previously applied methods identified vertical resistance from susceptibility by producing hypersensitive reaction within 48 hours from infiltration of inoculum of 10^5cfu/ml. Horizontal resistance was detected by counting colony-forming units after plating the sap of the tissues previously infiltrated with an inoculum of 10^3 cfu/ml.

Methods of varietal screening with detached leaves in vitro have been developed. The detached leaves usually lose freshness after several days even under saturated air moisture conditions. This did not allow for reading of the reactions, which took more time than did the hypersensitive ones.

Pedicels of the detached leaves were placed on sponge plugs which in turn were used to stuff the holes of a plastic pipe, through which tap water ran continuously. The whole system was sealed by polyethylene film to keep the air humidity near saturated at the ambience of the leaves.

These methods allowed for the freshness of the detached leaves to be maintained up to 40 days or more. This also allowed expressions of both vertical and horizontal resistance on the detached leaves. These resistances showed visually different reactions from each other and from susceptibility characteristics. Hypersensitive reaction in the vertical type was reported. Small spots developed in the horizontal type within 25 days from inoculation with 10 cfu per ml. Slow but expanded lesions developed in the susceptible genotypes with 25 days from inoculation with the same inoculum density as that for the horizontal one.

In anthracnose, improved inoculation methods is crucial to produce more stable and reliable data. Most of the TMV selected progenies showed resistance to both strains of T and OM. Many commercial varieties marketed in Korea are already equipped with resistance to the strains of TMV. TMV-P was reported to be the most problematic strain in the country at present. TMV-resistance breeding needs to be redirected.

Evaluation of newly collected materials for disease resistance. Some of the newly collected germplasms were evaluated for their reaction to major diseases with artificial inoculation in search of genetic resistance (Table 6). The same screening methods used before were applied.

A number of the tested accessions showed resistance to strains of TMV. Resistance to the strain, TMV-P was not evaluated. To bacterial leaf spot (Race 1 and 3) no accessions except those included in the differential host set showed vertical resistance. More than 60 accessions showed resistance to phytophthora stem rot and anthracnose (*X. campestris vesicatoria*), respectively. These may have to

be reconfirmed through repeated screening. Half of the 22 accessions evaluated for *X. dematium* was rated resistant.

Table 6. Number of newly collected accessions classified by their reaction to some major diseases.

Tobacco Mosaic Virus				Phytophthora stem rot			Bacterial leaf spot				Anthracnose					
T strain		OM strain					race 1		race 3		*C. gloeosporioides* (G strain)			*C. dematium*		
R	S	R	S	R	M	S	R	S	R	S	R	M	S	R	M	S
23	203	38	108	63	21	63	2	224	2	224	68	4	16	4	7	11

[a]Number of accessions tested differs from one pathogen to another. [b]R, M, and S refer to resistant, medium and susceptible reaction, respectively.

Germplasm evaluation for developing mechanized culture, harvest and drying of hot pepper. Hot pepper is a very important vegetable crop, being an essential component of the indispensable dish, Kimchi, and only next to rice as the farm income generator among all the crop commodities. Production, from seedling nursery to harvest, and drying, is however almost totally dependent on manual labor. To reduce the production cost it is necessary to mechanize every possible step from sowing to harvest and drying. For this goal new plant type has to be developed.

As a first step toward this goal a few hundreds of accessions and breeding lines were evaluated. Entries were sown in Feb. 1990 and seedlings were raised on hot beds. Ten to 20 plants in each entry were transplanted in May 15. No replications were made in the field trial. Entries with early maturity, determinant growth habit, clustered fruits will be further evaluated, although we have not developed the final idiotype(s) for this problem. The number of materials selected for further observations and/or intensive use in the crossing program are shown in Table 7. Materials selected for the improvement of processing quality of hot pepper and some promising sweet peppers are also included in the same table.

The difference among genotypes was much clearer in vivo than in vitro, presumably because of the better controlled environment in in vitro culture. Symptom development of the horizontal type could be made more rapid by controlling the temperature of the inoculation chamber.

Table 7. Selection and collection of breeding materials for labor-saving and processing type pepper varieties.

	No. evaluated	No. selected	Remarks
Newly introduced accessions	266	35	Resistance to virus (8), High pungency (2), Cluster (3), High sugar (2), Early and concentrated maturity (3), Promising sweet peppers (11), Others (8).
Fixed lines, commercial varieties	37	8	Fruit shape, fruiting density, healthy plant
Segregating populations	40	10	Fruit shape, early and/or concentrated flowering
Additional[a] introductions	–	10	Ps (Pod separation gene), Easy-to break gene, high sugar, and high pungeny

[a]Collected only during the later half of 1990, therefore not yet evaluated in the field.

Breeding for resistance to major disease. Virus complex, phytophthora stem rot, anthracnose and bacterial leaf spot are four major diseases in pepper growing in Korea. Horticultural Experiment Station had worked on breeding for resistance to these diseases. In 1990, progeny lines or families developed from the cross breeding program were selected for their best records regarding resistance and were reevaluated for the diseases of the original target. Inoculation methods and check varieties used gave out the following results.

Some progenies from the previous program showed a satisfactory level of resistance to phytophtora stem rot. No lines or families were found resistant to bacterial leaf spot and anthracnose. Some of the materials were resistant to Race 1, but none to Race 3 of the bacteria causing the leaf spot disease.

Tomato Breeding

Mini tomato trial with AVRDC lines

Mini tomato is becoming more popular. There are no desirable commercial varieties. Forty-seven AVRDC lines were tried together with seven commercial varieties collected from Japanese companies and one from a Korean firm. Seeds were sown in March on a heated bed and transplanting was done in May 1990 to open field and plastic film houses. Both trials in the open field and under structure had two replications in which plots were arranged following randomized complete block design.

The trial under structure was severely damaged by the toxic gas produced from the compost supplied immediately before transplanting and therefore, data taken for this trial was omitted.

In the field trial, many of the AVRDC lines were maintained in healthy state and they kept bearing fruits until they were removed in early September.

Many AVRDC lines (shown in Table 8), if not all, were comparable to the commercial varieties in skin hardness, acid content and soluble solid content. Their distribution by fruiting habit did not differ from that of the commercial entries. However, they were much larger than the commercial varieties in fruit size.

Many of the AVRDC lines showed a higher early, late and total commercial yield compared to other lines. Some of them also were more resistant to leaf roll and the disease caused by *Cladosporium fulvum*. Yield of some selected entries are shown in Table 8.

In summary, AVRDC's mini tomato lines grew well and produced a high yield, but it is necessary to reduce their unit fruit weight to 15-20 g to beat the commercial varieties available from Japanese and Korean seed campanies.

Table 8. Yield of some selected mini tomatoes.

Code	Entry yield	Early commercial yield (g/plant)	Late commercial fruits (g/plant)	Total commercial (g/plant)	Rate of commercial (%)
(AVRDC lines)					
4	CHT-HS4	741	385	1,126	93
17	CHT-HS17	829	472	1,301	90
25	CHT-HS25	701	362	1,063	76
30	CHT-HS30	692	540	1,232	89
40	CHT-HS40	851	988	1,839	84
41	CHT-HS41	1,209	577	1,786	92
42	CHT-HS42	1,211	935	2,146	92
43	CHT-HS43	1,255	865	2,120	90
44	CHT-HS44	1,202	1,087	2,290	85
45	CHT-HS45	1,219	980	2,199	90
46	CHT-HS46	1,067	1,533	2,602	96
	Average	998	793	1,791	89
(Foreign commercial vars.)					
49	Pico	682	353	1,035	81
50	Yellow Pear	600	99	699	82
52	Mini Carol	644	587	1,231	85
	Average	642	346	984	83
(Local commercial var.)					
55	Ruby	311	233	545	86

AVRDC-MARDI Vegetable Research Program

Tomato

Yield Trials on Fresh and Processing Tomato Lines

A total of 49 tomato lines were evaluated for *Pseudomonas solanacearum* in two sets of experiments under epiphytotic conditions. The trials were conducted on peat soil at Jalan Kebun station. A randomized complete block design (RCBD) with three replications was used. Each replicate had 10 plants. They were planted in a triangular pattern on double row beds. Routine maintenance was given to the crop. Liming was done to increase the soil pH to 4.15 prior to the planting of the crop. The soil was not burned ensuring the presence of *Pseudomonas solanacearum* in the experimental plots. MT 11 and MT 1 were used as check varieties against fresh market tomato and processing tomato, respectively.

Out of 40 fresh market tomato lines tested, six lines, namely, CLN 475 BC1F2-265-9-0, CLN 657 BC1F2-285-0-20-0-24, CLN 475 BC1F2-265-12-1-20, CLN 657 BC1F2-285-0-21-0, CLN 466 BC1F2-45-34-9-8-8 and CLN 698 BC1F2 yielded between 4.2 and 3.1 kg in descending order and produced 90, 71, 89, 54, 59, 62 fruits per plot, respectively. All the six lines were significantly higher yielding than the check variety, MT 11. In terms of fruit size, CLN 657 BC1F2-285-0-20-0-24 and CLN 657 BC1F2-285-0-21-0 produced heavier fruits weighing 76 and 66 g, respectively. Lines CLN 466 BC1F2-45-34-9-8-8 and CLN 698 BC1F2-585-0-17-1 produced medium-sized fruit of more than 50.0 g. This was followed by the check (MT 11) and varieties CLN 475 BC1F2-265-12-1-1- 20 and CLN 475 BC1F2-265-9-0, which produced fruits of about 45 g each. All the six varieties and MT 11 showed a high survival rate of more than 75%.

MT 11 is still the best variety in terms of resistance to bacterial wilt and overall performance. This is followed by lines PT 4060, PT 4165, PT 4026, which showed survival rates of more than 50%. All the three lines produced reasonably good yields and acceptable fruit sizes of about 35-50 g each. The red fruit color is also acceptable for processing purposes.

Chinese Cabbage

A total of five Chinese cabbage varieties, including two promising AVRDC varieties (No 82-156 and 77M (3)-40) were tested against the check variety, Saladeer, in four locations in 1989. This trial was repeated for the second season in 1990.

In the 1989 workshop, only three locations were reported, namely, Jalan Kebun (peat), Sungai Baging (coastal sand) and Terengganu (alluvial). Varieties No. 82-156 (12.8 t/ha) and 77M(3)-40 (11.8 t/ha) produced yields comparable to the check variety, Saladeer (12.1 t/ha). The head size of No. 82-156 was significantly smaller than that of 77M(3)-40 and Saladeer. However, the average head weight of variety No. 82-156 (513.1 g) was higher than that of 77M(3)-40 (487.8 g). This indicated that No. 82-156 was much more compact compared to 77M(3)-40. Saladeer (584.5 g) produced the highest average head weight among all the varieties tested.

The second season evaluation trial at Bertam in 1990 produced better yield results. Both No. 82-156 (33.6 t/ha) and 77M(3)-40 (29.3 t/ha), significantly outyielded the check variety, Saladeer

(21.6 t/ha). Although no significant differences in terms of head length was observed, variety No. 82-156 produced significantly greater head width. The average head weights were, however, significantly heavier for both AVRDC varieties (1.0-1.1 kg), compared to the check variety, Saladeer (0.8 kg). Little pest damage was observed but all varieties were susceptible to soft rot disease.

In the second season evaluation trial at Jalan Kebun in 1990, both AVRDC varieties, No. 82-156 (10.3 t/ha) and 77M(3)-40 (10.4 t/ha) significantly outyielded the check variety, Saladeer (9.4 t/ha). Head size of all three varieties was similar. The major problem in this trial was the high incidence of soft rot disease which was due to the wet conditions that prevailed during the trial. Early harvesting had to be done quite often and this greatly affected the final yields.

Soybean

Advanced Yield Trial on Soybean

An advanced yield trial (AYT) was conducted at Serdang to evaluate the performance of nine soybean varieties obtained from AVRDC. The varieties tested were: C1-58-2-3, BP 125/5, 8008-31-32-5-60, DG 62/8, Egsy 91-7, BP 135/7, P1-92-27-3-30, AGS-8, C1 -188-39-49, and UFV 1.

The data from the trial were analyzed; the general performance of most varieties was very good.

Sweet Potato

Multilocational Trials on Selected Sweet Potato Varieties from AVRDC

Six AVRDC clones (CN 1229-16, CN 1232-19, AIS 0122-2, PCI 177, CN 1181-32 and CN 1219-1) introduced some years back were selected for multilocational testing at Bertam (upland soil) and Pontian (drained peat) with Bukit Naga and Serdang 1 (check clones).

At Pontian the highest yielder was Bukit Naga (26.5 t/ha). All six test clones had yields (11.0-15.0 t/ha) which were not significantly different from Serdang I (11.7 t/ha).

Boiled tubers of the clones were tested for taste. Generally, none of the AVRDC clones were superior to Bukit Naga and Serdang I in sweetness, taste and general acceptability. However, CN 1181-32 (an orange-skinned and orange-fleshed clone) was well liked for its flesh-colored skin.

Introduction of Elite Clones of Sweet Potato from AVRDC

Ten clones of sweet potato were successfully introduced in the form of in vitro cultures from AVRDC in 1989 through the Department of Agriculture Malaysia. These clones include: I 57, CN 1108-13, I 981, I 423, CN 1345-8, CN 1517-139, CN 1216-10, CN 1280-3, CN 1421-46, and CN 1367-2.

Currently, some of these clones are being multiplied by the Tissue Culture Laboratory and some in the field.

Germplasm Enhancement Subnetwork of AVNET

Seeds of 16 yardlong bean cultivars have been dispatched to the respective coordinators in early October 1990. The yields of the cultivars are given in Table 1.

In the meantime, the regional trial for all the 16 cultivars and the check, a popular variety imported from Taiwan, was conducted at the Agriculture University farm in mid-September 1990. The general procedures, experimental design, plot size, agronomic practices and data on characters to be collected were in accordance with the standard methods outlined in the training course held in Lembang, Indonesia, 29 January to 3 February 1990. Crop growth was very good.

Table 1. Yields of yardlong bean cultivars at the Agriculture University farm, Serdang.

Country of origin	Cultivars	Pod yield/plant (g)
Indonesia	KP1 1018	159
	KP2 1019	282
	USUS Hijau	290
	LV 801	329
Malaysia	KP #5	467
	Taiwan White	280
	ML #30	325
	DOA	431
Philippines	CSD 4	403
	CSD 5	373
	CSL 19	431
	PS1	299
Thailand	K.U. #7	268
	K.U. #8	465
	R.W. #24	222
	Rajburi	238
	Local check	302

Each sample seed lot is approximately 120 g.

Bacterial Wilt of Tomato and Anthracnose of Chili

Disease survey. A survey of the incidence and severity of anthracnose in chili farms in Kelantan and Terengganu showed the presence of at least three species of *Colletotrichum* pathogens: *C. capsici*, *C. gloeosporioides* and *C. acutatum*. Disease severity ranged from 0% on the resistant varieties to 35% on the susceptible varieties.

Germplasm resistance. Eighteen lines of chili exchanged for in-country testing of anthracnose incidence and severity were planted out in Jalan Kebun to multiply seeds for a proper replicated trial. Observations showed that varieties C1, C2, C3, C4, C5 from Thailand had very high resistance to anthracnose. Varieties from AVRDC sources had disease incidence ranging from 10.4 to 96%.

IBWN for tomato. The IBWN has been set up in MARDI Serdang. Testing of eight AVRDC accessions has been completed.

Planting dates were 25 and 26 June 1990 using a randomized complete block design (RCBD) with three replicates. Varieties tested were: 143-0-10-3-0-1-10, 6047-1-1-2-3-2-7-0, CLN 65-249-D5-2-0, CLN 475 BCI F2-265-4-19, BL 350, BL 355, BL 410, BL 342, MT 1 and MT 11 (both local checks).

All the eight AVRDC lines tested had very high resistance to bacterial wilt with an average of 1% of the plants wilted, 3 weeks after planting. The local checks MT 1 and MT 11 had 2% and 9% wilted plants, respectively. The susceptible AVRDC check, L 390, had 98% of the plants wilted, 2 weeks after planting. This indicated the high inoculum potential in the trial plot.

Mass Rearing of *Diadegma eucerophaga* and *collaris*, Parasites of DBM in Cameron Highlands, Malaysia

Training

AVRDC. Siti Asmah Dhiauddin (MARDI) and Mr. Razlan Abdul Ghani (Department of Agriculture) mass reared *T. bactrae* (lowlands) and *Diadegma eucerophaga* (highlands), respectively.

In-country training. MARDI and the Department of Agriculture successfully organized a 10-day in-country training course on IPM of DBM at Serdang, Malaysia from 11-19 February 1990. A total of 30 participants from both agencies attended the training course. The training program emphasized

mass rearing of parasitoids of DBM and field assessment of DBM damage. The participants will implement the IPM program in various locations in Malaysia.

Mass Rearing of *Diadegma eucerophaga*

Mass rearing was initiated in October 1989, after the trained personnel returned from AVRDC. The mass rearing program was based on the method adopted by AVRDC. Mass rearing of *Diadegma eucerophaga* was expanded to 200 cages (40 cm × 40 cm × 40 cm) in September 1990, with the production of approximately 5000-8000 pupa per week.

High humidity in the rearing houses caused problems in October 1990. A heater was installed and switched on during the day to maintain relative humidity at 65-70% and a temperature of 25°C. The heater has improved the rearing conditions with increased parasitization and reduced occurrence of DBM diseases in the culture.

A study was conducted to determine the optimum period of exposure of the second instar larvae to *D. eucerophaga* to be parasitized. The trial showed that 4 days gave the highest levels of parasitization.

Mass Rearing of *Tyreella collaris*

The mass rearing of *T. collaris* was initiated in February 1990. The mass rearing procedure is similar to that for *D. eucerophaga*. However, the pupae stage was exposed to *T. collaris* adults. At present 500 *T. collaris* can be produced weekly. Records were collected on the number of *T. collaris* collected from cages before and after the heater was installed in the rearing houses. The results showed that the number of *T. collaris* collected increased by 50% after heating.

National Seminar on IPM on DBM in Malaysia

A national seminar titled 'DBM Management in Malaysia:Perspective and Strategies' was held in Kuala Lumpur on 24 August 1990. The seminar was jointly organized by MARDI, Department of Agriculture and Malaysian Plant Protection Society (MAPPS). A total of 200 participants attended the one-day seminar. A total of eight papers were presented. After the paper presentations, a panel discussion was held to summarize and propose future strategies in research activities on IPM of DBM.

The seminar concluded that DBM in the highland areas was well under control at present due to the adoption of IPM by more than 50% of the vegetable farmers. However, IPM of DBM has to be intensified in the lowland areas.

Mass rearing of *Corcyra cephalonica*, a host of the egg parasite, *Trichogrammatoidea bactrae* at MARDI, Jalan Kebun

Corcyra cephalonica was reared in a temporary laboratory room at 28-32°C at 70 100% RH. Newly collected *Corcyra cephalonica* eggs were introduced into a transparent plastic container filled with wheat flour. The eggs were left to hatch for 3 days . Once the larvae hatched, they began feeding on the wheat flour (1 cc of eggs to 50 cc of flour was used). The container was then covered with muslin cloth with a central opening for ventilation. After 10-14 days, the young larvae were transferred into a plastic container which contained the medium. The medium was made up of 100% unpolished rice. The larvae were left in this medium until hatching. The period of completing one life cycle was about 40-50 days. Upon emerging from the pupae, adults were collected using a vial and transferred into a modified PVC cylindrical cage to produce the next generations. All the eggs were laid on the outer surface of the netting and at both ends of the cylinder. These eggs were then gently brushed into an aluminum tray; sieved with a brass sieve (mesh aperture 500 μm) to remove unwanted debris such as insect legs, broken wings, scales, etc. Daily egg collection was recorded.

Egg production of *C. cephalonica* was highest in May (200 eggs) and showed a progressive monthly decline to the lowest in October (55 eggs). The small number of eggs obtained especially from September 1990 onwards was due to the parasitization of the larvae by parasites such as *Bracon* spp. and mites. The adults also produced fewer eggs probably due to inadequate nutrients in the growing medium when unpolished rice was substituted for corn.

Mass rearing of *T. bactrae* failed because egg collections from those brought in from Taiwan was insufficient for parasitization. The percentage of parasitization was also very low. The culture of *T. bactrae* was cultured only for four generations.

Improvement of facilities and infrastructure as well as reduction of damage by harmful parasites and diseases are under way to provide more ideal conditions for the mass rearing of both *C. cephalonica* and *T. bactrae*.

Regional Program

AVRDC-Thailand Outreach Program

Chinese Cabbage

Research on crucifers, especially Chinese cabbage, was being conducted only during the cool season. Since this season falls on the training period, most of the research for 1990 was conducted by the 8th Regional Training Program scholars from China and Vietnam.

Chinese cabbage varietal trial. Eighteen improved heat-tolerant varieties of Chinese cabbage from AVRDC, China and Thailand were evaluated for their yield and horticultural characters at AVRDC-TOP from November 1989 to January 1990. Significant differences were found in yield potential, mean head weight (MHW), heading efficiency ratio (HER), solidity, early maturity and insect damage ratio before heading among all entries tested. Hybrid *59 gave the best performance in terms of marketable yield and had the best horticultural characteristics. Hybrid *62 was the earliest to mature with high HER and solidity. B 40 produced the highest marketable yield and also had the highest insect damage rating, poor HER and solidity. It will be tested again in the hot season.

Relationship between total yield and total NPK and chlorophyll content in Chinese cabbage. The relationship between total yield and concentrations of total N,P,K,Ca and chlorophyll content in Chinese cabbage, *Brassica campestris* ssp. *pekinensis* were studied during the cool season from November 1989 to February 1990.

Among the eight entries tested, B 40 produced the highest yield of 87.8 t/ha. Significant correlations between total yield and total content of elements N,P,K and Ca of the whole head were found at harvest time.

A positive correlation was found between the chlorophyll content of the outer leaves and the nitrogen content of Chinese cabbage, but not between the total yield and the chlorophyll content of outer leaves.

Effect of humus and nitrogen on Chinese cabbage yield. The use of different rates of humus and nitrogen on Chinese cabbage ASVEG *1 resulted in significant differences in plant growth, total yield and head yield. Yield increased with humus and nitrogen levels. The highest yield was produced by the combination of 12 t humus and 120 kg N/ha. However, no significant differences were observed between the effect of humus and nitrogen application.

Germination rate and disease infection of treated and untreated Chinese cabbage seed. Selected Chinese cabbage lines from AVRDC, Chiatai, Hey Nguan Hong Seeds, Tia Seng Hua Seed, PA Seeds, Ltd. and Sakata Seeds were used in this experiment to observe germination, disease infection and yield. Seeds from 15 Chinese cabbage cultivars were treated with the fungicide Captan. Germination rate was determined using two germination test methods: use of roll paper and plastic flats. The experiment was conducted from 6 December 1989 to 5 February 1990.

No significant differences in germination rates between the treated and untreated seeds in both paper roll method and plastic flats were observed.

No significant difference in disease infection on the seedlings between the treated and untreated seeds was found. Likewise, no significant difference in disease resistance of all entries was found between treated and untreated seeds. However, there were significant differences among entries.

Entries such as Hie 23, No. 1, OK, Tropical Delite and 77M(213)-46 were high yielding and resistant to diseases.

Reactions of Chinese cabbage cultivar to *Peronospora parasitica*. Twenty-five Chinese cabbage cultivars and lines mostly collected and developed by AVRDC were tested for their resistance or susceptibility to *Peronospora parasitica*. A randomized complete block design with three replications was used in this study. The results indicated that 16 cultivars/line have moderate resistance to *P. parasitica*. Cultivar Aeroplane Brand, ASVEG #1 and line 85-216 showed more resistant reactions with disease infection (DI) ratings less than 40%. Nine other cultivars/lines were rated susceptible or highly susceptible to downy mildew disease.

Chemical control of downy mildew on Chinese cabbage. Fungicides Ridomil, Ridomil-MZ and Mancozeb at different rates of application were tested for their effectiveness in controlling downy mildew on Chinese cabbage caused by *Peronospora parasitica* under epiphytotic conditions with reinforced artificial inoculation in the field. Ridomil 25 WP, applied four times at weekly intervals, starting from 17 days after transplanting at the rates of 1.2 and 1.5 kg/ha and Ridomil-MZ at the rate of 1.2 kg/ha were found to be the best agents for controlling downy mildew of Chinese cabbage. These three treatments resulted in 47-54% increase in the yield of marketable heads. Mancozeb at 2.2 kg/ha gave a 35% increase in marketable yield. Seed treatment with Apron 35SD (Ridomil) at the rate of 5 g (a.i.)/kg seed did not result in downy mildew-free Chinese cabbage up to head forming stage. The data obtained from this experiment were highly significant at 1% level using Fisher's least significant difference (LSD).

Effect of time and duration of water deficit on tipburn and head formation in Chinese cabbage. This experiment was conducted in AVRDC/TOP, from November 1989 to January 1990. Plants were subjected to water stress for durations of 3 and 6 days at different growth stages starting from 14 days after transplanting to its full development. Grown in pots, plants received water at the rate of 300% potential evapotranspiration (PET) as determined by the Penman method, except when water stress was imposed, during which water was reduced to 100% PET. After 39 days, significant differences in plant growth and yield among treatments were observed. Marketable yield and heading rate suffered most when plants were exposed to water stress 3-10 days after head initiation (23-29 DAT); this period was considered critical in Chinese cabbage. Water shortage and imbalance of water supply and demand during the heading stage caused tipburn development. The tipburn incidence became severe when water shortage occurred during the critical period. Although not statistically significant, longer water stress duration reduced yield and increased tipburn incidence.

Hybrid seed production of ASVEG #1 Chinese cabbage and parental line maintenance. With the release of AVRDC's ASVEG *1 in Thailand as 'April Jade', demand for hybrid seeds increased more than 10 times so that seed production and maintenance of parental lines is a must to meet the demand. Trials for production of ASVEG *1 seeds were carried out in three places representing different agroclimatic conditions: Kasetsart University in Kamphaeng Saen representing the hot humid central plain; PakChong representing a cooler, drier area than Kamphaeng Saen; and Ang-Kang representing the cool highlands.

Seeds of parental lines B-18 and E-17 were produced at Kamphaeng Saen campus, KU and PakChong station using vernalization technique and insect pollination. Seeds from PakChong were better than those from Kamphaeng Saen. Parental line maintenance by self-pollination produced only few seeds. E-7 was more difficult to be self-pollinated than B-18. High quality ASVEG *1 seeds were obtained from the Ang-Khang production site which has a cooler climate. However, the seeds produced from Ang-Khang were still not enough to meet the local demand. The amounts of seeds produced from the areas mentioned are shown in Table 1.

Based on this trial and subsequent retrials hybrid seeds of ASVEG *1 could be transplanted into nylon net-covered plots. Release of bees inside the net was necessary to help pollination. However, vernalization time for B-18 and E-7 recommended by AVRDC is not suitable to Thailand's conditions.

Table 1. Yield of hybrid seeds of ASVEG *1 grown in different locations.

Location	Parental lines plants	No. harvested (g)	Yield		
			Amount (g)	per plant (g)	No. of seeds
PakChong	B-18	607	2680	4.68	318
PakChong	E-7	627	1060	1.97	502
KPS	B-18	421	490	1.42	464

Mungbean

Mungbean research is the most successful research activity at AVRDC-TOP. Several AVRDC lines have already been released for use by Thai farmers. These varieties are performing well and will soon be completely replacing the locally used traditional varieties.

PSU mungbean varietal trial. Seven mungbean lines selected by the Prince of Songkhla University Mungbean Improvement Program were tested against three established varieties PSU1, KPS1 and UT1 during the rainy season (May-August) of 1990.

There was a significant difference in yield among the 10 varieties of mungbean tested. PSU1 gave the highest yield followed by PSU 1428-101-21 (PN) in the southern part of Thailand. Uthong 1 gave the lowest yield. Five entries including KPS1 gave an average yield of more than 1.9 t/ha. PSU lines were found to be resistant to powdery mildew but not to Cercospora leaf spot. KPS1 was the most affected by powdery mildew in this trial followed by Uthong 1. Powdery mildew blocks photosynthesis res ulting in low yield. PSU lines possessed darker leaves than KPS1 and Uthong 1 which could be another reason for its higher yield.

In terms of yield and important yield components, PSU 1428-101-21 (PN) and PSU 1528-103-29 (BS) are the two lines that have the potential for release after PSU1. PSU 1428-101-21 (PN) had high resistance to diseases while PSU 1528-103-29 (BS) had good lodging resistance. These two characteristics are important especially if these lines are released for planting in the southern part of Thailand where humidity is high because of the rain year-round.

Effect of paclobutrazol on yield and quality of mungbean. The effect of application rates of paclobutrazol, 500 and 700 g ai/ha, sprayed 7, 10 and 13 days after 50% flowering on mungbean KPS1 was determined in early summer 1990.

A growth retardant, paclobutrazol had no effect on growth characters and reproductive parts of KPS1 except at a high rate of 750 g ai/ha which induced a long period of flowering. In terms of yield and yield components, this chemical was found not to have much effect although yield tended to increase. There was also a profound effect on seed quality.

Post-emergence herbicide trial. The effectiveness of a new early post-emergence herbicide, Imazethapyr (Pursuit), in controlling weeds and its ability to inflict possible crop injury was tested in summer 1990 at AVRDC-TOP.

Seven days after application percent weed covering was rated visually. The prominent grass species were *Echinochloa colonum* and *eleusine* while the dicots were *Trianthema portulacastrum* and *Portulaca oleracea*. The toxicity level of the herbicide varied from 0 (normal) to 5 (dead). Total weeds, broadleaves and grasses were much less in the treated plots than in the untreated ones. Pursuit at 400 cc/rai (125 g ai/ha) gave poorer control than at 800 cc/rai (250 g ai/ha). However, the latter inflicted more injury to the mungbean plants.

The herbicide seemed to have a beneficial effect on seed yield per hectare. The treated plots tended to yield more than the hand-weeded plots. However, this tendency was vague considering the yield components. Number of seeds/pod and number of pods/plant also did not display any trend or pattern. Plant heights at flowering of the treated plots were shorter than those of the untreated ones, probably due to two reasons. First, Imazethapyr had some adverse effect on mungbean at the earlier stages of growth. Second, in the hand-weeded plots, weeds competed with mungbean at the earlier stages

of growth and thus were rather etiolated. However, height of the treated mungbean caught up and at harvest there was no varietal difference on this trait. The chemical seemed to prolong flowering and ripening of mungbean. All hand-weeded plots were harvested earlier than treated ones. The more Imazethapyr used, the longer the days to first ripe pod. The chemical caused stunting at the early vegetative stage resulting in slower development to flowering and maturing. The chemical had no effect on lodging and Cercospora leaf spot disease scores.

Chemical evaluation for control of Cercospora leaf spot, powdery mildew and damping-off. No outbreak of damping-off occurred during the experiment, thus, chemical efficiency against this disease cannot be determined. No clear advantage of chemical use that exhibited good control of powdery mildew and Cercospora leaf spot was noted except for Vamine-S. The plots sprayed with Vamine-S tended to have larger seeds and more pods/plant. However, these chemicals were primarily recommended for the control of damping-off rather than foliar diseases.

17th international mungbean nursery trial. Twenty mungbean entries were evaluated in this trial. Significant differences in grain yield, number of pods per plant, number of seed per pod, 1000-seed weight and plant height were found among the entries . Varieties with earlier maturity and higher resistance to Cercospora leaf spot (CLS) and powdery mildew (PM) were identified. Moderately early and uniform maturing VC 4066A with 1.3 t/ha was the highest yielder. It was highly resistant to CLS and moderately resistant to PM. VC 4080A, an early uniform maturing variety ranked third with 1.3 t/ha. It had the heaviest 1000-seed weight, the lightest seed color, resistance to CLS and moderate resistance to PM. Although other entries had early, uniform maturity and resistance to both CLS and PM, they yielded lower than these entries.

Preliminary study on heterobeltiosis for yield and yield components of 10 mungbean F_1 crosses. Ten mungbean F_1 crosses together with parental lines were grown in observational plots without replication to test the presence and magnitude of heterobeltiosis for seed yield components. Heterobeltiosis was detected in all agronomic traits studied except for the number of seeds per pod. The experimental cross VMC 31 × KPS 2 had the highest heterobeltiosis effect for seed yield per plant (212%), pod per plant (154%) and pods per cluster (23%).

Currently, the production of F_1 hybrid seed in mungbean for farm use is not yet economically feasible in the absence of enough sources of male sterile lines and insufficient natural outcrossing.

Pepper

Activities on pepper, a new AVRDC crop, were mainly on germplasm collection, characterization and evaluation. Most of the work was done by the 8th RTP training scholars.

Preliminary evaluation of 20 hot pepper varieties. An evaluation trial of 20 hot pepper varieties from Thailand and Vietnam was carried out from 25 October 1989 to 1 March 1990. A randomized complete block design with three replications was used. The results showed that all of the varieties were susceptible to viral diseases and beet armyworm. The color of the hypocotyl, stem and flower were found to be correlated and can be used for differentiating the varieties. TPP 10, 11, 15 and 17 were susceptible to viral disease and pests, were late maturing and had low yield potential. The other distinguishing characters of leaf, flower, stem and fruit were also recorded.

Pepper seed production. Variety S9-13-10 from Vietnam gave the highest fresh fruit weight per plant and number of seeds per fruit. All 27 varieties can be divided into three groups according to days to flowering and into two groups according to days to fruit setting. The degree of fruit infection in hot pepper was observed as a function of plant age; as plants get older, the damage caused by the virus became more severe. The early flowering varieties were the most susceptible while the moderately late flowering varieties had the least damage.

Effect of drying and extraction methods on seed quality of hot pepper. Variety Leung gave the best seed yield, followed by Chee Phar, Jinda and Khee Noo Suan. Variety Jinda gave the highest seed germination rate. No-drying method produced the highest seed germination rate. Chee Phar showed the best seed vigor. Among the extraction methods, the blender extraction method resulted in the highest rate in the seed vigor test. Interaction among varieties, drying methods and extraction methods were significant.

Soybean

In the past year, the popularity of vegetable soybean in Thailand increased. Because of its high export potential, farmers clamored for seeds of varieties suited for vegetable soybean production under Thailand conditions. In this regard, several studies on varietal selection and cultural and management practices were conducted by AVRDC-TOP.

Effect of plant density and spacing on fresh yield of vegetable soybean. Several planting densities and spacing were tested using AGS 292 White Lion as test materials. Results showed that the suitable spacing for these two varieties when grown for vegetable soybean production is 50 x 12 cm at two plants/hill or a planting density of 51,200 plants/rai or 321,200 plants/ha. High yields of 4.5 t/ha for AGS 292 and 3.2 t/ha for White Lion were obtained.

Effect of cytozyme plus and soil plus on growth and yield of soybeans. The effect of cytozyme on growth and yield of Nakhon Sawan 1 (NS1) and KUSL soybeans was studied from November 1989 to March 1990.

The analysis of variance revealed varietal differences between these two soybean lines. KUSL 20004 was better than NS1 in yield per unit area, number of seeds per pod, number of pods per plant, plant height, shattering resistance and seed quality. NS1, on the other hand, had higher 100-seed weight and shorter maturity or growing period. NS1 in this experiment had significantly more plants per unit area. Both lines had similar lodging scores. Chemical application affected only the number of seeds per pod.

Although soybean sprayed with crop plus and soil plus together resulted in the highest number of seeds per pod, the chemicals were found to have no influence on number of pods per plant and thus had no effect on seed yield. No interaction was detected among soybean lines and chemicals in any trait.

The coefficient of variation (CV) derived from this experiment was within the acceptable range except for number of pods per plant and shattering. Therefore, it could be concluded that cytozyme had no effect on agronomic traits of soybean under Kamphaeng Saen conditions. These results confirm those of the same experiment conducted last year.

Test of soybean lines for western Thailand. Eighteen advanced soybean lines were tested for superior genotypes and adaptability to the growing conditions in Western Thailand. These lines include those from the advanced breeding lines of Kasetsart University such as KUSL 10001, 10002, 10006, 10008, 10009, 20004, 20014, 20018, 20043, 20050 and 30006; the advanced breeding line of the Department of Agriculture Soybean Breeding project such as LN 14 and 8122-7; and advanced breeding line of Chia ng Mai Soybean Breeding Project such as CM 001-1 and check cultivars SJ 4, SJ 5, SK 1 and CM 60.

Based on the agronomic characteristics of these lines when tested during the dry season, KUSL 20010 and 20018 were the highest yielders with 23 t/ha. These yields were significantly better than that of SK1 and CM 60. KUSL 20043 had small seeds (11.2 g/100 seeds), fewer pods/plant (35.1 pods) and fewer seeds per pod (2.5) compared to other KUSL lines. KUSL 10009 had the most seeds while KUSL 10002 had the lowest among the KUSL lines. The number of pods/plant ranged from 52 in CM 6 0 to as low as 35 in KUSL 20018 and 20043. SK1 had the most seeds/pod in this experiment. CM001-1 was the tallest line (1 m) and thus, it lodged heavily compared to other lines. KUSL lines flowered and matured earlier than the check cultivars. Harvest of the former lines

was within 90 days after sowing except for KUSL 30006 which was harvested later. With the exception of LN 14 and 8122-7, most of the lines did not shatter.

Disease ratings of all entries revealed that no line offered any resistance to downy mildew with SK 1, SJ 4 and CM 001-1 being least affected. Since the growing conditions were very warm and dry, some lines had an early senescence (shedding of leaves and drying out of pods). These conditions resulted in low seed quality.

Due to favorable weather conditions, yield was higher during the rainy season. The yield varied from over 3 t/ha in KUSL 20004 and 20010 to 2.2 t/ha in KUSL 30006. A relatively high 100-seed weight, more pods per plant and more seeds per pod were responsible for higher yields. Plant height varied from 92.5 cm in CM 001-1 to 50.9 cm in KUSL 10001. The former lodged more than any other lines. Due to high soil moisture content, average days to flower and days to maturity were higher in this experiment than in the dry season. KUSL 20010 was the earliest maturing line at 95 days while CM 001-1 was harvested within 103.7 days, on the average. Downy mildew disease rating showed SK1 to be the most resistant among the tested lines.

Preliminary evaluation of AGS lines. AVRDC soybean lines or AGS lines were evaluated for other uses at AVRDC-TOP.

Results of this evaluation showed that some lines such as AGS 190, 191 and 292 are of the vegetable type having 100-seed weights of 28.9, 32.4 and 35.9 g, respectively. However, these lines were found to have fewer pods per plant. On the other hand, lines with low 100-seed weight such as AGS 154 (11.9 g) and AGS 222 (13.0 g) had 145 and 217 pods/plant, respectively.

Effect of nitrogen fertilizer on marketable yield of vegetable soybean varieties. The effect of N-fertilizer on marketable yield of five vegetable soybean varieties was evaluated at AVRDC-TOP. Application of nitrogen highly affected the marketable yield of vegetable soybeans in general. Significant differences were found between plants with and without N-fertilizer in varieties Kegon and White Lion. However, no significant differences in total yield were observed among all varieties. Kegon gave the highest marketable yield of 8.1 t/ha with N-fertilizer but had only 6.8 t/ha without fertilizer. Line PI 459025 had the lowest marketable yield with or without the added N-fertilizer.

Marketable yield of all varieties increased due to increase in marketable pods per plant. Basal application of N-fertilizer and at flowering in vegetable soybean demonstrated the importance of timing of fertilizer application to attain maximum marketable yield.

Effect of nitrogen fertilizer level on soybean yield. This study determined the effect of N application levels on seed yield and plant growth of soybeans. All the treatments with N gave higher yields than the control (without N). N application levels of 60 and 30 kg/ha, which significantly enhanced yield, had the highest yields of 2.8 t/ha and 2.6 t/ha, respectively. Yield changed as a parabolic curve with increasing N application levels. The optimum N application level should be 30 kg/ha. Theoretically, under the conditions of this experiment the optimum N requirement of the variety used is 73.4 kg/ha.

Genetic interrelationship of some quantitative and qualitative traits in (CM 60 × AGS 129) F_2. Five qualitative and six quantitative traits of soybean (*Glycine max* L. Merr.) were studied for genetic interrelationship, using the F_2 generation of the cross CM 60 × AGS 129. The inheritance of leaf shape, color of flower, hypocotyl, pubescence and hilum were attributed to major genes. Genetic association between the color of flower and hypocotyl as well as between the color of pubescence and hilum was detected.

Broad sense heritability among the quantitative traits studied was highest for days to flowering. Seed yield per plant had a heritability of 28.6%. Genotypic correlation among the six metric traits were higher than the phenotypic correlations. The number of pods per plant and the number of branches per plant had significantly high phenotypic and genotypic correlations with yield. These two traits exhibited higher heritability than seed yield.

The yield components, namely, pod/plant, seeds/pod and 100-seed weight, were positively affected by N application. Other agronomic characters like plant height and number of branches/plant were also examined. High level of N application slightly delayed flowering and maturity of the soybean plant.

Sweet Potato

Research on sweet potato is limited because it is not a very important crop in Thailand. Most of the research activities were done only by training scholars in the 8th RTP. For this year, only one sweet potato varietal trial was conducted.

Sweet potato varietal trial. A sweet potato varietal trial including eight AVRDC varieties with the Chinese variety, Xuzhu 18, and the local variety, Ungbuay, as checks was conducted from 2 November 1989 to 2 March 1990 at AVRDC-TOP.

CN 1517 from AVRDC, with deep orange flesh, higher dry matter content and higher harvest index, produced the highest dry root yield of 8.8 t/ha. It is a suitable variety both for food and industrial raw materials production. Two other varieties, CN 1656-97 and CN 1510-25, with high dry matter content, had slightly higher dry root yield levels (7.7 kg/ha) than Xuzhu 18. They are also suitable for production.

Tomato

Seed yield and quality as affected by fruit position. Results showed that fruit position had no effect on seed number, seed weight and germination percentage. However, the time of harvest resulted in differences in seed yield and germination percentage. The highest seed yield was obtained from plants with all ripened fruits extracted for seeds only.

Cherry tomato varietal trial in summer. To breed high yielding, heat tolerant, oval shaped and pink fresh tomato lines, nine lines (five AVRDC heat tolerant lines, three AVRDC-TOP cherry tomato developed cultivars and the local variety Seeda) were tested in summer 1990. Except for Seeda all tomato lines were semideterminate. In this regard, staking was necessary to prevent the plants from lodging and the fruits from touching the ground to reduce fruit rot.

In terms of fruit characteristics, all of the varieties produced small fruits but of different shapes. The fruits of CHT 14-171C-3-1-1, CHT 14-171C-15-3, CHT 14-171C-16-0-0 and CHT 14-171C-16-1-0-0 and CHT 14-171C-20-19-4 were globe shaped with a mixture of red and orange skin peel and light orange gel. The line CHT 33-7C-14-5-5 had pear-shaped fruits with similar skin peel and gel color. On the other hand, the four Seeda lines were oval. Seeda, Seedathip II and III had pink skin while Seedathip I had a mixture of orange and red.

All tomato lines evaluated had relatively low yields because of high temperature. CHT 14-171C-20-19-4 gave the highest yield of 2.4 t/ha followed by Seedathip III with 2.0 t/ha and CHT 33-7C-14-5-5 with 1.6 t/ha. Seedathip III gave the least nonmarketable yield of 21.2% of the total yield.

Tomato line CHT-14-171C-20-19-4 may have produced the highest yield but the shape and color of the skin were not what the consumers prefer. Only two lines, Seedathip II and III, can be recommended for commercial use.

This trial was repeated a month after to determine the effect of high temperature and high humidity. The performance of the lines was better than that in the previous experiments because of the decrease in day temperature during fruit setting. The CHT lines gave relatively lower yield than expected, but still higher than the local Seeda. Seedathip I produced the highest yield at 10.2 t/ha, followed by Seedathip III and II with 7.4 and 6.3 t/ha, respectively. The CHT lines had showed uniform maturity since harvesting was done only three times. In terms of nonmarketable yield, CHT-33-7C-14-5-5 gave the highest of 40.3% of the total yield while Seedathip III gave the lowest of 21.3% of the total yield.

Small fruited table tomato F_1 hybrid trial. The production of high yielding small fruited table tomato preferred by Thai farmers and consumers is a problem in Thailand where the temperature is high especially during summer. Most of the local varieties/lines used are not heat tolerant, thus a trial to determine high yielding varieties suitable to Thai conditions and with fruit qualities liked by consumers was conducted at AVRDC-TOP. Ten lines included in this trial were: 39-9B-1-2 × 3-12B4-1-17-2-3-1, CrN 80-1-1B-1 × 3-12B4-1-17-2-3-1, 34-9B-1-2 × 26-4-3-4-1-1-1, 34-9B-1-2

× CrN 80-1-1B-1, CrN 193: 41-1-5-4B × 34-9B-1-2, S 111, S 112, Seedathip II, Seedathip III and Seeda.

The climatic conditions at the time of the trial were found unsuitable to tomato production. Due to extremely high temperature, fruit cracking was common and fruits were extremely small resulting in very low yields.

Except for Seeda all of the AVRDC improved F1 hybrid lines were semideterminate and needed to be staked to prevent lodging and reduce rotting of fruits. All lines tested were found to flower within 38-40 days after transplanting. The F1 hybrid 34-9B -1-2 × 3-12B4-1-17-2-3-1 had an orange-red flesh when ripe and also had the thickest fruit wall. S 111 and S 112 were oval shaped. Seeda had the thinnest fruit wall.

CrN 80-1-1B-1 × 3-12B4-1-17-2-3-1 had the highest yield 14.0 t/ha, followed by 34-9B-1-2 × 3-12B4-1-17-2-3-1 with a yield of 13.4 t/ha. These yields were significantly different from the rest of the lines tested. The pure line Seeda had the lowest yield of 0.6 t/ha. The two highest yielders also had the highest nonmarketable yield. Seeda had the lowest nonmarketable yield of 0.5-1.0 t/ha.

Considering the preference of the consumers for pink and oval shaped fruits, the line 34-9B-1-2 × CrN 80-1-1B-1 with a yield of 10.4 t/ha could be improved further and recommended to the farmers.

When this trial was repeated towards the end of summer, yield significantly increased because of favorable conditions for fruit setting. F_1 hybrid CrN 80-1-1B-1 × 3-12B4-1-17-2-3-1 with a yield of 21.2 t/ha and 34-9B-1-2 × 3-12B4-1-17-2-3-1 with 20.1 t/ha were still the first two highest yielders. The local pure line Seeda was still the lowest yielder with 3.0 t/ha.

Other Vegetables

In addition to the six AVRDC mandate crops, AVRDC-TOP in cooperation with Kasetsart University and other Thai agricultural agencies also conducted research on other vegetables of commercial importance to Thailand and other countries in the Asian region. Research on crops such as yardlong bean, cucumber and okra are part of the activities of AVNET. Research work on asparagus and baby corn is being carried out in both AVRDC-TOP field and farmers' field. AVRDC-TOP has been one of the frontrunners in conducting on-farm research and extension work on asparagus production. This vegetable, introduced into Thailand via AVRDC-TOP in 1987, is now one of the fast rising vegetable exports in Thailand. The 8th RTP trainees also conducted some research on these crops.

Effect of fruit position at harvest on cucumber seed production. Effect of fruit position at harvest on seed quality of cucumber was studied. Fruit position (1-3) had no effect on seed number and seed size but the highest seed germination percentage was obtained from the fruit at first position. Highest seed yield was obtained from plants with or without harvested first young fruit.

Harvesting index, precooling, packaging and storage of okra. Harvesting index, precooling, packaging and storage of OK*2 okra pods were studied in Kasetsart University from March to May 1989. Pod growth and chemical changes were recorded daily. Results showed that the growth pattern of okra was a single sigmoidal curve. Okra pods were harvested 4-6 days after full bloom. At this stage the pod was about 1.7-2.7 cm wide, 6.2-13.9 cm long and weighed 20.2 g.

Okra pods were placed in nylon net and foam trays, wrapped with PVC film and directly packed in corrugated boxes, then stored at 10 and 15°C. Okra pods in foam trays, wrapped with PVC film were found to have the longest storage life of 15 days with best quality retention and least weight loss.

Okra pods were precooled by room cooling, hydrocooling and no cooking (control), then placed in foam trays and wrapped with PVC film before keeping at 10 and 15°C. Okra pods precooled by hydrocooling had the best appearance in the first 4 days, but had shorter storage life than okra pods precooled by room cooling as well as the control.

Pathological confirmation on asparagus stem blight in central Thailand. Laboratory experiments confirmed that the cause of asparagus stem blight was the fungus *Phomopsis asparagi*

(Sacc.) Bubak, because it could produce pycnidium. Its four isolates from KPS, Banglane, Hubkaphong and Kanchanaburi showed creamy mycelium colonies and except for the Banglane isolate produced pycnidium in stroma. Hubkaphong isolates grew best.

A scanning electron microscope study found that pycnidium was either round or flask shaped. Its average size was 435 × 815 μm. Mature pycnidium are protruding, long and slender. Their terminals have branches called phialide. There are two types of conidium, alpha and beta. No beta conidium was found from the natural diseased samples.

Efficiency testing of four fungicides — benomyl, carbendazin, captan and mancozeb — found that chemical spraying in the nursery 2 days after inoculation, following the manufacturer's recommended rates, could slightly control the disease. The application of the two nonsystemic fungicides with surfactant offered better control of the disease than those without surfactant. In field spraying, it was found that effective control could be achieved using Mancozeb every 7 days during severe infection.

Common cabbage varietal trial. Seven common cabbage varieties from six different seed companies were evaluated for yield and other agronomic characters to select good varieties that had high and stable yield, early and uniform maturity and resistance to soft rot, black rot and mosaic virus disease. The yield, head width, mean head weight and number of days to maturity were significantly different among all entries tested. No. 1 from Chia Tai Seed Co. gave the best performance in terms of yield and horticultural characters.

Cauliflower varietal trial. Seven cauliflower varieties from three different seed companies were evaluated for yield (high and stable yield) and horticultural characters (early and uniform maturity and resistance to soft rot, black rot, and mosaic virus diseases). The yield, curd width, mean curd weight, number of days to maturity and abnormally developed curd (ADC) were significantly different among all entries tested. Sunny 235 from Chia Tai Seeds had the highest yield. ATM gave the highest marketable yield. Champ matured the earliest but gave the lowest yield.

Other Research Activities

All AVRDC-TOP developed or evaluated lines were screened first in farmers' fields in different regions of Thailand, before they were recommended for release. This promoted fast adoption of technologies or crop materials. Economic feasibility studies on some of the newly introduced technologies or varieties were conducted in cooperation with the Department of Agricultural Economics of Kasetsart University.

Comparative study on costs and returns of vegetable production with and without insect screen. Vegetable production using insect screens or nets in the areas of Phrakhanon, Phasicharoen and Bangbuathong districts gave lower returns than those without screens at approximately US$1,299.62/ha/year. However, in the Pathumthani area production, using insect screens was more profitable than not using them, resulting in returns of about US$273,442.62/ha/year. This could be attributed to differences in farm management employed by the farmers as well as location.

Home garden. Activities on home gardens were mostly on the development of cropping patterns suitable for specific locations in Thailand. One of these patterns included the growing of vegetables under the net. A total of 1.7 t of vegetables were produced in AVRDC-TOP home garden in 1990.

Research or trials involving minor or indigenous vegetables and seed production was conducted in home gardens. Home gardens also served as demonstration plots for the newly released varieties and developed cultural management practices.

Graft compatibility of bittergourd and scion on spongegourd and bottlegourd rootstocks. Using the shoot grafting method developed by a Japanese researcher, 87% plant survival was obtained for bottlegourd-spongegourd grafts. Grafting was found useful in breeding for bittergourd.

Training. Twenty training scholars completed the 8th RTP in March 1990. To date, a total of 131 researchers from 11 countries in Asia have undergone the 5-month regional training course in vegetable production and research at AVRDC-TOP. These researchers are now the frontliners in agricultural research and extension activities.

The 1990-91 training program is the 9th training course conducted by AVRDC-TOP. Some 26 training scholars from 11 Asian countries attended the course. These scholars come from China, Indonesia, Kampuchea, Laos, Malaysia, Myanmar, the Philippines, Sri Lanka, Thailand and Vietnam. Their participation was supported by ADB and other international funding agencies like UNDP-Special Programs, UNICEF and nongovernmental religious organizations like COERR and BfDW.

With the evolution of SAVERNET, participation of researchers/extension workers from South Asia to the AVRDC-TOP RTP will be possible during the 10th training course.

Publications and information exchange. Two publications were released this year — the 8th RTP Training Report and the Updated Directory of Training Alumni. Because of the demand, several AVRDC-TOP publications were scheduled either for revision or reprinting.

AVRDC-TOP still serves as the repository and exchange distribution center for all AVRDC publications as well as those coming from mainland China.

Germplasm collection and-distribution. Collection of materials in countries where AVRDC has no access is a priority of AVRDC-TOP. Germplasm exchange is facilitated through participation to the regional training program. For 1990, a total of about 100 kg of seeds were distributed to more than 20 entities excluding those received for AVRDC-TOP trials.

Germplasm materials from AVRDC have been successfully distributed to various countries in the region, especially to those countries which cannot obtain materials directly from the headquarters. To date, two varieties of tomato, four mungbeans, and one heat-tolerant Chinese cabbage developed in cooperation with AVRDC, had been released and extensively planted in Thailand. Over 41% of the total mungbean area of Thailand was planted to AVRDC improved mungbean varieties. In the central part of Thailand such as Nakhon Pathom, 80% of the tomato area was planted to AVRDC-TOP released tomato varieties.

Other activities. AVRDC-TOP, starting 1989, has actively coordinated the study tour programs of several agricultural agencies in countries such as China, Malaysia, Nepal, the Philippines, Sri Lanka, Vietnam, and Ethiopia involving not only researchers but mostly policymakers who came to Thailand to observe developments in vegetable production. The Director/Resident Scientist was also actively involved as adviser to an FFTC-Chiang Mai cooperative project on irrigation being conducted in Chiang Mai University.

International Cooperation

Regional program collaborative work with other countries in the region has been successfully initiated. Formal international cooperation has been forged between AVRDC-TOP and China and just recently Bangladesh. Although there is no formal agreement yet, cooperation with Vietnam has been carried out through this program since 1987. Linkage with Laos, Nepal and Sri Lanka have also been forged through training.

AVRDC/TOP-China. Through the support of international agencies such as IDRC, GTZ and ADB, programmed cooperation on vegetable research with China was established through AVRDC's TOP program to increase production of Chinese cabbage, tomato, sweet potato, soybean and mungbean in China. This objective was accomplished through regional crop trials of AVRDC improved materials in China, germplasm exchange, training/personnel development of Chinese researchers and exchanges of scientific information as well as visits of scientists between China and AVRDC by way of AVRDC/TOP.

The activities of the project include: varietal trials or testing of AVRDC materials in China, training/personnel development, sponsorship of workshops and symposia, exchange of crop genetic materials and technical and scientific information exchange.

Regional Training

A total of 48 Chinese researchers have undergone the 5-month regional training course in vegetable production and research in Thailand. These scholars came from Beijing and many Chinese provinces like Heilongjiang, Liaoning, Hebei, Jiangsu, Hubei, Sichuan, Guangdong, Yunnan and Xinjiang and many have been assigned or promoted to key research roles in their respective institutions. Majority of the scholars were under the sponsorship of IDRC and some by GTZ.

Symposia, Workshop and Meeting

Through the project, several leading Chinese researchers were able to attend important international workshops and symposia. Their attendance at those gatherings enabled them to exchange scientific knowledge and information with prominent researchers from other countries in the world. This kind of interchange can foster scientific cooperation among scientists which will contribute to the advancement of research and development in agriculture.

Research Activities

Regional trials of AVRDC improved materials were carried out by leading Chinese national and provincial agricultural research institutions located in Harbin, Beijing, Xuzhou, Nanjing, Chengdu, Wuhan and Guangzhou, and recently in two additional experimental sites, Kunming, Yunnan and at Urumgi, Xinjiang. Results of crop trials conducted at these locations showed that considerable success has been achieved with AVRDC crops like mungbean, Chinese cabbage, tomato and sweet potato. AVRDC mungbean lines yielded an average of more than 2 t/ha. AVRDC's mungbean line, VC 1973Ad was released earlier in Jiangsu Province as a local variety Xuyin *1 and recently, as Zhong Lu No. 1. Other mungbean lines such as VC 2778A from AVRDC were released in Hubei province as E Lu *2 in February 1989 and another VC line as SuLu No. 1 by Jiangsu AAS in 1990. The Chinese-released AVRDC mungbean lines have currently replaced more than half of the total mungbean hectarage planted in China.

The AVRDC heat-tolerant Chinese cabbage is well adapted and accepted in China, especially in the areas of Beijing, the northern provinces and south of the Yangtze River. Two of these AVRDC heat-tolerant Chinese cabbage lines have been released by Jiangsu AAS in Nanjing under the Chinese variety names of Fu Bao (Hybrid *58) and Xia Feng (Hybrid *62). These two varieties can give an average yield of 25-30 t/ha in 50 days. Hybrid seeds of both AVRDC Chinese cabbage Hybrid No. 62 and No. 58 were produced by the Jiangsu AAS on a national basis, with a total of 2 t produced in 1989 alone.

More than a hundred experiments on mungbean, soybean, Chinese cabbage, tomato and sweet potato have been conducted. For 1989-90, experiments were set up in nine locations.

Germplasm exchange. A considerable amount of vegetable germplasm has already been collected from all over China by the scientists. Many of these accessions have been brought by the training scholars from China to AVRDC-TOP and forwarded to the Center to enrich the total germplasm collection of AVRDC.

Field surveys of major diseases. Brief surveys on soybean, tomato and pepper diseases in the experiment plots and in farmers' fields in Beijing, Xuzhou, Nanjing, Wuhan, Chengdu, Guangzhou and Xinjiang in cooperation with local scientists were started in 1989.

Despite financial constraints the survey on soybean rust caused by *Phakopsora pachyrizi* in several provinces of Central and Southern China and the general survey on virus disease of tomato on a wider geographical range within China are being conducted intensively.

AVRDC/TOP-Vietnam

AVRDC/TOP-Vietnam collaboration on vegetable production and research started in 1986. Vietnamese study groups come to Thailand to observe, study and engage in germplasm exchange. A new tomato variety No. 12 was recently released in South Vietnam.

AVRDC mungbean materials have already been released as varieties by Cantho University. These are: VC 2768A as DX 102, VC 2770A as DX 102, VC 2770 A as DX 102, VC 2770 A as DX 103 and VC 1560 A as DX 91. These varieties are already extensively planted in the Mekong Delta. Recently, VC 2768 B was chosen as one of the most promising among present lines tested for possible future release.

AVRDC/TOP-Bangladesh

The activities of Bangladesh Outreach Program of AVRDC which is supported by USAID is also coordinated by AVRDC-TOP. An MOU between AVRDC-TOP and the Bangladesh Agricultural Research Center has been signed recently. This cooperative program is officially sanctioned by the Thai Government through Kasetsart University.

The program will be sending Bangladesh researchers and extension workers to undergo a 5-month vegetable research and production training course at AVRDC-TOP.

Appendices

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Publications

Symposium Proceedings

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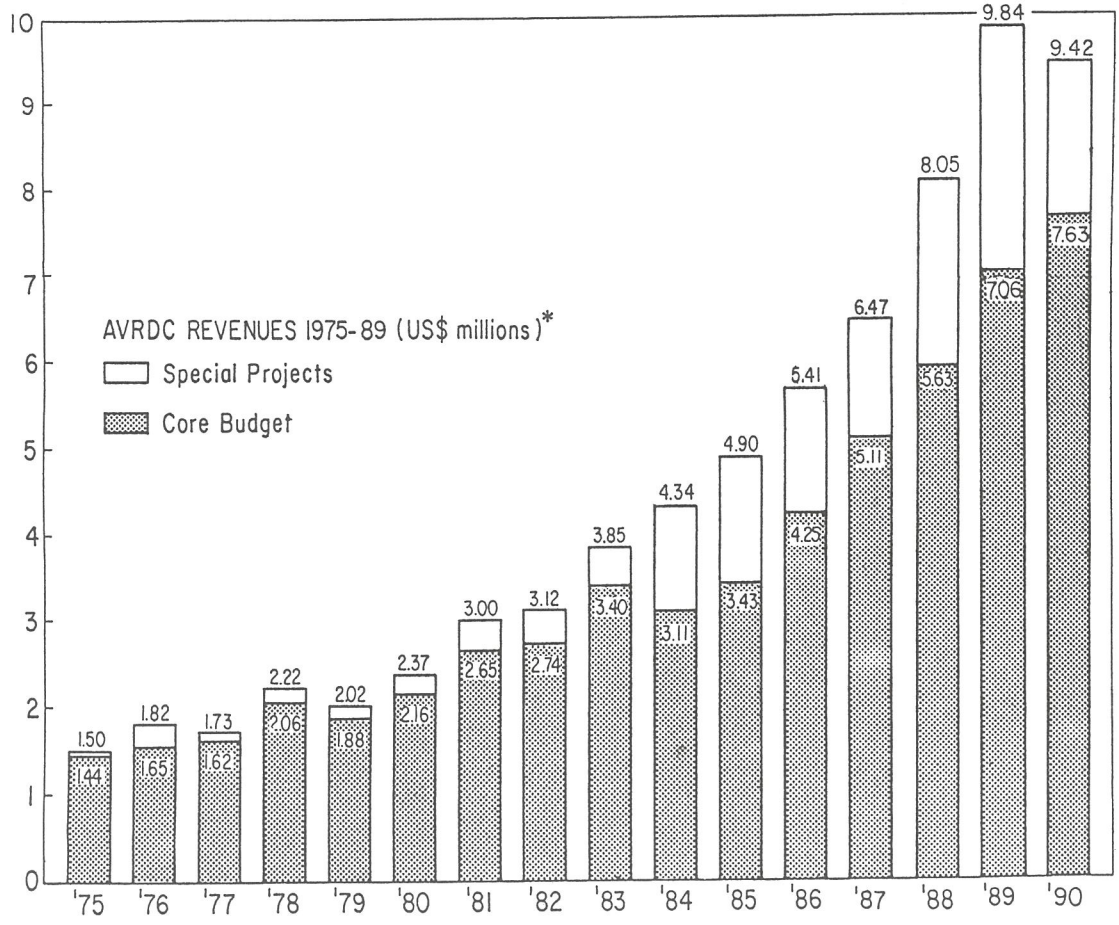
Finances

AVRDC's projected budget for 1990 was US$9,030,000 compared with an actual income of US$9,421,000 and total expenditures of US$9,065,494. In 1990 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
- Philippines
- 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 Agency for Technical Cooperation (GTZ) and the Technical Centre for Agricultural and Rural Co-operation (CTA), International Potash and Phosphate Institute.



* A total of US$ 6.79 million was received for 1971-74 of which US$ 4.2 million was for capital expenditure.