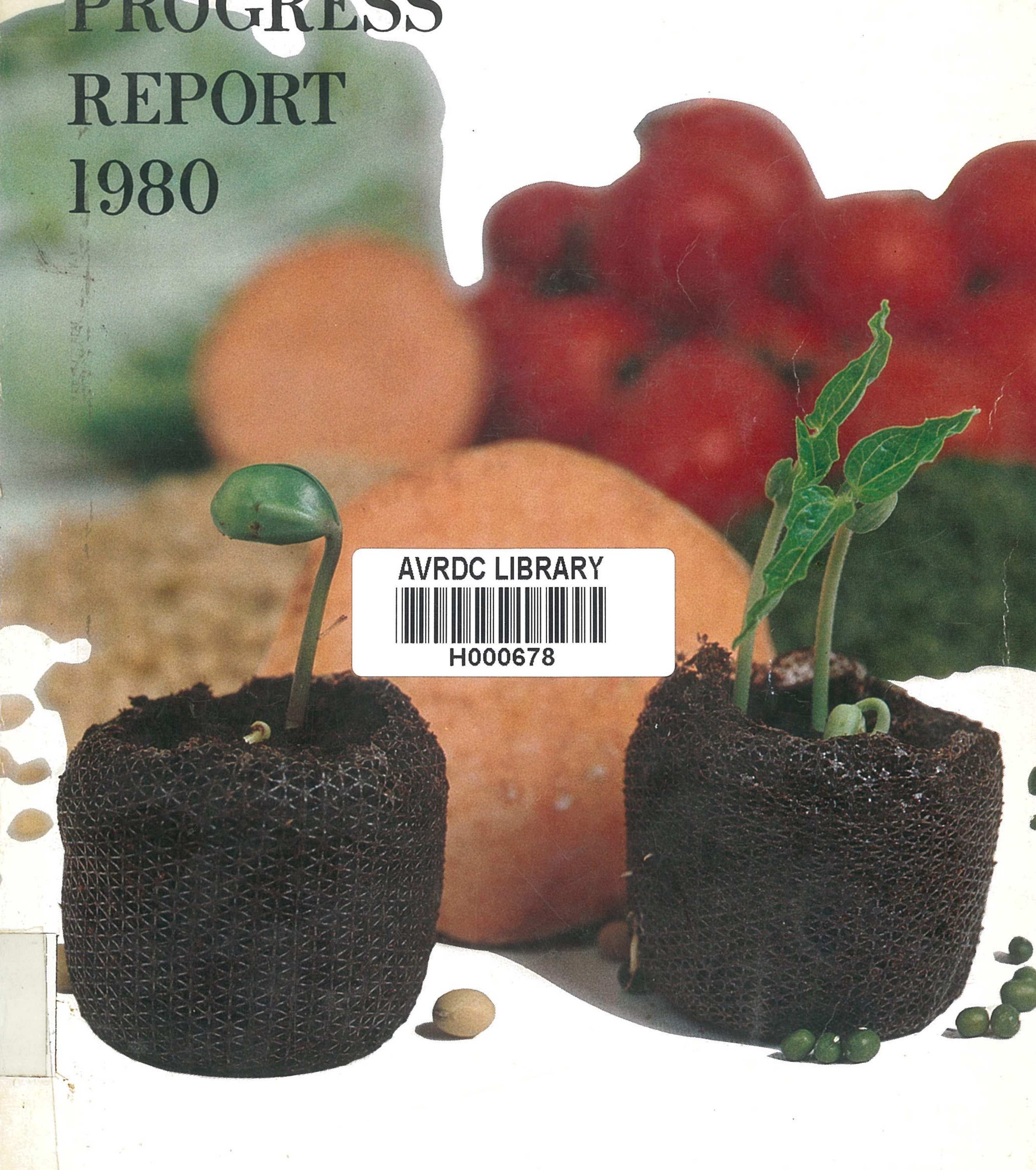
AVRDC

PROGRESS REPORT 1980



THE
ASIAN
VEGETABLE RESEARCH
AND DEVELOPMENT
CENTER

PROGRESS REPORT FOR 1980

1981
THE ASIAN VEGETABLE RESEARCH AND DEVELOPMENT CENTER
P.O. BOX 42, SHANHUA, TAINAN 741, TAIWAN

About this report

AVRDC is the international research and training organization responsible for improving production and quality of selected vegetable and legume crops in the hot, humid lowland tropics.

The 1980 Progress Report summarizes research, training, and outreach activities for the 1980 research year. More detailed accounts of individual studies can be obtained by writing the program leader or scientists involved. Scientists in other countries are urged to correspond with AVRDC investigators regarding technical points and problems.

Data are presented in metric units, and monetary values are in US dollars unless stated otherwise. "Control" means an untreated experimental plot, and "check" or "check cultivar" refers to a cultivar which is used for purposes of comparison, unless stated otherwise. The use of the term "resistant" refers to levels of resistance observed at AVRDC unless stated otherwise. Pedigrees in the AVRDC breeding program are identified by a slant bar (/). Commercial chemical names are used occasionally for identification; such use does not imply endorsement by AVRDC.

Information and conclusions in this report are solely the responsibility of AVRDC.

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Director's Foreword

Freedom from want is one of the rights of man. Freedom does not exist for people who are starving or malnourished. Abject poverty eliminates choices, and malnutrition alters the functioning of mind and body. A full belly is not enough. A lack of protein, vitamins and minerals interferes with man's capacity to work and think.

International agricultural research and training centers in cooperation with national programs have made great strides during the past two decades in increasing the availability of staple foods. Through this "Green Revolution", some nations once deficient in staple crops are today net exporters. Despite this, the increase in food production overall is barely keeping pace with world population, and natural and man-made catastrophies have contributed to reduced stocks of food and feed. Physical suffering has not been eliminated even in certain countries which export staples such as rice and wheat. Moreover, nutritional deficiencies continue to persist even among groups who have managed to achieve sufficient intakes of cereals and other staple foods.

Vegetables and pulses in the diet are means of combatting nutritional deficiencies. Unfortunately, production of these crops has traditionally received little attention, particularly in developing countries. The establishment of international centers with attention to plant proteins, such as IITA in Nigeria, and CIAT and CIP in South America (all under the financial umbrella of the Consultative Group for International Agricultural Research, CGIAR) is recognition of the world's need. AVRDC, which is not financially supported by the CGIAR, is the only international research center responsible for the improvement of vegetable crops.

We at AVRDC recognize the importance of staple crops, but also recognize that the quality of life for the malnourished can be greatly improved by increased intake of the proteins, vitamins and minerals that vegetables can provide. Integrated crop production involving both staple crops and vegetables not only increases the nutritional diversity of the food produced, but also increases the quantity produced per unit area, an important goal for any country deficient in foodstuffs.

When farmers begin to incorporate vegetables into their staple-based cropping systems, intercropping, multiple cropping or relay cropping offer endless opportunities for increased production of food rich in nutrients. The emphasis must be on rotations of vegetables with staple crops from the very beginning. Some developing nations are now finding that once farmers are introduced to a profitable, monocropping system with rice, it is very difficult, time consuming and expensive to introduce more advantageous multiple cropping systems. There is a crop to fit every time interval. A crop of soybeans requires 100 days, mungbean

60 days and various *Brassica* crops range from 20 to 60 days. Systems involving vegetables provide many other side benefits. Countries with too many mouths to feed typically have too many hands for the available work. Vegetable production, an intensive operation requiring hand labor, helps to solve simultaneously both problems of unemployment and food scarcity.

A situation in which a growing population strains the available food resources is usually accompanied by over-use of land resources with concomitant problems of soil erosion, low soil organic matter content, thin soil mantle and low soil fertility. Vegetable production, with its subsequent addition of plant residues and organic matter to the soil, decreases the impact of rainfall on the soil, reduces soil erosion, improves soil structure and permeability, and ultimately improves soil fertility. With proper attention to these basic principles of crop production developed in Asia thousands of years ago, rediscovered in Europe before the tenth century and practiced again in North America during the 1930's, and with the use of improved technologies, food production can be increased while improving soil fertility.

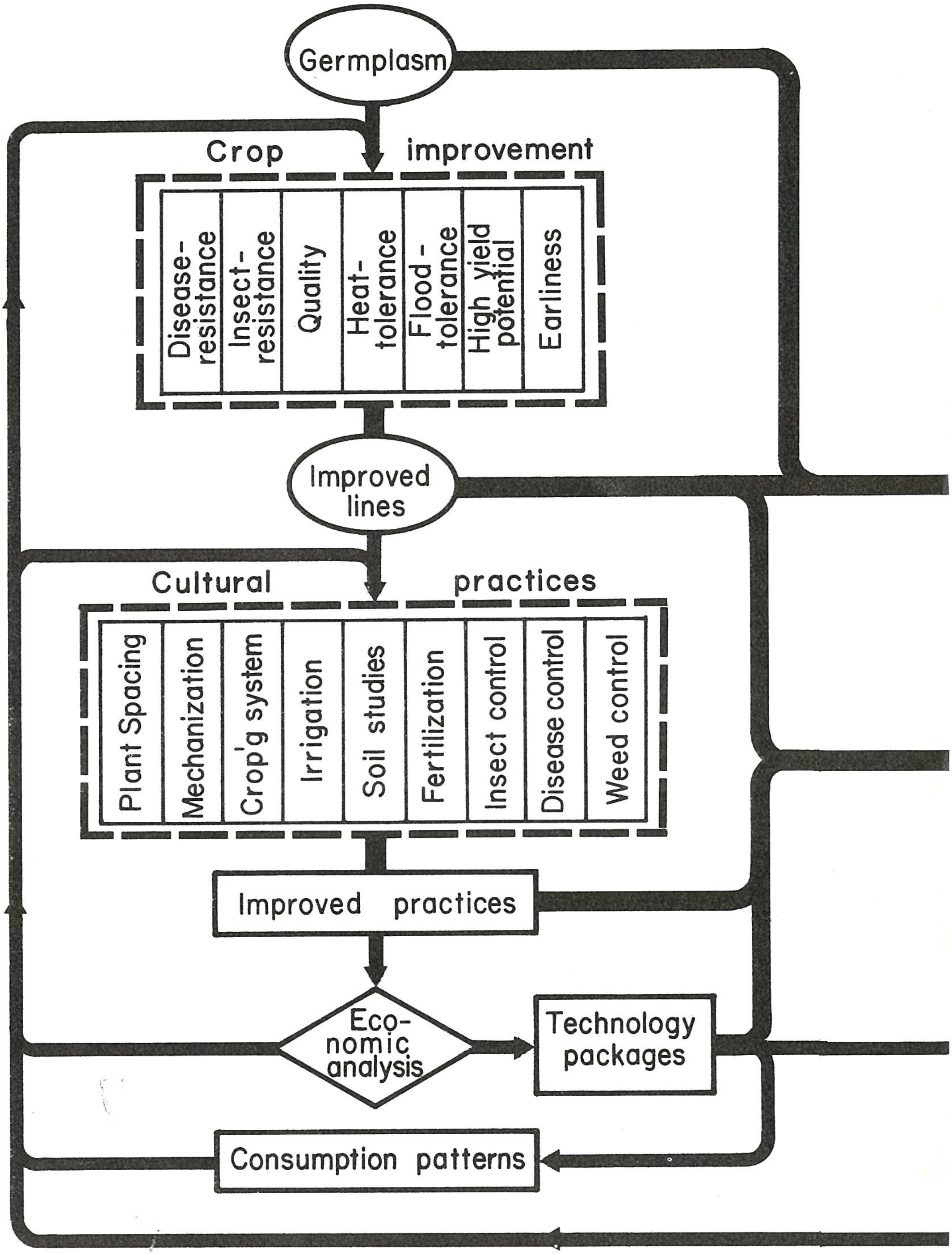
Research alone, however, cannot contribute to increased food supplies without the availability of knowledgeable and skilled extension personnel. It is they who must introduce these technologies to farmers in a way that they can be adapted, developed and improved. They must therefore be well trained in agricultural technologies and strongly motivated to match these technologies with farmers' needs. AVRDC remains committed to the highest standards for the training and preparation of such personnel.

As the only international research center responsible for improving vegetable production, AVRDC has the unique mandate to develop the potential which vegetables have for improving world nutrition levels. Although the Center is internationally financed, lack of sufficient funds limits the efficiency of its operations. Nevertheless, scientific and practical contributions from AVRDC have been significant. A modest contribution to the budget of AVRDC can help improve the quality of life for those people living in the more than 80 countries with which AVRDC cooperates.

The more than 300 graduates from AVRDC's training programs, representing 25 countries, are taking a place of leadership at home and continue to associate with AVRDC in research, training, extension and teaching. Contributions from private and public organizations and commercial enterprises for AVRDC training scholarships provide the opportunity for small farmers to develop self-sufficiency and contribute more fully to the health and economies of communities and nations.

G W Selleck

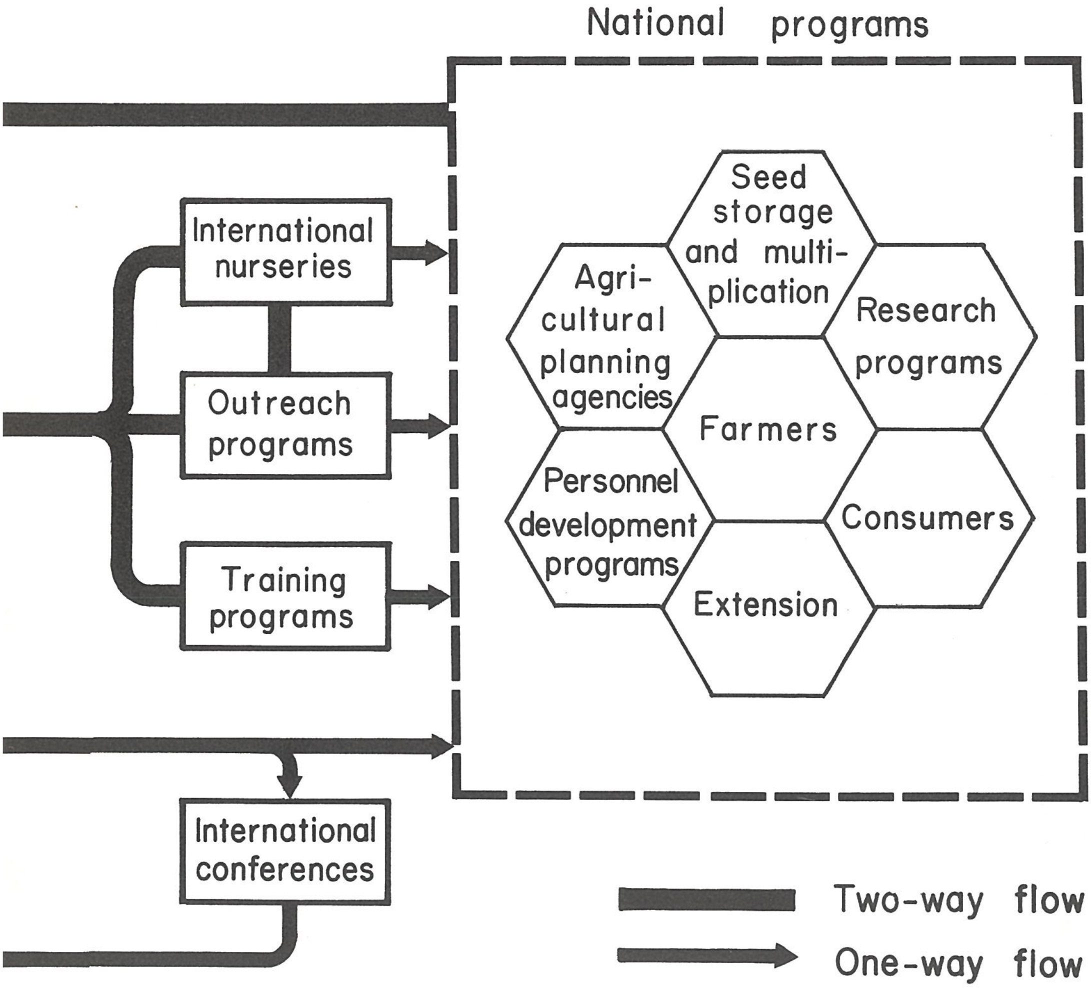
G. W. Selleck
Director
1980



Germplasm
Crop improvement
Disease-resistance
Insect-resistance
Quality
Heat-tolerance
Flood-tolerance
High yield potential
Earliness
Improved lines
Cultural practices
Plant Spacing
Mechanization
Crop'g system
Irrigation
Soil studies
Fertilization
Insect control
Disease control
Weed control
Improved practices
Economic analysis
Technology packages
Consumption patterns

AVRDC Research and Development Scheme

AVRDC is working to increase the yield potential and nutritional value of selected vegetable crops which can make significant contributions to improving staple diets, increasing total food production per unit area and improving soil conservation. Through improved germplasm, the development of appropriate crop technologies, and cooperation with national programs and other organizations, it is the goal of AVRDC to focus these efforts on the tropical farmer to improve agricultural self-sufficiency, to increase income and to expand the capacity for feeding the world's malnourished.



A trainee from Peru monitors his tomato evaluation trial

TOMATO

PLANT BREEDING

Germplasm collection and hybridization

Twenty-five tomato accessions acquired in 1980 brought the total tomato germplasm collection to 4843. A total of 766 crosses were made, concentrating on improving the virus resistance of AVRDC tomato breeding lines.

Fall regional yield trials

In cooperation with the Tainan District Agricultural Improvement Station and financial support from the Council for Agricultural Planning and Development in Taiwan, regional yield trials of AVRDC processing tomato lines and accessions were conducted over six locations during fall and winter, 1979-80. Except for insignificant differences among entries in marketable yield, all traits were significantly influenced by location, season and entry. From the 24 entries, seven lines and one accession were selected for 1980-81 regional trials on the basis of good fruit appearance and acceptable processing qualities (Table 1).

Table 1. Marketable yield and other traits of promising breeding lines selected for inclusion in 1980-81 regional yield trials[a], 1980, Taiwan

Entry	Marketable yield (t/ha)	Fruit size (g)	Days to flowering	pH	Soluble solids (°Brix)	Titratable acidity (%)	Color Hunter brightness (a/b)
L 124	46	60	24	4.1	4.8	0.36	2.20
CL 1561-6-0-1-3-2	46	55	24	4.1	4.5	0.33	2.32
CL 1561-6-0-4-3-3	46	61	24	4.2	4.4	0.32	2.27
CL 1561-6-0-5-1-3	46	59	24	4.2	4.2	0.32	2.27
CL 1561-6-0-10-3-7	48	65	26	4.2	4.2	0.29	2.26
CL 1591-5-0-1-1-4	44	62	28	4.1	5.1	0.43	2.19
CL 1591-5-0-1-2-0	44	58	28	4.1	5.0	0.41	2.26
CL 1591-5-0-1-3-1	42	59	28	4.1	5.0	0.42	2.19

[a]Means of three replications over six locations (Shui-Lin, Tai-Pao, Hsi-Kang, An-Nan, An-Ting and AVRDC) across three seasons (August 9-15 and October 14-15, 1979, and January 14-15, 1980)

Summer yield trials

A total of 16 advanced and preliminary yield trials were conducted during the summer season. All trials were hit by severe epidemics of virus diseases, and selections were therefore made on the basis of high fruit set and absence of virus symptoms. Despite the virus disease outbreak, some selections showed promise. CL 2729-0-2-1 yielded 8 t/ha compared with 1 t/ha from local check L 387 in June and July plantings. In an August planting, selection CL 143-0-10-3 yielded 10 t/ha against 3 t/ha from L 387. Selection CL 110-0-2-1 yielded 16 t/ha in June preliminary trials, and CL 641-1-1-1 produced 25 t/ha in a July planting.

Ethrel applications for uniform ripening

Ethrel applications on processing tomatoes have been used to promote more uniform ripening and thus reduce the number of pickings per tomato harvest. Four ethrel application rates (0, 100, 200 and 300 ppm) were used on tomato varieties UC 134-61D and CL1561 to determine optimum application rates. Plants were sprayed when they had either 10% or 20% red and pink fruits. Applications at 200 ppm on cultivar UC 134-61D with 10% red and pink fruits were the most effective, reducing the number of necessary pickings from four to two.

PLANT PATHOLOGY

Strain detection for tomato and cucumber mosaic viruses

Samples of mosaic-infected tomato leaves were collected from the major tomato growing areas in Taiwan to determine the tomato strains of tobacco mosaic virus (ToMV) and cucumber mosaic virus (CMV) that are present in Taiwan. The field samples were processed according to the scheme in Figure 1. Twenty-one ToMV isolates and 11 CMV isolates have been collected.

If tomato yellow leaf curl virus (TYLCV) is found to be present in Taiwan, it also will be included in the tomato virus resistance screening program. TYLCV damages tomato crops in tropical (India, Thailand, Indonesia) and subtropical (Israel, Sudan) areas. Although it has not been reported to occur in Taiwan, TYLCV-like symptoms have frequently been observed in surveys of tomato growing areas in Taiwan.

Fifty-seven leaf samples from tomato plants showing curling, yellowing and stunting, were tested in an agar gel immuno-diffusion test using tobacco leaf curl antiserum, which reacts positively to the Japanese tomato yellow dwarf virus. Tomato yellow dwarf virus appears closely related to tomato yellow leaf curl virus. Seventeen of the leaf samples gave a distinct precipitaton line in agar. No such line was produced on two apparently healthy samples. This is a strong indication that TYLCV or tomato yellow dwarf virus is present in Taiwan. White fly transmission tests with *Bemisia tabaci* are presently being conducted to further characterize the causal agent.

Fig. 1. Collection and detection scheme for tomato strains of tobacco mosaic virus

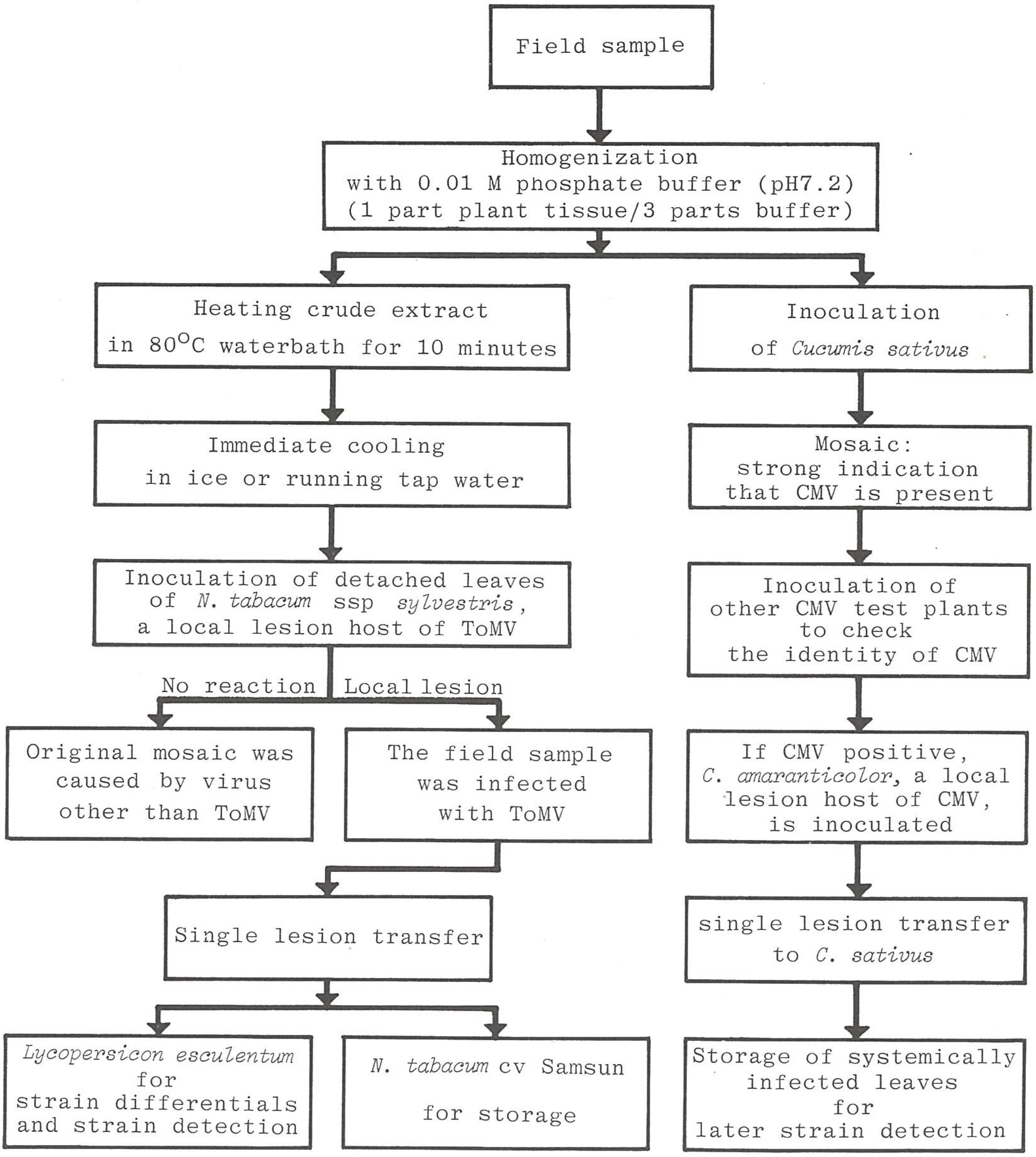


Table 2. Tomato accessions and breeding lines highly resistant (0 to 2 galls) to root-knot nematode after two or more field screenings, 1975-80, AVRDC

Two screenings	Three screenings	Four to six screenings
L 4124, CL 129-0-1-0, Cl 193-0-1-0, CL 203-2-3-0, CL 203-2-5-0, CL 203-2-7-0, CL 203-2-8-0, CL 214-1-1-0, CL 273-0-1-0, CL 281-1-0-0, CL 281-2-1-0, CL 281-2-4-0, CL 297-1-1-0, CL 297-1-4-0, CL 321-1-1-0, CL 338-1-2-0, CL 502-0-0-0, CL 503-0-0-0, CL 507-0-0-27-1, CL 598-1-0-0, CL 647-0-0-0, CL 1009-0-0-0, CL 1009-0-0-1, CL 1009-0-0-2, CL 2725-2-2	L 97, L 4109, L 4110, L 4126, L 4129, CL 106-5-1-0, CL 170-6-1-0, CL 170-27-1-0,	L 275, L 672, L 673, L 272, L 274, L 313, L 383,

Screening for resistance to root-knot nematode (*Meloidogyne incognita*)

Twenty-seven tomato accessions and 145 breeding lines were screened for resistance to root-knot nematode in spring 1980. The results of this and previous screenings since 1975 are shown in Table 2.

Biological and abiological control of root-knot nematodes on tomato

Aldicarb 10G (Al), *Tagetes patula* cv. Janie (French Marigold) (Ta), chicken manure (Ma), compost (Cp), and a nematode-trapping fungus *Arthrobotrys oligospora* (Ao) were used in combination to control *Meloidogyne incognita*. The combinations of Al+Cp+Ma, Al+Ao+Cp, Al+Ao+Cp+Ma stimulated plant growth, increased yield, and reduced galling in a greenhouse test. All combinations involving aldicarb (including aldicarb by itself), Ta+Cp or Ta+Ma reduced galling in field trials. No definite trend was observed in the effect of the treatments on fruit quality.

Screening for resistance to bacterial wilt (*Pseudomonas solanacearum*)

A total of 594 tomato breeding lines were screened for resistance to bacterial wilt. The plants were inoculated at the three-leaf stage by clipping the lower leaves with scissors which had been dipped in a suspension of 10^9 bacteria/ml water. AVRDC *P. solanacearum* isolate 76 (race 1), which shows high virulence to tomato, was used for the inoculations. Plants were evaluated at 15 days after the inoculation. Five breeding lines (CL 275-0-1-2-1, CL 949-0-8, CL 1219-0-8, CL 1351-1-6 and CL 1351-1-9) rated resistant (wilting of less than 10% of the plants).

ENTOMOLOGY

Screening for resistance to tomato fruitworm (*Heliothis armigera*)

Widespread damage by the tomato fruitworm has been reported in the Philippines, Thailand and India, and the pest has been causing significant damage to tomato crops in Taiwan in recent years. Larvae initially feed on the leaves and later bore into the fruits which then become susceptible to secondary infections by bacteria and fungi.

A total of 800 tomato accessions were screened for resistance to fruitworm in single row, 5m x 1.5m raised beds. The trial was managed according to suggested cultural practices except the use of insecticides. Damage was assessed by counting the number of fruitworm-infested fruits per plot at 7, 9, 11 and 17 weeks after transplanting. Resistance ratings were made by subjecting the percentage of damaged fruits to a statistical analysis based on the mean and standard deviation (Figure 2).

Most of the accessions were harvested after the third observation (11 weeks after transplanting). Although a substantial number of these appeared highly resistant in at least one of the observations, only 20 accessions consistently demonstrated high resistance across all three observations. The fourth observation was made for mostly late-maturing, wild relatives of tomato. Although none of these wild varieties rated highly resistant, ten were without any damage. Two of these, entries 76W and 77W, were reported resistant to fruitworm in trials at North

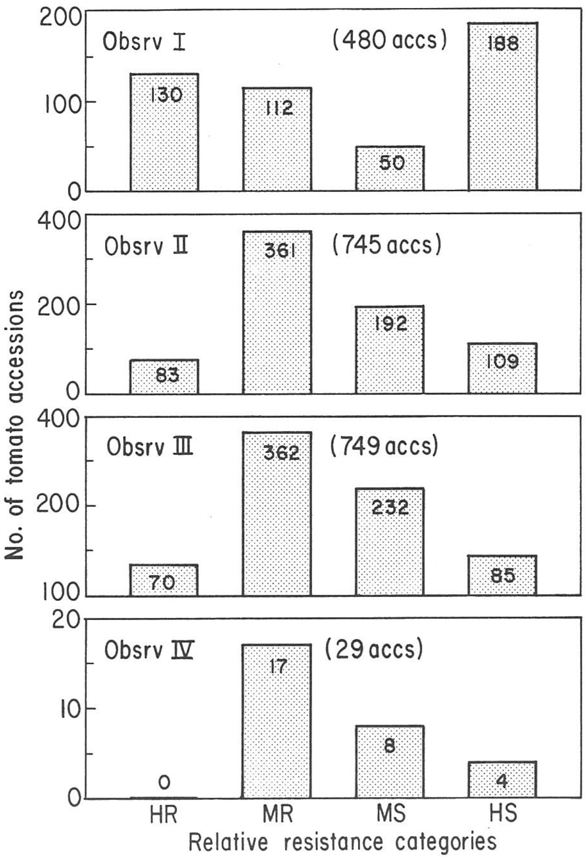


Fig. 2. Relative fruitworm resistance ratings of tomato accessions in four observations, 1980, AVRDC

Highly resistant (HR):

% damaged fruits < (mean - 1sd)

Moderately resistant (MR):

(mean - 1sd) < % damaged fruits < mean

Susceptible (S)

mean < % damaged fruits < (mean + 1sd)

Highly susceptible (HS):

% damaged fruits > (mean + 1sd)

Carolina State University in the United States and will be included in the AVRDC resistance breeding program.

PLANT PHYSIOLOGY

Screening for flood tolerance

The screening of all AVRDC tomato accessions for tolerance to excessive soil moisture was completed in 1980. Four-week-old seedlings of 4630 accessions were flooded in flats for three days in a heat room programmed for 30-32°C and 12 hour photoperiods. A total of 110 accessions (2.4%) demonstrated flood tolerance which is usually indicated by absence of leaf chlorosis, petiole epinasty and wilting.

After two subsequent field trials in which the crops were twice subjected to soil flooding during the growing period, eight accessions (L 123, L 125, L 973, L 3072, L 3091, L 4313, L 4422 and L 4360) were selected for consistent tolerance in all screenings.

In a related experiment, the flood tolerance of tomato accession L 123 was compared with that of amaranthus (AVRDC accession no. 26), Chinese cabbage (B 189), mungbean (V 2184), soybean (G 38), sweet potato (AIS 35-2), water convolvulus (Green Stem) and wingbean (UPS 102). All plants were evaluated for plant growth, chlorophyll content and root oxygen consumption after four days of soil flooding in the field. Based on shoot and root growth, both amaranthus and tomato appear to be very sensitive to soil flooding, and sweet potato and water convolvulus demonstrated the greatest tolerance (Table 3).

Soil flooding and temperature stress

The interaction of soil flooding and temperature was studied in six-week-old tomato seedlings of accession L 387. The seedlings were subjected to three days of flooding under air temperatures of either 33.4°C-26.1°C or 23.9°C-12.7°C (maximum-minimum); or soil temperatures of 18°C, 24°C or 30°C. After flooding, tissue proline content (a stable physiological indicator of flooding stress) was measured. Both high air and soil temperatures aggravated soil flooding stress (Table 4).

Ethylene production and flood damage in tomato

Soil flooding stimulates ethylene production in tomato plants, and this has been hypothesized as the primary cause of flood damage symptoms. To examine the role of ethylene production in tomato flooding stress, three-month-old flood tolerant and susceptible tomato accessions were subjected to flooding under 35°C-25°C conditions. After 24 hours of flooding, shoot tissues were measured for ethylene production. Although ethylene production differed among accessions, no relation between flood tolerance and ethylene production was found.

A second experiment compared the growth of tomatoes which had been exposed to either ethylene treatments or soil flooding for four days.

Table 3. Effects of flooding on plant growth, chlorophyll content and root oxygen consumption of selected vegetables[a], 1980, AVRDC

Crop	Relative root growth	Relative shoot growth	Relative chlorophyll content	Relative root oxygen consumption
Amaranthus (accession no. 26)	0.35	0.62	0.38	0.78
Chinese cabbage (B 189)	0.90	0.74	0.75	0.80
Mungbean (V 2184)	0.67	0.63	0.77	0.73
Soybean (G 38)	0.82	0.83	0.64	1.18
Tomato (L 123)	0.25	0.13	1.03	0.28
Wingbean (UPS 102)	1.00	0.95	0.88	0.76
Water convolvulus (Green Stem)	2.00	0.90	1.04	3.73
Sweet potato (AIS 35-2)	1.03	1.29	0.91	1.95

[a]Average oxygen contents were 6.0% and 20.8% for flooded and non-flooded plots respectively. All figures express the ratio of flooded plants/ control

Table 4. Proline content and dry weight of L 387 after three days of flooding under different temperature treatments[a], 1980, AVRDC

Treatment		Proline content (m moles/g fresh weight)		Shoot dry weight (g/plant)	Root dry weight (g/plant)
		Shoot	Root		
Air temperature 33.4°C-26.1°C	Flooding	16.8±4.1	19.3±17.5	0.9±0.3	0.07±0.04
	Control	3.2±1.7	2.4 ± 1.3	1.5±0.4	0.17±0.03
Air temperature 23.9°C-12.7°C	Flooding	2.2±1.2	2.8 ± 0.9	1.6±0.4	0.11±0.03
	Control	1.5±0.4	1.9 ± 0.3	1.5±0.3	0.19±0.06
Soil temperature 18°C		9.2±1.3	3.7 ± 3.5	1.9±1.4	1.08±0.48
Soil temperature 24°C		6.2±6.1	2.4 ± 2.0	1.0±0.5	0.08±0.06
Soil temperature 30°C		39.3±11.4	7.5 ± 3.0	1.5±1.1	0.10±0.01

[a]Flooding for air temperature treatments was done at 44 days after sowing. Flooding for soil temperature treatments was done at 51 days after sowing, and maximum-minimum air temperatures were 27.5°C and 14.4°C respectively

Table 5. Response of tomato growth to ethylene or flooding treatments, 1980, AVRDC

Entry	Treatment (ethylene (ppm) or flooding[a])	Root dry weight (g/plant)	Shoot dry weight (g/plant)	Chlorophyll content (mg/g fresh weight)
L 123	0	2.0	7.4	0.50
	10	1.1	6.7	0.54
	100	1.1	6.5	0.58
	Flooding	0.6	4.1	0.18
L 166	0	2.7	6.7	0.54
	10	2.4	7.0	0.43
	100	1.9	6.6	0.49
	Flooding	0.6	3.1	0.08
L 275	0	2.1	10.0	0.42
	10	1.3	9.3	0.66
	100	1.2	7.0	0.45
	Flooding	0.5	3.8	0.20
L 3040	0	1.1	4.6	0.55
	10	1.0	4.7	0.69
	100	1.0	4.5	0.54
	Flooding	0.6	2.7	0.42
LSD 5%		0.7	1.9	0.2

[a]Flooding for four days without ethylene treatments

Table 5 shows that soil flooding had a much more harmful effect on plant growth than ethylene applications alone, indicating that ethylene production alone cannot fully account for flood stress in tomato.

Heat tolerance studies

Past studies have shown that poor tomato fruit set under high temperatures is not the result of a single physiological factor, but rather a number of factors involved in the complex fruiting process (such as production of viable pollen, transfer of pollen to the stigma, germination and growth of pollen in the style, and style viability and fertilization). Heat tolerance in tomato depends on the performance of these factors under high temperatures, and combining the best factors from different genotypes into a single breeding line should enhance fruit set under high temperature conditions.

Thirty-eight heat tolerant tomato accessions (AVRDC Journal Paper no. 24) and 16 heat tolerant breeding lines and heat sensitive accessions were screened twice for fruit set and stigma exsertion. The plants were subjected to mean maximum and minimum temperatures of $35.2\pm3.6^{o}C$ and $24\pm3.4^{o}C$ respectively upon reaching the second cluster stage. Only accessions L 283 and L 1488 demonstrated both high fruit set (60%) and non-exserted stigmas, further suggesting the complexity of fruiting.

In a second study, fifteen heat tolerant accessions and breeding lines were planted in the field to determine critical temperatures for dehiscible pollen grain production, stigma exsertion and pollen viability. The specific physiological factors of each entry were correlated with the heat degree-hour sum (HDHS) as given by the formula

$$HDHS = \sum_i (Ti - B)$$

where

i = hourly indexes beginning ten days before investigation

Ti = hourly maximum air temperature (^{o}C)

B = 'potential critical temperatures' selected in $1^{o}C$ increments from $23^{o}C$ to $35^{o}C$.

$$(Ti - B) > 0$$

The temperature most closely correlated with the physiological factor was identified as the critical temperature.

The results show a strong negative correlation between HDHS above $26^{o}C$ and dehiscible pollen grain production (-0.99**), a negative correlation between HDHS above $32^{o}C$ and pollen viability (-0.90*) and a strong positive correlation between HDHS above $30^{o}C$ and stigma exsertion (0.99**). Although there were no significant differences between cultivars in dehiscible pollen grain production above $26^{o}C$, cultivar differences were evident in critical temperatures for stigma exsertion and pollen viability. Accessions L 18, L 99, L 229, L 283 and L 2991 have high critical temperatures ($33^{o}C$) for stigma exsertion, and all except L 18 also have high critical temperatures ($31^{o}C$-$32^{o}C$) for pollen viability. These entries exhibited high fruit set in the previous fruit set screening, suggesting that the HDHS correlation technique can be used to evaluate the heat tolerance of the factors responsible for fruit set in tomatoes.

CHINESE CABBAGE

PLANT BREEDING

Germplasm collection

Fifty-two new accessions brought the total collection of Chinese cabbage and related species to 750 in 1980.

Advanced trials for high yield stability and heat tolerance

Five advanced trials of 12 AVRDC Chinese cabbage breeding lines were conducted throughout summer 1980 in a continuing screening for stable, high yielding, heat tolerant cultivars. Table 1 shows the entries which yielded higher than the average of all cultivars over all planting dates. As in 1979 tests, AVRDC hybrids #58, #59 and #62 yielded highest across all environments.

A graphical analysis of the yield performance stability of the best entries is shown in Figure 1. The regression lines of the best entries are positioned higher than that of the average for all varieties (b = 1), indicating their above-average yields across the range of environments

Table 1. Yield (t/ha) of outstanding Chinese cabbage entries in advanced trials[a], summer 1980, AVRDC

Entry	Trial transplanting date					Variety mean
	May 19	June 23[e]	July 21	Aug 26	Sept 24	
77 M(2)-25	20.1 cd[b]	10.2 c	22.2 cd	24.4 bc	22.2 b	19.8
77 M(2/3)-43	17.3 cde	11.3 bc	19.2 cde	24.1 bc	22.4 b	18.9
AVRDC #58	25.1 ab	23.3 a	31.3 a	27.9 a	27.3 a	27.0
AVRDC #59	28.6 a	9.2 c	21.0 cd	31.4 a	27.9 a	23.6
AVRDC #62	26.1 ab	14.1 b	26.8 b	30.4 a	26.6 a	24.8
B 189 (check)	17.4 cde	12.2 b	17.8 de	17.8 d	18.8 c	16.8
Environment mean[c]	19.1	9.6	19.0	23.7	22.5	18.8[d]

[a]Sown in $12m^2$ plots with four replications
[b]Mean separation within columns by Duncan's multiple range test (5% level)
[c]Grand mean of all entries over all environments
[d]Yields of the June 23 trial suffered from severe diamondback moth infestation

(planting dates) studied. Hybrid #58, the highest yielder, has a regression line highest above that of the average. A low regression coefficient (b = 0.32) indicates that hybrid #58 performed consistently across environments. Hybrid #62 has a regression coefficient slightly above unity (b = 1.09), indicating that although the hybrid yielded above average across all environments, performance was always better when the environment was favorable. Hybrid #59 yielded above average within the range of environments tested, but a high regression coefficient (b = 1.53) suggests that it will yield below average in very poor environments while

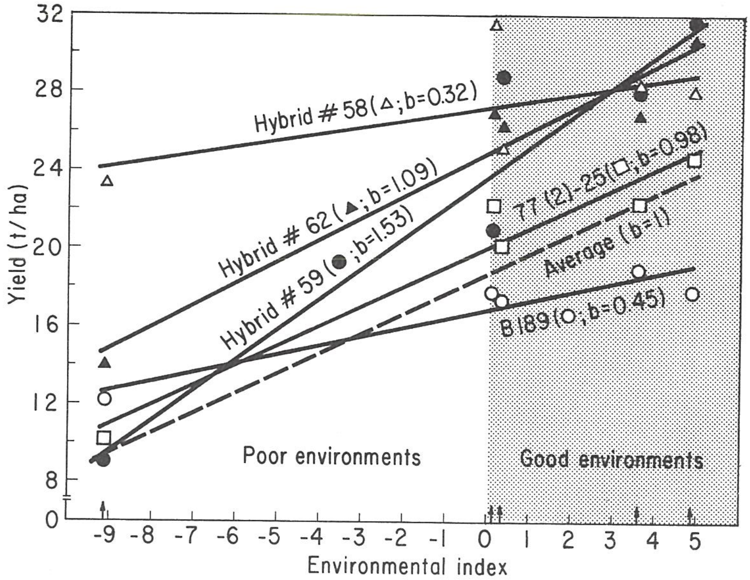


Fig. 1. Yield response of selected Chinese cabbage entries to various environments determined by planting date (↑), 1980, AVRDC

performing well in good environments. Open-pollinated 77 M(2)-25 yielded only slightly above average, but is similar to hybrid #62 in the nature of its stability. By comparison, local check B 189 had below average yields in good environments. A low regression coefficient (b = 0.45), however, indicates that it performed above average in poor environments.

Stability across environments is greatly determined by two characters: the heading rate (percentage of total stand that forms heads) and the harvest rate (percentage of total stand that is harvestable). The coefficients of variation for these two characters were measured in selected entries from the advanced yield trials (Table 2). Those cultivars which yielded above average and with relative consistency across all environments ($0=b<1$; "Type 2" stability) had consistently low variability for both heading and harvest rate. Varieties which yielded above average in all environments, but always higher in good environments than in poor ($b = 1$; "Type 1" stability), showed low variability for heading rate but somewhat high variability for harvest rate. Unstable ($b>1$) entries 77 M (3)-26 and 77 M(3)-35 showed high variability for both characters.

The unstable heading and harvest rates of 77 M(3)-26 and 77 M(3)-35 suggest low levels of heat tolerance. Heading rates of both entries tended to be lower during the hot midsummer months than in early or late summer plantings (Figure 2). By comparison, hybrid #58 had a 100% heading rate (and thus a high harvest rate) across all planting dates.

In the advanced trials, the earliest maturing entries (hybrid #58 and B 189) also had the lowest softrot infection. Correlation analyses of maturity against softrot infection rate showed highly significant positive

Table 2. Yield stability and coefficients of variation for harvest and heading rates of selected Chinese cabbage entries, 1980, AVRDC

	Regression coefficient	Deviation from regression	Stability type and yield[b]	Coefficient of variation[a]	
				Harvest rate	Heading rate
77 M(2)-25	0.98	ns	Type 1, above	24	7
77 M(2/3)-43	0.88	ns	Type 1, above	26	6
Hybrid #62	1.09	ns	Type 1, above	23	4
Hybrid #58	0.32	ns	Type 2, above	7	0
B 189 (check)	0.45	ns	Type 2, below	8	4
Hybrid #59	1.53	*	unstable, above	33	4
77 M(3)-26	1.22	**	unstable, below	52	22
77 M(3)-35	1.21	*	unstable, below	49	18

[a]Measured across environments and taken from angular transformations of the original percentage data
[b]Yield is compared with the average of all entries
*Significant at the 5% level
**Significant at the 1% level

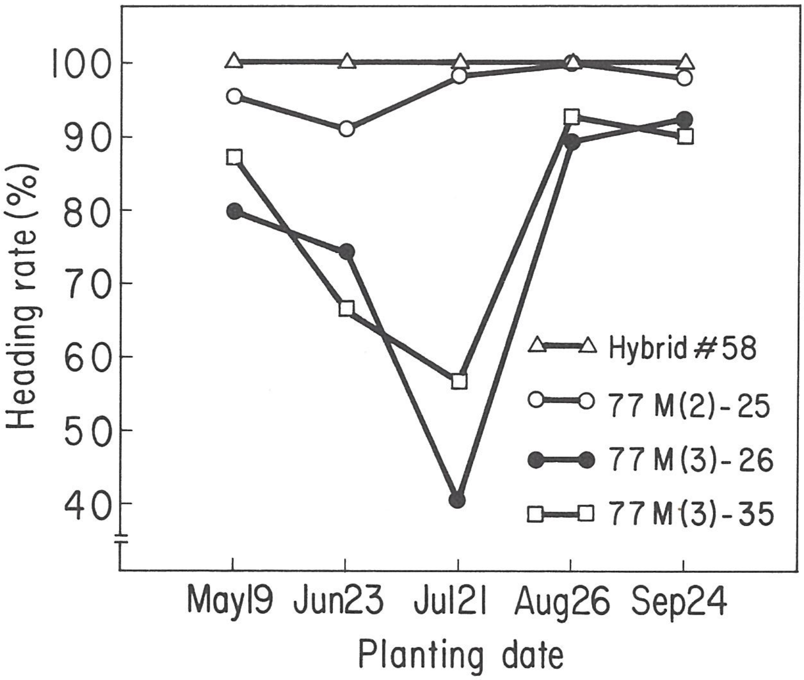


Fig. 2. Comparative heading rates (%) among Chinese cabbage entries with various yield stabilities, 1980, AVRDC

correlations in three of the advanced trials (significant r ranged from 0.3 to 0.7). This suggests that, under certain conditions, early maturing cultivars may be able to escape softrot infection.

Combining ability trials

A total of 65 new combinations were evaluated against commercial hybrids and check cultivar B 189 in an effort to identify better heat tolerant hybrids among crosses between inbred lines. Four combinations gave better average performances than B 189 in midsummer and late summer plantings (Table 3). A fifth combination, C 2-7/0-2, performed well in a non-replicated trial planted in early summer, yielding 25.4 t/ha in 31 days compared with 8.9 t/ha in 31 days from check B 189. The combination also appeared resistant to softrot and turnip mosaic virus under natural field conditions.

Reciprocal cross tests on promising hybrids

Economical production of hybrid Chinese cabbage seed can be achieved by blending seeds produced on male and female parents, provided both carry strong self-incompatibility. Before blending can be performed, however, the assumption that negligible horticultural differences exist between direct and reciprocal hybrids must be satisfied. Head weight and maturity of hybrids #58 and #62 were therefore evaluated for future consideration in commercial seed production. Differences between direct

Table 3. Yield and other horticultural characters of selected combinations in two combining ability trials[a], 1980, AVRDC

Combination	Yield (t/ha)	Maturity (DAT[b])	Head weight (g)	Harvest rate (%)	Heading rate (%)	Soft rot (%)	TuMV (%)
C 2-7/U-1	25.2	38	793	98	100	1	0
E-7/T-1	27.3	40	871	95	100	7	0
E-9/T-1	23.0	41	760	93	100	7	0
E-9/U-1	26.2	42	928	92	97	5	0
B 189 (check)	12.6	38	419	94	100	5	1
AVRDC #58 (check)	23.2	40	694	92	100	5	0

[a]Sown June 27 and September 4, 1980, in 7.2 m^2 plots with two replications
[b]Days after transplanting

and reciprocal hybrids of #58 were highly significant for both head weight and maturity. For hybrid #62, deviation in head weight was insignificant. Whereas the difference in maturity of #62 was statistically highly significant, the actual one-day difference between the direct and reciprocal hybrids indicates that the possibility of seed blending for hybrid #62 is not a remote one.

Cytosterility backcross program

Research continued into the feasibility of using cytoplasmic sterility (CS) as an alternative to the system of self-incompatibility (SI) in hybrid production. CS does not break down under high temperatures as SI tends to do. In 1979, original CS families from the University of Wisconsin were backcrossed three times to selected heat tolerant accessions and inbred lines with good combining ability but weak self-incompatibility. In summer 1980, 200 plants from each of the three families were planted with local heat tolerant cultivar B 129 as the recurrent parent. The objective was to select heat tolerant derivatives with good horticultural characteristics for further backcrosses.

General observations of the BC_4 families have shown an unexpected predominance of the phenotypic characteristics of B 129. Ten heat tolerant plants were selected for further backcrossing on the basis of earliness, large and compact heads, and relative resistance to disease, particularly downy mildew to which B 129 is susceptible. In two or three more backcrosses, it should be possible to test the cytosterile populations in a hybrid seed production program.

Turnip mosaic virus (TuMV)

Backcross efforts to incorporate TuMV resistance into AVRDC advanced heat tolerant Chinese cabbage inbred lines began in 1979, using B 141 as the genetic source of immunity to TuMV. The recurrent parental lines were B 11, C 9, D 10 and E 9, with good combining ability and susceptibility to TuMV. Five hundred plants of each of the four BC_1 families were planted in summer 1980 to select heat tolerant, TuMV-immune plants for further backcrosses. Selection efforts were concentrated on the cross with B 11 since it exhibited the highest degree of susceptibility to TuMV. Seven heat tolerant, TuMV-resistant plants were selected for further backcrosses.

Flowering behavior of parental inbreds of AVRDC hybrids #58 and #62

The flowering behavior of parental inbreds of AVRDC #58 and #62 under natural field conditions was evaluated for characteristics essential for future commercial or semi-commercial hybrid seed production. Stock seeds were direct-seeded seven times starting on November 28, 1979 and continuing at two-week intervals thereafter. Female parents of hybrids #58 and #62 flowered six to eight days earlier than their male counterparts when sown in December. A January sowing reduced the difference in flowering time to three to five days. Flowering response in the November 28 sowing was unpredictable; the deviation between male and female parents was 12 days in #62 and only four days for #58. Thus, plantings to achieve optimum flowering synchronization of both parents should be staggered according to the sowing date.

A preliminary test on the effect of trimming old leaves from bolting plants showed that flowering can be delayed by five to seven days. This treatment, however, tends to reduce the number of floral stalks per plant. This test will be repeated to evaluate trimming as an alternative method for flowering synchronization.

PLANT PATHOLOGY

Downy mildew (*Peronospora parasitica*) resistance screening

Sixty-eight new accessions were evaluated for downy mildew resistance in the field using a standard artificial inoculation procedure. The inoculum consisted of a suspension of 2 x 10^4 conidia/ml water and resistance ratings were based on disease incidence Symptom appearance was evaluated twice at two and four weeks after inoculation. Six accessions (B 606, B 607, B 608, B 609, B 727, B 742) rated highly resistant (0% disease incidence) and four accessions (B 638, B 652, B 717, B 730) rated moderately resistant (1%-25% of the plants infected). These accessions will be subjected to at least two more field screenings. Twenty-five accessions which rated resistant in previous screenings were rescreened. Only three (B 304, B 313, B 595) remained moderately resistant. Fourteen breeding lines including open-pollinated lines, inbred lines and F_1 hybrids were screened in the field. Six were moderately resistant: 77 M(3)-26, 77 M(3)-35, 77 M(3)-38, hybrids #58, #59 and #62.

Turnip mosaic virus (TuMV) resistance screening

A total of 73 accessions and 115 breeding lines were screened for TuMV resistance in the field after inoculation at the 2-4 true leaf stage. The inoculum, applied to the leaves with an inoculum-soaked cotton pad, was prepared by macerating infected mustard (*Brassica juncea*) leaves in a 0.01 M phosphate buffer solution at pH 7.0 (one gram infected tissue/5 ml buffer solution). Visual symptoms were recorded at seven and 14 days after the inoculation.

Seventeen accessions (B 188, B 233, B 521, B 662, B 703, B 713, B 716, B 720, B 721, B 730, B 734, B 738, B 742, B 743, B 744, B 747, B 749) rated moderately resistant (0%-20% of the plants infected). Resistance was observed in 34 breeding lines, 12 of which had 0% disease incidence: hybrids #58, #59, #62, Ping Luh Sib 1, 77 M(3)-26, 77 M(3)-27, 77 M(3)-35, 9816-1 (T-1-7-1), 9818-5 (C-2-7-5), 9830-6 (0-2-3-6), 9830-7 (0-2-3-7) and 0-2-3-22.

TuMV purification

TuMV was purified using PEG and Triton X precipitation and subsequent differential centrifugation. The resulting TuMV preparation showed a UV absorption curve typical of nucleoproteins with UV absorption rates ($E_{280/260}$ and $E_{max/min}$) of 0.9 and 1.03 respectively. The virus preparation was then used for antiserum production.

The antiserum, produced in rabbits, reacted with TuMV-infected plant sap even when diluted 128-fold in agar gel immunodiffusion tests. TuMV usually does not produce a reaction in gel diffusion tests unless it is fragmented by ultrasonic treatment. This procedure was avoided by treating both the antigen and agar gel with SDS, a detergent effective in degrading viruses. By using an SDS medium, a positive precipitation line was obtained from TuMV-infected leaf disks as well as from infected plant sap.

Softrot resistance screening

Eighty-one breeding lines were field-screened for the first time for resistance to bacterial softrot in summer and fall 1980. Entries were inoculated in the field just prior to heading with 2ml of a 1×10^8 bacterial cells/ml water suspension injected by a hypodermic syringe. Seventeen lines rated moderately resistant, and two inbred lines, 9198-1-(77 M(3)-38-11-1) and 9816-1-(T-1-7-1), rated highly resistant with a 0% incidence of the disease.

Disease interaction between TuMV and downy mildew

The development of a simultaneous or sequential multi-disease resistance screening technique will facilitate more rapid and efficient resistance screenings. The technique, however, is effective only when no interaction between pathogens and host plants exist. A preliminary study investigated possible interactions between TuMV-infected Chinese cabbage and the downy mildew fungus. Twenty plants of each of four TuMV-susceptible accessions were inoculated first with TuMV and then with downy mildew (*Peronospora parasitica*) two weeks later. Another 20 plants of each of the same accessions were inoculated with *P. parasitica* only.

When inoculated with *P. parasitica* alone all accessions rated moderately susceptible to downy mildew with 50%-60% of the plants infected (Table 4). When the plants were inoculated with both downy mildew and

Table 4. Disease rates for downy mildew as affected by interaction between downy mildew and TuMV, 1980, AVRDC

Accession no.	Artificial inoculation with downy mildew only			Artificial inoculation with TuMV and downy mildew		
	infected plants/ total plants	disease (%)	rating	infected plants[a]/ total plants	disease (%)	rating
B 205	10/20	50	MS[b]	20/20	100	HS[c]
B 305	21/35	60	MS	35/36	97	HS
B 309	10/19	53	MS	20/20	100	HS
B 400	10/18	56	MS	20/20	100	HS

[a]All plants infected with downy mildew were first infected with TuMV
[b]Moderately susceptible
[c]Highly susceptible

TuMV, however, the same accessions rated highly susceptible to the downy mildew fungus, with more than 95% of the plants infected. This indicates an interaction between TuMV and downy mildew, with TuMV infection apparently increasing susceptibility to downy mildew infection. The results also suggest that screening for downy mildew resistance should not be done on plants previously inoculated with TuMV. The study will be repeated in 1981 using accessions that are resistant to downy mildew and highly susceptible to TuMV.

ENTOMOLOGY

Biology of cabbage webworm (*Hellula undalis*)

The basic biological study of cabbage webworm that was initiated in 1978 continued in order to fully understand the nature and extent of the damage caused by this destructive insect pest. Heat tolerant Chinese cabbage accession B 189 C_1 was planted three times between June and September on 0.05 ha plots. All standard cultural practices (AVRDC guide 81-150) were followed except the use of insecticides. Weekly observations were made on infestation levels, larval instars and larval feeding habits beginning seven to ten days after planting. Larvae of each instar were present in all observations. First and second instar larvae predominate during early plant growth, with the pattern shifting toward later instar larvae as the plant nears maturity. These observations confirm the generation overlap which was observed in 1979, indicating that the crop requires full protection regardless of when it is planted from June to September.

The number of larvae feeding on the growing point, stems and inner and outer leaves was also recorded. Webworm larvae prefer to feed on the growing point or those leaves closest to the growing point (Figure 3). As a result of this feeding habit, the plant usually dies or produces only axillary shoots which do not form marketable heads. Suitable control methods must therefore protect the growing point, especially in the early growth stage beginning immediately after transplanting.

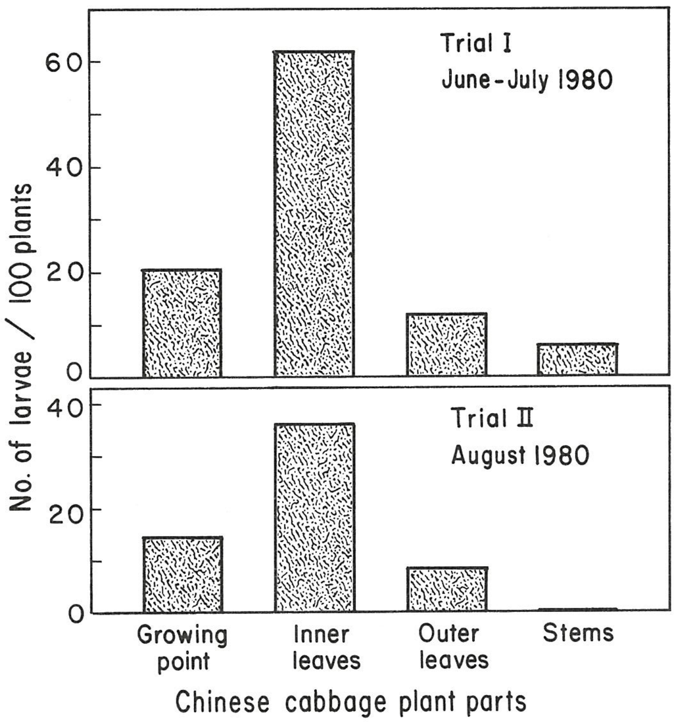


Fig. 3. Feeding sites of cabbage webworm larvae on Chinese cabbage, 1980, AVRDC

Cultivar resistance to cabbage webworm

Twenty-eight Chinese cabbage accessions which had shown some resistance to webworm in earlier screenings were selected for a field screening in 1980. The plants were raised in flats in the greenhouse and transplanted on June 27 in 5m x 1.5m raised beds with two replications. All suggested cultural practices were followed except the use of insecticides. The plots were allowed to be infested by the prevailing webworm population in the field. At one and three weeks after transplanting, ten-plant samples from each plot were observed for webworm larvae population and the number of webworm-damaged plants. Based on a statistical analysis using the mean and standard deviations of the number of insects per ten-plant sample, five accessions rated moderately resistant.

Fourteen of the most promising accessions were then transplanted into clay pots in the greenhouse at ten pots/accession. Four days after transplanting, a large number of webworm adults were released in the greenhouse. After three days, the number of eggs laid was recorded, and 15 days after the insect release, the number of insect larvae feeding on the plants was counted. Using the statistical analysis applied in the field screening, accessions B 411 and B 501 had the lowest oviposition and number of larvae. Accession B 411 rated susceptible in the field screening, and B 501 belongs to *Brassica juncea*, a close relative of Chinese cabbage.

Chemical control of cabbage webworm

Insecticide screenings in 1978 and 1979 showed parathion as the cheapest and most effective insecticide for the control of cabbage webworm. An application timing experiment was therefore conducted to find the best control at minimum cost. All insecticide treatments were initiated at three days after transplanting since insect damage during the first week results in greater yield loss than damage at later growth stages. Both yields and the percentage of marketable heads of all insecticide treatments were significantly greater than those of the control, but there was no significant difference between treatments (Table 5).

At harvest, two samples of two Chinese cabbage heads each were collected from each treatment and analyzed for parathion residues. The plants were chopped in a Hobart food chopper and samples were extracted for 12 hours in a Soxhlet extraction apparatus using a 1:1:1 mixture of methanol, acetone and benzene. The extracts were further processed using routine methods, and parathion residues were quantitated by gas liquid chromatography with a flame photometric detector. Residues were calculated on a fresh weight basis. The insecticide treatment that resulted in the most effective control, highest percentage of marketable heads and highest yield left only 0.015 ppm parathion residues two weeks after the final spraying (Table 5).

Table 5. Application timing of parathion for optimum control of cabbage webworm on Chinese cabbage[a], 1980 AVRDC

Spray intervals at days after transplanting	Damaged plants% 1 Aug	Damaged plants% 14 Aug	Marketable heads(%)	Yield (t/ha)	Insecticide cost (US$/ha)	Parathion residue[b] (ppm)
3-6-9-12-15-18-21-24-27-30	8.0 c	0.00 b	51.6 a[c]	9.2 a	33.33	0.170
3-6-9-12-15-18----24----30	5.0 c	0.00 b	59.9 a	9.9 a	26.94	0.074
3-6-9-12-15----21----27---	10.0 c	2.50 b	56.8 a	8.8 a	22.22	0.043
3-6-9-12----18----24----30	5.0 c	0.00 b	52.6 a	8.8 a	22.22	0.059
3-6-9----15----21----27---	5.0 c	0.00 b	65.1 a	12.0 a	19.44	0.015
3-6---12----18----24----30	3.0 c	0.00 b	59.9 a	10.3 a	19.44	0.010
3---9----15----21----27---	8.0 c	0.00 b	62.0 a	11.5 a	16.67	0.006
3--------15----------27---	63.0 b	0.00 b	60.9 a	10.1 a	11.11	0.002
3-----------18------------33	63.0 b	0.00 b	54.2 a	8.9 a	11.11	0.185
Control	100.0 a	100.00 a	3.1 b	1.7 b	00.00	0.000

[a]AVRDC hybrid #58 was planted on June 17, 1980 in 15 m^2 plots with four replications and harvested August 29, 1980. Parathion 47 EC was applied at 0.5 kg a.i./ha, and observations made on August 1 and August 14
[b]Calculated on a fresh weight basis
[c]Mean separation within columns by Duncan's multiple range test (5% level)

In insecticide screening trials, weekly sprays of EPN, Triazophos, Evisect, fenitrothion and chlorpyrofos at 0.5 kg a.i./ha each gave as effective control of webworm as parathion. None of eight commercially available stickers used with parathion improved webworm control over the use of parathion alone.

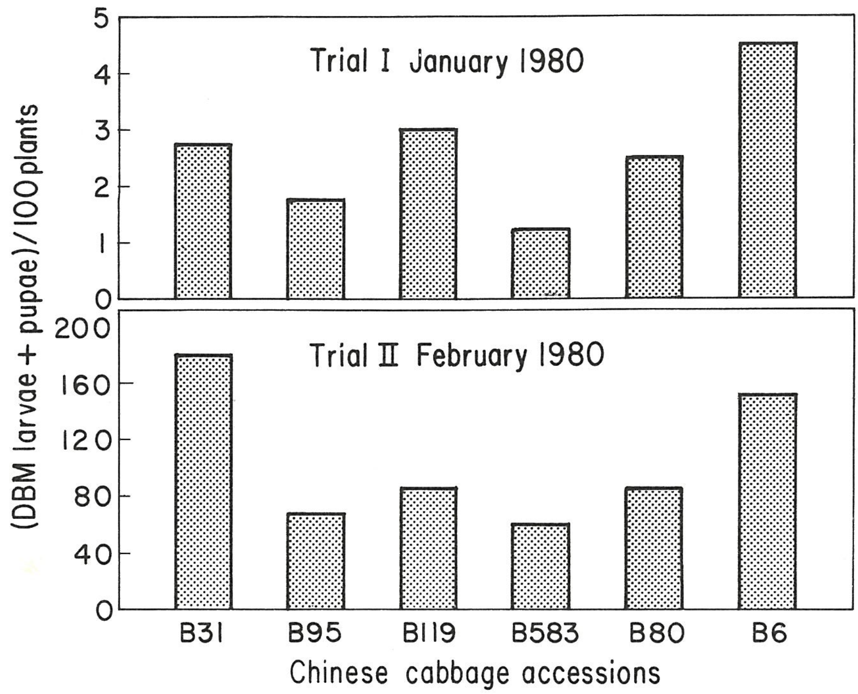


Fig. 4. Infestation levels of diamondback moth on selected Chinese cabbage accessions in two trials, 1980, AVRDC

Cultivar resistance to diamondback moth (*Plutella xylostella*)

Five Chinese cabbage accessions with promising resistance to diamondback moth were screened in two trials planted in November 1979 and January 1980. All entries were grown on 5m^2 plots with four replications using suggested cultural practices except the use of insecticides. The number of larvae and pupae on a ten-plant sample was recorded twice or three times during crop growth. Accessions B 583 and B 95 were the least affected in both screenings (Figure 4). Both belong to *Brassica compestris* ssp *parachinensis*, a non-heading Chinese cabbage cultivar.

Chemical control of diamondback moth and aphids (*Myzus persicae* and *Rhopalosiphum pseudobrassicae*

In insecticide screening trials, tokuthion, decamethrin, DPX 4481 and PH 60-44 (an analog of Dimilin) gave effective control of diamondback moth whereas tokuthion, DPX 4481 and Pirimicarb gave satisfactory control of aphids. All insecticides significantly increased Chinese cabbage yields over that of the untreated control.

Characterization of heat tolerant Chinese cabbage

Physiological characterization of heat tolerant and heat sensitive Chinese cabbage cultivars continued in 1980 in an effort to identify better selection criteria and gain further understanding of the mechanism of heat tolerance in Chinese cabbage. Previous studies have shown that heat tolerant Chinese cabbage plants maintain a good root system and have high sap electrical conductivity under high temperature conditions.

Nine Chinese cabbage entries (B 6, B 40, and B 71 previously identified as heat sensitive; B 14 identified as moderately heat tolerant; and B 31, B 129, B 140, B 189 and hybrid #58 identified as heat tolerant) were transplanted on May 16, 1980. Heat tolerant entries sustained better root growth, had thicker leaves, higher chlorophyll content, fewer trichomes on their leaf surfaces and higher sap electrical conductivity than heat sensitive entries (Table 6).

Table 6. Physiological characteristics of heat tolerant and heat sensitive Chinese cabbage grown under high temperature conditions[a], 1980, AVRDC

Entries	Yield (t/ha)	Heading rate (%)	Root growth (g/plant)	Leaf thickness (μm)	Chlorophyll content (mg/dm^2)	Trichome/cm^2	Conductivity[b] ($\mu mhos/cm^2$)
B 6	0 c[c]	0 c	0.4 c	321 b	2.85 c	4.8±0.5	81 d
B 40	0 c	0 c	0.6 bc	343 b	3.39 c	1.9±0.8	89 cd
B 71	0 c	0 c	0.6 bc	384 ab	2.83 c	2.2±2.1	85 d
B 14	7.5 b	40 b	0.9 bc	424 a	4.31 ab	0.7±0.3	84 d
B 31	9.9 ab	85 a	0.8 bc	443 a	4.02 b	0	106 ab
B 129	10.3 ab	75 a	0.7 bc	429 a	4.01 b	0	102 bc
B 140	14.2 a	94 a	1.7 a	440 a	4.38 ab	0	118 a
B 189	9.6 ab	84 a	1.0 b	432 a	4.65 a	0	90 cd
Hybrid #58	9.1 ab	56 b	1.1 b	399 a	3.39 c	0.5±0.4	99 bc

[a]Transplanted May 16, 1980. Mean maximum and minimum temperatures were 33.1°C and 23.3°C respectively. Yield, heading rate, root growth, leaf thickness and chlorophyll content were measured at 25 DAT. Trichomes were counted at 40 DAT

[b]Measured (October 1, 1980) on pot-grown Chinese cabbage sown on September 1, 1980. Mean maximum and minimum temperatures were 32.2°C and 22.7°C respectively.

[c]Mean separation within columns by Duncan's multiple range test (5% level)

A second study was conducted to examine water relations as they differ in heat tolerant and heat sensitive Chinese cabbage plants. Seedlings of heat sensitive accession B 6 and heat tolerant B 31 were subjected at 25 days after planting to seven days of temperature treatments and then measured for relative water content (RWC) and water potential and its components (Table 7). B 31 maintained a higher RWC and a lower osmotic potential than B 6 under both high and low temperatures. A high number of electrolytes available in the tissues of B 31 is probably responsible for the low osmotic potential, which in turn results in a high RWC. A greater electrolyte content can be attributed to increases in soluble sugars resulting from high photosynthetic rates (as suggested in Table 6 by the higher chlorophyll

Table 7. Effect of temperature on relative water content (RWC), plant water potential and sap osmotic potential of heat tolerant and heat sensitive Chinese cabbage, 1980, AVRDC

Entries	Heat response	Treatment (°C)	RWC (%)	Plant water potential (bar)	Sap osmotic potential (bar)	Pressure[a] potential (bar)
B 6	Sensitive	20 - 25	91.9 ± 2.2	-7.5 ± 1.0	-5.8 ± 0.1	-1.7 ± 1.0
		25 - 30	86.9 ± 1.3	-8.3 ± 0.9	-6.6 ± 0.0	-1.7 ± 0.9
B 31	Tolerant	20 - 25	94.8 ± 2.1	-8.3 ± 1.1	-9.2 ± 0.0	0.9 ± 1.1
		25 - 30	95.4 ± 1.7	-7.5 ± 1.1	-8.9 ± 0.1	1.4 ± 1.1

[a]Pressure potential = (water potential) - (osmotic potential)

content of B 31), or increases in inorganic ions from a greater mineral nutrient uptake (as suggested in Table 6 by the better root growth of B 31).

Measurements of various heat tolerant and heat sensitive Chinese cabbage entries confirm that heat tolerant plants maintain relatively lower osmotic potentials (Table 8). Low osmotic potentials should lead to the maintenance of high tissue turgor, which in turn may facilitate head formation under high temperatures.

The results suggest that the physical aspects of water relations in Chinese cabbage play an important role in heat tolerance with regard to head formation. Measurements of the stable parameters of sap electrical conductivity, root system and leaf thickness might provide simpler methods for determining the level of heat tolerance in Chinese cabbage.

Screening for soil flooding tolerance

Soil flooding is one of the greatest constraints to Chinese cabbage production in the lowland tropics, preventing profitable production from

Table 8. Plant water potential and sap osmotic potential in heat tolerant and heat sensitive Chinese cabbage, 1980, AVRDC

Entries	Heat response	Water potential (bar)	Osmotic potential (bar)	Pressure[a] potential (bar)
B 6	Sensitive	-7.4 ± 0.6	-8.3 ± 0.6	0.9 ± 0.8
B 14	Intermediate	-6.2 ± 1.4	-7.6 ± 1.0	1.4 ± 1.7
B 33	Sensitive	-6.7 ± 1.1	-8.1 ± 1.0	1.4 ± 1.5
B 31	Tolerant	-6.4 ± 1.1	-10.7 ± 1.2	4.3 ± 1.6
B 129	Tolerant	-3.8 ± 0.1	-14.8 ± 3.1	11.0 ± 3.1
B 189	Tolerant	-8.0 ± 0.9	-11.4 ± 2.4	3.4 ± 2.6

[a]Pressure potential = (water potential) - (osmotic potential)

May to September. In 1980, screening for genetic sources of soil flooding tolerance was initiated. A total of 585 Chinese cabbage accessions were grown in seedling flats in the greenhouse. At three weeks, the flats were immersed for four days in a water tank filled with tap water. Three days after immersion, six seedlings per entry were evaluated visually for survival and the extent of damage. From two such screenings, 25 accessions were selected for field tests, after which 16 accessions rated relatively tolerant to soil flooding.

To facilitate future flooding tolerance screenings and flooding stress studies, the interaction of temperature and soil flooding was studied for their effects on Chinese cabbage. Three-week-old seedlings of accession B 14 were subjected in seedling flats to flooding for six days under air temperature ranges of 36.5°C-33.7°C/28.5°C-26.7°C; 29.0°C-27.6°C/18.0°C-16.2°C; and 27.5°C-25.9°C/16.3°C-13.1°C (day/night). The results indicate that Chinese cabbage was adversely affected by flooding only under high temperatures (Table 9). When proline accumulation was used as an indicator, flooding stress was evident only under high temperatures.

Table 9. Growth and proline levels of Chinese cabbage after flooding under different temperature regimes[a], 1980, AVRDC

Temperatures (°C day/night)	Treatment	Shoot dry weight (g)	Root dry weight (g)	Proline content (m moles/g fresh weight) Shoot	Root
36.5-33.7/28.5-26.7	Flooding	0.65 b[b]	0.03	5.53 a	6.20 a
	Control	1.19 a	0.05	0.49 b	0.46 b
29.0-27.6/18.0-16.2	Flooding	0.62 b	0.03	0.76 b	1.70 b
	Control	1.35 a	0.04	2.02 b	1.08 b
27.5-25.9/16.3-13.1	Flooding	1.13 a	0.05	0.57 b	1.58 b
	Control	1.16 a	0.03	0.91 b	1.08 b

[a]Sown on October 29, flooded December 1-8, observations made on December 8, 1980
[b]Mean separation within columns by Duncan's multiple range test (5% level)

In a second experiment, B 14 seedlings were subjected to flooding for six days under controlled soil temperatures of 18°C, 24°C and 30°C and (day/night) air temperatures of 29.2°C-24.2°C/16.3°C-14.4°C. Plant growth was unaffected by soil flooding under these three soil temperature conditions although proline levels tended to accumulate slightly after flooding under 30°C soil temperatures. These results suggest that air temperature plays an important role in flooding damage.

Water usage by Chinese cabbage

Maximum growth and yield of Chinese cabbage is dependent on a plentiful supply of moisture throughout plant growth, but information is lacking on how that moisture is used by the plant. Therefore, nine plants from each of accession B 6 and hybrid #59 were grown on loam soil in 80 x

120 x 30 cm^3 plastic containers and observed for water usage. Moisture levels were kept at field capacity through two buried clay pipes connected to a water reservoir. Water drain from the reservoir was recorded and replaced daily. Most of the water absorbed by the plants was lost through transpiration (Table 10). Both entries required at least 150 g water in order to produce one gram dry weight during the first 70 days of growth.

In a second experiment, single plants of accessions B 189 and hybrid #62 were planted in 5 x 10^{-4} acre Wagner pots and subjected to different watering treatments beginning at seven days after planting. The treatments consisted of four different water levels: 50, 100, 200 or 400 ml/pot per day during the first 30 days and increased to 100, 200, 400 and 600 ml/pot per day respectively thereafter. The results indicate that a single Chinese cabbage plant requires at least 24 kg water throughout a hot growing period if the soil is not mulched. The plants also showed signs of drought stress when less than 400 ml water/day was applied.

Table 10. Average water usage by Chinese cabbage, 1980, AVRDC

Entries	Plant age (days)	Shoot dry weight (g/plant)	Average water usage (ml/plant per day)	Estimated transpiration (ml/plant per day)	Calculated water retention (%)
	35 - 41	7.0	80	79	11.1
	42 - 48	12.1	138	123	10.6
Hybrid #59	49 - 55	20.0	167	155	7.4
	56 - 61	24.2	162	154	4.9
	62 - 68	30.5	154	144	6.8
	35 - 41	10.3	101	93	8.1
	42 - 48	14.4	176	166	5.5
B 6	49 - 55	23.5	205	186	9.2
	56 - 61	31.7	188	170	9.6
	62 - 68	41.7	194	184	5.1

SWEET POTATO

PLANT BREEDING

Germplasm collection and hybridization

Five new sweet potato accessions were received in 1980, bringing the total collection of sweet potato germplasm to 427. A total of 272 crosses were made, with a focus on incorporating early maturity and resistance to witch's broom disease and sweet potato weevil (*Cylas formicarius*). Breeders and biochemists also established breeding goals for various nutrients of different sweet potato types (Table 1).

Fall yield trials

The fall planting, planted in 1979 and harvested in early 1980, consisted of 13 advanced, eight preliminary and 53 observational trials. All trials received 60 kg P/ha and 45 kg K/ha at planting and 30 kg N/ha and 45 kg K/ha side-dressed at one month after planting.

In the advanced trials, 44 sweet potato lines (34%) yielded at least 25 t/ha and four lines (3%) yielded 40 t/ha or more (Table 2). Selection CI 591-28 has high sugar and β-carotene contents, making it suitable as a dessert type sweet potato. A total of 158 entries were included in the preliminary trials, with 12 lines producing 40 t/ha or more. Although

Table 1. AVRDC breeding goals for various nutrients in different sweet potato types, AVRDC, 1980

Sweet potato type[a]	Nutrients				
	β-carotene (mg/100g fresh weight)	Protein (%)	Starch (%)	Sugar (%)	Dry matter (%)
Staple	<1	5-8	>20[b]	3-5	25-35
Dessert	10-15	NC[c]	NC	>20	NC
Animal feed	<1	5-8	>20	3-5	25-35
Industrial	0	<3	>20	3-5	25-35

[a]All types should have white to yellow flesh except dessert type which should have orange flesh
[b]Preliminary goal
[c]NC=amount not critical

most of these high yielding lines had low dry matter, protein and β-carotene contents, they are potential sources of high yield as parentals in the breeding program. Selection CI 624-14 yielded only 25 t/ha but consisted of 27% dry matter, 5.8% protein and low sugar content.

A total of 259 lines (25%) were selected for promising yields in observational trials. An additional 165 lines were selected for further evaluation of post-harvest quality after remaining in good condition when stored under ordinary room conditions for five months.

Spring yield trials

Sixteen observational trials were planted on March 13-14, 1980 and

Table 2. Highest yielding sweet potato selections from fall advanced trials[a], 1980, AVRDC

AVRDC selection no	Pedigree	Marketable yield (t/ha)	Dry matter (%)	Protein (%)	Sugar (%)	Beta-carotene (mg/100g)
CI 345-6	Centennial/OK 6-3-106	59	26*	5.1*	21	0
CI 591-28	Poly Tainung 57 (2)	46	16	5.6*	35	11*
CI 478-6	PI 344129/Tainung New 31	45	23*	4.6*	21	0
CI 243-2-1	B 7078/Tainung 56	42	26*	3.8	23	0
CI 543-6	B 6708 (OP)/PI 344129	36	22	5.5*	24	2
CI 478-5	PI 344129/Tainung New 31	35	24	4.5	21	0
CI 0122-2-16	B 6708 (OP)	34	20	4.5	26	0
CI 598-1	Poly PI 344129	34	27*	4.7*	20	0

[a]130 entries, sown September 14-22, 1979 and harvested January 14, 1980 (120 days); four replications
*Acceptable levels

fertilized according to the fall planting schedule. Because of the prevailing dry conditions of the 1980 summer, all trials were irrigated twice. Six lines (2%) produced 15 t/ha or more (Table 3). Selections CI 551-3 and CI 926-3 yielded well with high protein contents, although dry matter contents were low. From the standpoints of marketable yield, dry matter and protein content, selections CI 913-18 and CI 916-46 appear promising for use as starch and animal feed.

Table 3. Promising high yielding sweet potato selections from spring observational trials[a], 1980, AVRDC

AVRDC selection no.	Pedigree	Marketable yield (t/ha)	Dry matter (%)	Protein (%)	Beta-carotene (mg/100g)
CI 913-7	PI 344129/Red Tuber Tail/ OK 6-3-118///B 6712	39	24*	3.1	0
CI 916-35	PI 344129//Red Tuber Tail/ OK 6-3-118///Red Tuber Tail	36	0	0	2
CI 551-3	B 6708 (OP)//Tainung 27/HDK 8	28	20	6.1*	4
CI 913-18	PI 344129//Red Tuber Tail/ OK 6-3-118///B 6712	27	27*	4.9*	0
CI 911-7	PI 344129/B 6708 (OP)//Red Tuber Tail	26	18	4.6*	2
CI 910-1	PI 344129/B 6708 (OP)//PI 315342	25	24	3.2	0
CI 926-3	Poly Tainung 57 (1)/PI 286621	20	19	6.1*	8
CI 916-46	PI 344129//Red Tuber Tail/ OK 6-3-118///Red Tuber Tail	20	25*	4.0	0

[a]310 entries, sown March 13-14 and harvested July 16 (124 days); two replications
*Acceptable levels

Summer yield trials

All summer plantings were severely infested with sweet potato weevil, most likely the result of the hot, dry conditions of the 1980 summer. As a result, most of the materials in the advanced trials did not produce any marketable yield. High yields of 25 t/ha or more were obtained from seven selections in summer preliminary trials.

Low sugar crosses

A program to develop low sugar sweet potato cultivars was initiated in 1979 to make sweet potato more suitable as a staple crop. A chemical analysis of the AVRDC sweet potato collection showed sugar contents ranging from 8% to 40%. Sixteen crosses of low sugar lines were made, and seeds were collected together with seeds from open-pollinated low sugar parents and parents in polycross nurseries. A total of 122 potentially low sugar seedlings were grown and then analyzed for sugar contents (Table 4).

Table 4. Sugar contents (% dry weight) of low sugar sweet potato crosses[a], 1980, AVRDC

Source of materials	No. of seedlings	Sugar range	Sugar mean
		-------(%)-------	
Parents[b]	7	8.7-16.1	10.8
Crosses	48	6.4-16.2	11.0
Polycrosses	25	6.4-11.9	11.2
Open-pollination	83	5.7-13.4	10.3

[a]Data supplied by the Agricultural Chemistry Department, AVRDC
[b]Data are for the seven parents used in the crosses

Although mean sugar contents differed only slightly between materials from different sources, the range of sugar contents within each group was wide. This suggests that seedlings from controlled crosses, polycross nurseries of low sugar lines, or open-pollinated low sugar parents are all potential sources of low sugar lines.

ENTOMOLOGY

Sweet potato weevil resistance screening

Screenings of sweet potato accessions and breeding lines for resistance to sweet potato weevil (*Cylas formicarius*) continued in 1980. Two screening tests were conducted at AVRDC and another two on Penghu Island in the Taiwan Strait. At AVRDC, the field experiments were conducted according to a technique developed in 1974 (AVRDC Annual Report 1974) whereby test materials are planted between heavily infested source rows of a susceptible cultivar. At Penghu Island, weevils were released in the experimental area two months after planting. Evaluation of resistance was based on the number of insects found per unit weight of root, and damage was calculated as the percentage of damaged roots by weight (AVRDC Progress Report 1976).

The first screening evaluated 102 accessions planted on November 6-7, 1979 in 5m x 1m rows and harvested on May 19-20, 1980. Among those accessions yielding enough to give a reliable resistance rating (0.5 kg/row), 15 entries rated moderately resistant. When the experiment was repeated on Penghu Island (sown April 8-9, 1980 and harvested September 19, 1980), none of the accessions yielded enough roots to give a reliable resistance rating because of drought conditions.

A total of 252 breeding materials were evaluated in the second screening at AVRDC. Of the 164 entries yielding 0.5 kg/row, 17 rated moderately resistant. When the experiment was repeated at Penghu Island, however, all 17 rated susceptible. Accessions I 123 and I 152, which previously demonstrated consistent moderate resistance, rated susceptible in the 1980 screenings.

Table 5. Sweet potato accessions with promising resistance to stemborer at Penghu Island, 1980[a]

AVRDC accession no.	Damaged plants (%) without insecticide	Damaged plants (%) with insecticide
I 46	20.2 f[b]	20.7 cde
I 55	32.7 ef	2.9 e
I 92	24.0 f	4.5 e
AIS 35-2[c]	86.4 abc	61.2 a

[a]Planted April 25 and observed October 20
[b]Mean separation within columns by Duncan's multiple range test (5% level)
[c]Susceptible check

Sweet potato stemborer resistance screening

A total of 22 accessions, previously identified as moderately resistant to a lepidopterous stemborer (*Omphisa illisalis*) in Penghu screenings, were again screened on Penghu Island in 1980. The entries were planted on April 25 in 5m x 1m single row plots with six replications. Three replicates received applications of carbofuran 3G every two weeks at the rate of 2 kg a.i./ha, and the remaining three were not treated. The insecticide treatment commenced two weeks after planting and ceased two weeks before observation on October 20, 1980.

Accessions I 46, I 55 and I 92 were significantly less damaged than susceptible check AIS 35-2 in both treatments with and without insecticide (Table 5). Furthermore, stemborer infestation of I 46 remained the same irrespective of insecticide treatment, while insecticide applications considerably reduced insect damage in accessions I 55 and I 92. Insecticide treatments were also far more effective in reducing infestation in I 55 and I 92 than in susceptible AIS 35-2. Although I 46 appears to possess the highest degree of resistance to stemborer, the response of I 55 and I 92 to insecticides will lend a greater degree of control over this pest.

Chemical control

Insecticide screenings were conducted at AVRDC and Penghu Island to determine the application schedules and dosages of carbofuran for optimum control of sweet potato weevil and stemborer at minimum cost in terms of both quantity of insecticide and frequency of application. Selection AIS 35-2 was planted and two dosages and four application schedules were evaluated: 2 kg a.i./ha or 1 kg a.i./ha applied once every one, two, three or four weeks. Insecticide granules were broadcast along the vines starting two weeks after planting and continued until two weeks before harvest. A fixed number of weevils was released in each plot six to eight weeks after planting. At both AVRDC and Penghu Island, root yield was recorded and five kg of roots and five 50cm stems were collected from each plot. At Penghu Island, the number of plants damaged by stemborer was also recorded just prior to harvest. Root samples were sliced in 2.5mm slices and number of weevils (larvae, pupae and adults) and weight of each sample were recorded.

At AVRDC, weevil infestation was nonexistent when carbofuran was applied at 2 kg a.i./ha weekly, every two weeks or every three weeks, or 1 kg a.i./ha at weekly intervals. Although root yields for all treatments (including the check) were not significantly different, the quality of roots from the check plots was poor due to weevil infestation. From the standpoints of labor and insecticide quantity, carbofuran applications of 2 kg a.i./ha every three weeks were the most economical for effective weevil control at AVRDC. At Penghu Island, carbofuran applications at 2 kg a.i./ha weekly or every two weeks gave effective control of both weevil and stemborer and root yields almost twice that of the untreated check.

The relationship between insecticide dosage, frequency of application, insects/kg root and root yield/ha for both locations is shown in Figure 1. Although sweet potato weevil does not appear to significantly reduce root yields of AIS 35-2 (AVRDC Progress Report 1978), tolerable quality reductions due to weevil infestations should be taken into account when determining insecticide application schedules.

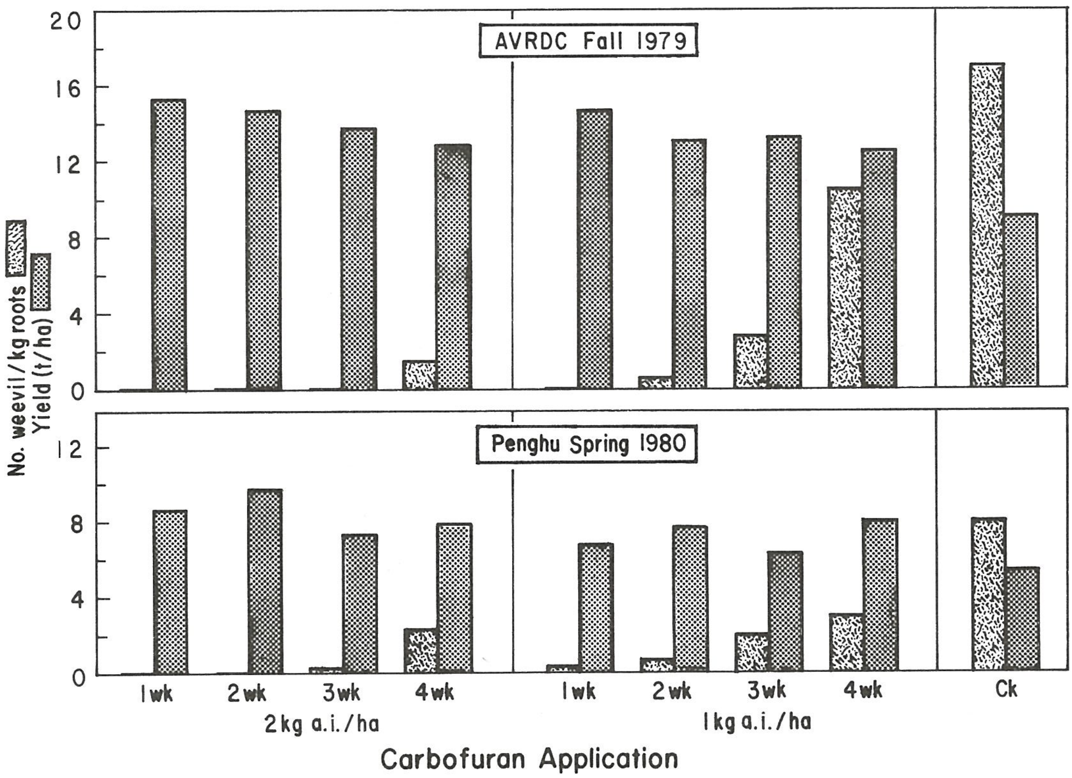


Fig. 1. Weevil control and yield response of sweet potato after various carbofuran treatments, 1980, AVRDC

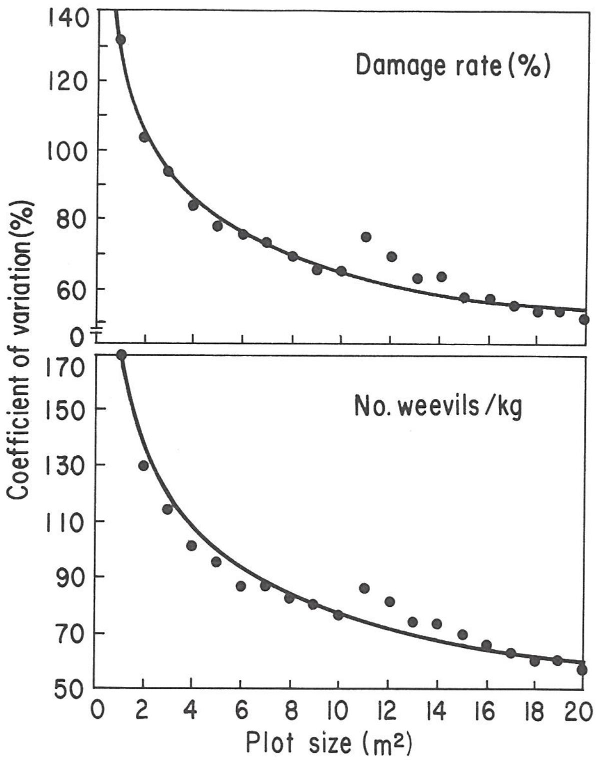


Fig. 2. Coefficients of variation for percent damage and number of sweet potato weevils/kg root as determined by various plot sizes, 1980, AVRDC

Analysis of carbofuran residues

Root samples from each plot of the preceding carbofuran experiment were chopped in a Hobart food chopper, and 100g samples were analyzed for carbofuran residues. Residues were measured using gas liquid chromatography. Higher insecticide applications resulted in higher recovery rates of carbofuran residues. Based on US Environmental Protection Agency tolerance limits (1 ppm carbofuran in root and tuber crops) which may serve as guidelines elsewhere, carbofuran applications of 2 kg a.i./ha every two or three weeks do not pose health hazards to consumers.

Uniformity trial for weevil experiments

A uniformity trial was conducted in a 20m x 20m plot uniformly infested with weevil to determine the optimum plot size for sweet potato weevil experiments. At harvest, the plot was divided into 20m x 1m rows with harvested roots collected from individual 1m squares. The roots were cut into 2.5mm slices and measured for weight and number of weevils (larvae, pupae and adults). The number of weevils/kg root and percent root damage was statistically analyzed to obtain the coefficients of variation for plot sizes ranging from $1m^2$ to $20m^2$ (Figure 2). A high coefficient of variation reflects considerable variation in weevil infestation. AVRDC uses $5m^2$ plots for preliminary mass screening for weevil resistance, and $10m^2$ plots for advanced screening and insecticide testing.

MUNGBEAN

PLANT BREEDING

Germplasm collection and hybridization

The acquisition of 30 mungbean accessions in 1980 brought the total germplasm collection to 5016. A total of 533 crosses were made concentrating on combining the characters already assembled in AVRDC breeding lines. Only 50 crosses were made between mungbean accessions.

Five AVRDC breeding lines showed high levels of resistance to both *Cercospora* leafspot (*Cercospora canescens*) and powdery mildew (*Erysiphe polygoni*), and an additional six breeding lines were identified with high levels of resistance to either *Cercospora* leafspot or powdery mildew.

Performance of elite lines over three seasons

Advanced mungbean breeding lines yielded an average of 1.87 t/ha across spring, summer and fall seasons (Table 1). The coefficient of variation (CV) of yield was smaller than 10% in both summer and fall trials. AVRDC breeding line VC 1647 Sel B yielded highest in both summer and fall, producing the highest average across all three sea-

Table 1. Performance of ten selected mungbean breeding lines from elite yield trials across three seasons[a], 1980, AVRDC

AVRDC accession or cross no.	Parentage or cultivar name	Yield (t/ha) Sp	Su	Fa	mean	First harvest[b] Sp	Su	Fa	Disease[c] PM	CLS	Photo-period[d]	Lodging[e]	Seed appearance[f]
VC 1647 Sel B	CES 44/ML-3//PHLV 18	1.98	2.65	2.44	2.36	70	66	95	MR	S	N	M	6
V 3476 (check)	Pagasa	2.44	1.99	2.07	2.17	69	77	98	V	MS	M	R	7
VC 1482 Sel C	EG-MG-6D/ML-3	1.85	2.30	2.22	2.12	55	66	74	HR	MR	M	R	5
VC 1973 Sel A	Pagasa/EG-MG-16	2.31	1.89	2.07	2.09	81	76	97	VS	S	N	S	6
VC 1628 Sel A	Pagasa/PHLV 18	1.92	2.06	2.15	2.04	78	85	99	VS	S	M	R	7
VC 1177 Sel B	MG 50-10A(Y)/ML-5	2.06	1.99	2.02	2.02	76	83	95	MS	MR	S	R	5
VC 1974 Sel A	Pagasa/BPI glab 3	1.94	2.01	2.07	2.01	79	81	94	VS	S	N	R	8
VC 1168 Sel B	CES 59/ML-5	2.12	1.89	2.00	2.00	71	69	96	MR	MS	M	R	5
VC 1560 Sel D	BPI glab 3//CES 44/ML-3	1.69	1.93	1.95	1.86	54	68	21	HR	R	M	S	5
V 2984 (check)	KJ 5	1.76	1.66	1.73	1.72	75	81	96	S	VS	N	S	4
	Grand mean	1.89	1.85	1.84		69	74	86					6
	LSD (0.05)	0.40	0.16	0.17		10	6	6					1
	CV (%)	15	6	7		10	6	5					9

[a]Sown March 14, July 11 and September 10 for spring, summer and fall respectively. A total of 22 (spring) and 30 (summer and fall) entries were planted in 6-row plots, 6m x 0.4m, arranged in randomized complete block design with four replications
[b]Expressed as a percentage of total yield
[c]Powdery mildew (PM) was rated in both spring and fall and *Cercospora* leaf spot (CLS) in summer in highly epiphytotic disease nurseries. HR=highly resistant, R=resistant, MR=moderately resistant, MS=moderately susceptible S=susceptible and VS=very susceptible
[d]16-hour daylength, sown March 1, 1980. N=insensitive, M=intermediate and S=sensitive
[e]Lodging evaluated twice in summer and fall. R=resistant, M=intermediate and S=susceptible
[f]Seed appearance rated on a scale of 1 to 10 (1=worst and 10=best)

sons. These lines were further evaluated for disease resistance under highly epiphytotic conditions, photoperiod sensitivity, uniform maturity (the first harvest expressed as a percentage of total yield), lodging and seed appearance for consumer acceptibility. All of the lines except VC 1628 Sel A are currently included in the Ninth International Mungbean Nursery.

Selection criteria for mungbean characters

Table 2 shows correlation coefficients between yield and four other mungbean characters for each of four yield trials over three seasons. In summer, all four yield trials showed that yield was highly negatively correlated with the first harvest expressed as percentage of total yield, but positively correlated with mean maturity. These relationships however were reversed in the fall season. These correlations suggest that those varieties producing high yields during the summer are likely to be later maturing and less uniform in maturity, while in the fall, high yielding lines are earlier and more uniform than lines with lower yields. The relationship between yield and plant height suggests that taller varieties should be developed for the spring season but shorter varieties for the other two seasons.

In other calculations, plant height and lodging were positively correlated in all cases, suggesting the need to develop shorter varieties

Table 2. Correlation coefficients between yield and four agronomic characters from 12 mungbean yield trials[a], 1980, AVRDC

Season	Trial	df[b]	Correlation coefficient (r) of yield with 1st harvest (% of total yield)	Mean maturity	Plant height	Pods/ plant
Spring	Elite	20	.14	-.05	.40	.26
Spring	Advanced Yield Trial	38	.03	.30	.14	.45**
Spring	Intermediate Yield Trial	28	-.01	.07	.67**	-.03
Spring	Preliminary Yield Trial	122	.13	-.13	.33**	NA
Summer	Elite Yield Trial	28	-.28**	.30**	-.34**	.42**
Summer	Advanced Yield Trial	38	-.51**	.57**	-.12	.29**
Summer	Intermediate Yield Trial	38	-.39**	.46**	-.44**	.49**
Summer	Preliminary Yield Trial	68	-.26**	.33**	-.23**	.39**
Fall	Elite Yield Trial	28	.26**	-.26**	-.18	.39**
Fall	Advanced Yield Trial	28	.24**	-.24**	-.11	.08
Fall	Intermediate Yield Trial	28	.49**	-.49**	-.12	-.04
Fall	Preliminary Yield Trial	149	.43**	-.43**	-.31**	.29**

[a]Sown early March, mid-July and late September for spring, summer and fall seasons respectively
[b]Degrees of freedon
**Significant at 1% level

for greater lodging resistance. The first harvest as a percentage of total yield was without exception negatively correlated with mean maturity, indicating that late maturing lines produce a smaller portion of their yield at the first harvest.

Inheritance of powdery mildew resistance

Six mungbean genotypes with different levels of susceptibility to powdery mildew and their F_1 progeny were planted in the fall season under naturally high epiphytotic conditions. Disease incidence was rated on individual plants on a scale from 1 to 6 (1=highly resistant, 6=very susceptible). Mean disease ratings for the six parents and their 30 F_1 progeny showed large variability in susceptibility, ranging from very resistant (VC 1560 Sel A) to very susceptible (V 1945) (Table 3). Ratings of hybrids between resistant and susceptible parents were intermediate or slightly higher than the mid-parent averages, suggesting that resistance is partially recessive under 12-hour day conditions. In contrast, resistance of V 4718 was controlled by a dominant gene under 16-hour days (1979 Annual Report). AVRDC breeding line VC 1560 Sel A (BPI Glabrous 3//CES 44/ML-3) shows even greater powdery mildew resistance than that of its resistant source parent (ML-3 (V 2773)), indirectly indicating that the genetic system for disease resistance could be polygenic. It thus might be possible to develop mungbean lines with even stronger powdery mildew resistance by accumulating resistant genes with small effect.

Table 3. Mean ratings for powdery mildew resistance of six mungbean genotypes and their possible F_1 progeny[a], 1980, AVRDC

Male parent	Female parent: VC 1560 Sel A	V 2773	VC 1089 Sel A	V 2184	V 1400	V 1945	F_1 array mean
VC 1560 Sel A	1.9[b]	2.8	3.2	3.3	4.0	3.8	3.4
V 2773	3.2	2.9	3.8	3.9	4.5	3.9	3.9
VC 1089 Sel A	3.5	4.1	3.8	4.5	4.5	4.1	4.1
V 2184	4.2	4.7	4.6	4.9	5.1	5.2	4.8
V 1400	4.1	4.1	4.6	5.5	5.1	5.2	4.7
V 1945	4.8	5.0	4.8	5.0	5.2	5.3	5.0
F_1 array mean	4.0	4.1	4.2	4.4	4.7	4.4	4.3

[a]Sown September 26 in randomized complete block design with three replications. V 1400 was planted in every third row as a disease spreader
[b]Each value is a mean of 180 observations

Continuous mungbean cropping and mungbean performance

Continuous mungbean croppings were suspected as the cause of increasingly severe instances of poor and non-uniform growth of subsequent mungbean crops in AVRDC trials over the past four years. Typical symptoms were poor growth, defoliation, and chlorosis and necrosis of the leaves, all of which varied with season, the field and the field's cropping history. Six plots with different mungbean cropping patterns for the past two years were therefore prepared for mungbean growth evaluation (Table 4). An analysis of the variance in performance between the different treatments showed that the effect of previous mungbean croppings was highly significant for all characters studied (yield, plant height, number of pods, number of seeds and 1000-seed weight), and that varietal differences were also significant for all characters except number of pods. Mungbean grown after five consecutive mungbean croppings was smaller in plant height, and produced less pods per plant and less seeds of lighter weight per pod. The results suggest that a mungbean crop should not be followed by another mungbean crop for at least three cropping seasons.

Table 4. Effect of previous mungbean croppings on five agronomic characters of succeeding mungbean crops[a], 1980, AVRDC

Previous mungbean cropping[b]	1979 Sp	1979 Su	1979 Fa	1980 Sp	1980 Su	Yield (kg/ha)	Plant height (cm) at 60 DAP	No. of pods/ plant	No. of seeds/ pod	1000 seed weight (g)
A —	M	M	M	M	M	25 c[c]	20 d	2.3 d	6.6 c	52 c
B —	M	M	M	M	X	102 b	22 cd	3.4 c	8.5 b	58 a
C —	M	M	X	M	M	115 b	23 c	4.1 bc	8.6 b	55 b
D —	M	M	X	M	X	136 b	30 b	4.8 b	9.1 b	57 ab
E —	M	M	X	X	M	103 b	25 c	4.2 bc	8.7 b	57 ab
F —	M	M	X	X	X	440 a	44 a	9.8 a	10.2 a	58 a
Mean						154	28	4.8	8.6	57
CV (%)						28	10	22	12	3

[a]Fall 1980 crop sown on September 25, 1980. Each value is mean of three varieties with three replications for each treatment
[b]M=mungbean, X=fallow
[c]Means followed by different letters are significantly different according to new Duncan's multiple range test (5% level)

Effect of different crops on succeeding mungbean crops

Nine crops (mungbean, soybean, tomato, Chinese cabbage, sweet potato, corn, crotalaria, sorghum and buckwheat) were grown as a preceding crop to mungbean. Mungbean was the most detrimental to a succeeding mungbean crop. Yields after mungbean were only 65 kg/ha compared with the yield of 346 kg/ha after tomato. The poor yield after mungbean was mainly due to retarded growth and plant death. Mungbean yield components were not significantly affected by previous crops.

International Mungbean Nursery (IMN)

AVRDC distributed 38 sets (13 cultivars and seven AVRDC advanced breeding lines) of mungbean materials for evaluation in the Eighth International Mungbean Nursery, and received data from 22 of the trials. Entries from the IMN outyielded the best local cultivars at all locations except on the Indian subcontinent, where mungbean yellow mosaic virus (MYMV) in certain seasons devastated all genotypes from areas where the disease is not endemic (Table 5).

The five average highest yielding entries over all locations were ML-5 (V 2272, India), VC 1000 Sel A (AVRDC), VC 1168 Sel B (AVRDC), 6601 (V 3484, Pakistan) and VC 1627 Sel A (AVRDC). These all carry some level of disease resistance, indicating the importance of disease resistance in the development of stable and widely adaptable varieties. The highest yield recorded was 2.77 t/ha from Uthong 1 (V 3404, Thailand) in Guadalupe, Peru.

Table 5. Average mungbean agronomic performance over 22 locations participating in the eighth International Mungbean Nursery[a], 1979-80

Country	Location	Latitude	DOP[b]	Temp. min-max (°C)	Yield ave. (t/ha)	Yield range (t/ha)	Rank	Days to flower	2 highest yielding lines
Peru	Guadalupe	7°S	4/9	15 - 26	1.46	0.62-2.77	3	48	V 3404, V 3388
Indonesia	Sukamandi	6°S	9/1	23 - 32	1.53	1.15-1.84	2	32	V 2984, V 3404
Somalia	Afgoi	2°N	4/26	23 - 32	1.03	0.34-1.91	7	32	VC 1209A, VC 1168B
Malaysia	Serdang	3°N	4/24	23 - 33	0.76	0.36-1.05	10	34	VC 1177B, VC 1627A
Philippines	Iloilo	11°N	5/17	24 - 32	1.26	0.59-1.67	6	40	V 3476, VC 1627A
Philippines	Iloilo	11°N	11/1	23 - 32	1.75	1.36-2.39	1	36	V 2272, VC 1628A
Philippines	Los Baños (POP)	14°N	6/18		1.34	0.79-1.89	5	35	VC 1089A, VC 1177A
Philippines	Los Baños (UPLB)	14°N	2/5	22 - 33	0.64	0.50-0.87	11	31	V 2010, V 1944
Thailand	Chiang Mai	19°N			0.91	0.58-1.28	8	32	V 3476, V 2984
India	Nagaya	20°N	7/22	21 - 30	0.41	0.23-0.79	16	33	V 1381, Local
India	New Delhi	28°N	8/10	20 - 35	0.61	0.13-1.92	14	49	V 3484, Local
India	Pantnagar	29°N	7/24	20 - 34	0.09	0.00-0.45	21	47	V 2272, V 3484
Taiwan	Shanhua	23°N	2/23		1.45	1.13-1.80	4	50	VC 1168B, VC 1628A
Taiwan	Shanhua	23°N	9/10		0.59	0.18-0.91	15	38	VC 1168B, VC 1000A
Bangladesh	Mymensingh	25°N	2/28	22 - 34	0.18	0.02-1.09	19	47	V 3484, V 2272
Bangladesh	Mymensingh	25°N	9/27	21 - 31	0.75	0.28-1.24	9	41	VC 1000A, VC 1089A
Nepal	Parawanipur	27°N	4/16		0.18	0.03-0.34	20	48	Local, V 1968
Nepal	Khumaltar	28°N	3/20	11 - 28	0.40	0.18-0.56	17	69	V 3404, VC 1168 B
Pakistan	Faisalabad	31°N	3/13	18 - 33	0.61	0.24-0.90	13	52	V 3404, V 2808
USA	Perkin, OK	36°N			0.62	0.26-1.21	12	42	V 1968, Local
Korea	Suweon	37°N	7/31	16 - 26				48	
Canada	Chatham	42°N	5/25	14 - 23	0.28	0.00-0.64	18	74	VC 1000A, V 1944
Grand Mean					0.80			43	

[a]Data are means of 20 IMN entries plus one or two local cultivars in 4 rows, 6m long and 40-60 cm apart, with three replications

[b]Date of planting

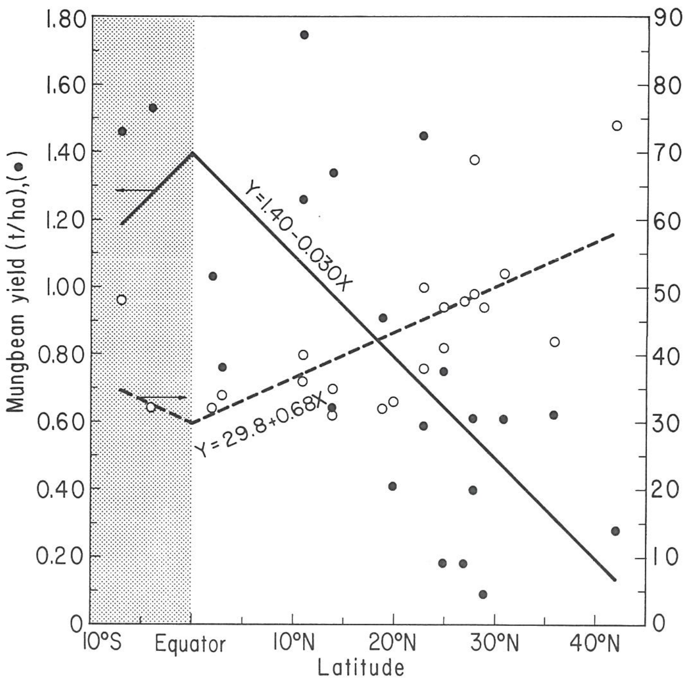


Fig. 1.
Mungbean yield and days-to-flower as determined by latitude in the 8th International Mungbean Nursery, 1980

Figure 1 shows average yield and days to flowering of the 20 mungbean entries plotted against the latitudes of the 22 locations. The regression equations indicate that average days to flowering increased by 6.8 days and average yield decreased by 300 kg/ha for every 10° latitude north of the equator. The same trend was noted in the 1979 Seventh IMN, strongly suggesting that mungbean has greater adaptability to tropical climates.

PLANT PATHOLOGY

Resistance to *Cercospora* leafspot

Only moderate levels of resistance to *Cercospora* leafspot (CLS) have been identified from the 4000 accessions screened over past years. An experiment was thus conducted to evaluate the development of a CLS epidemic and study the nature of CLS resistance. Four accessions and three breeding lines which previously rated resistant were planted in summer with one susceptible check cultivar. The rates of disease increase differed among the resistant cultivars, indicating a rate reducing type of resistance similar to what would be found with general resistance (Table 6).

Breeding line VC 1160-2B-14-2-2B-2-2B (a cross between resistant V 2773 and susceptible CES 55) produced not only a final disease severity rating less than that of its resistant parent but also a lower rate of disease increase. This indicates a multigenic response with respect to resistance, another characteristic of general resistance. Further experiments need to be conducted in different seasons and locations to provide sufficient evidence to fully establish the type of resistance. If the observed CLS resistance is general resistance, this could account for the difficulty in finding high levels of resistance.

No significant yield loss was associated with the fungicide-free plots of any cultivar, primarily because CLS developed late in the season. For the susceptible check, CLS development did not exceed 25% affected foliage until after the first harvest at 59 DAP. CLS development in the resistant cultivars did not exceed 25% affected foliage before the end of the experiment at 79 DAP.

Unidentified mungbean disorder

AVRDC mungbean plantings in 1979 and 1980 were severely damaged by an unidentified disorder with symptoms of severe root deterioration, discoloration of the stem vascular tissue, stunting, and chlorosis and necrosis of the leaves. The condition eventually led to the death of the plants. *Pythium* sp, *Rhizoctonia solani*, *Fusarium* sp and a high population of reniform nematodes were found to be associated with the diseased plants. Therefore, an experiment involving chloropicrin fumigation and mycorrhizae and rhizobium inoculations was conducted in AVRDC's root disease nursery in fall 1980.

Non-fumigated plots had a significantly higher disorder incidence than fumigated plots. In the non-fumigated plots, all of the plants were

Table 6. Rate of disease increase of *Cercospora* leafspot in mungbean, 1980, AVRDC

Cultivar	Rate of disease increase[a]	Correlation coefficient[b]
V 2010[c]	0.3074	0.9866
V 2272	0.2388	0.9708
V 2773	0.2113	0.9612
VC 1089 Sel D	0.2187	0.9252
V 4717	0.2065	0.9563
VC 1160-2B-14-2-2B-2-2B	0.1995	0.9412
VC 1560 Sel D	0.1173	0.7174
V 4718	0.0598	0.9386

[a] Regression coefficient
[b] Correlation between logit of percent infection and time
[c] Susceptible check

dead before the end of the experiment while more than 90% of the plants in the fumigated plots were healthy and productive. All of the fungi previously associated with the disease (*Pythium* sp, *Rhizoctonia* sp and *Fusarium* sp) were isolated from plants in the non-fumigated plots, but were not present in plants in the fumigated plots. Reniform nematodes were also extracted from the non-fumigated plots only. The high number of adult female nematodes in the roots indicate that nematodes may play a role in the unidentified disorder. The disorder appears to be a root disease complex caused by soil-borne pathogens rather than allelopathic effects from the previous crop. However, the previous crop undoubtedly plays a role in modifying the soil-borne pathogen population.

Screening for resistance to root-knot nematodes

Twenty-nine accessions rated highly resistant to root-knot nematode (0 to 2 galls per root system) and another 26 rated moderately resistant (3 to 10 galls per root system) after two field screenings. In preliminary screenings, 12 accessions rated highly resistant and another five accessions and ten breeding lines rated moderately resistant.

ENTOMOLOGY

Intercropping for beanfly control

Intercropping experiments in 1979 showed that mungbean planted with pearl millet, tomato, okra, ricebean, jute and cowpea significantly reduced beanfly infestation of mungbean. These crops were again intercropped with mungbean in 1980 to investigate further their influence on beanfly infestation and mungbean yields. The intercropping pattern consisted of three treatments: the intercrop planted two weeks ahead of mungbean in alternating rows 15 cm apart, the intercrop and mungbean planted simultaneously in alternating rows 15 cm apart, and mungbean seed mixed with the intercrop seed (50:50) and planted in rows 30 cm apart. Five weeks after mungbean germination, the number of beanfly larvae and beanfly damage in a 20 plant sample were recorded. The intercrop plants were uprooted immediately after the beanfly damage observation since beanfly infestation reduces mungbean yields only if it occurs within four weeks after germination. Mungbean yield was recorded at harvest.

In both the staggered planting date treatment and the seed mix treatment, there were no significant differences in beanfly infestation. In the treatment where mungbean and the intercrop were planted simultaneously in alternate rows, mungbean intercropped with jute had the lowest beanfly infestation and highest yield (Table 7).

Table 7. Intercropping mungbean with various crops for beanfly control[a], 1980, AVRDC

Intercrop	No. beanfly larvae and pupae/20 plants	Damaged plants	Yield (t/ha)
Pearl millet	6.0	53.3	0.19 b[b]
Tomato	9.0	51.7	0.56 a
Okra	9.7	55.0	0.30 b
Ricebean	9.0	61.7	0.29 b
Jute	5.0	41.7	0.77 a
Cowpea	8.7	55.0	0.55 a
Monocrop (check)	11.0	56.7	0.70 a

[a]Mungbean cultivar PHLV-18 sown on September 9, 1980 in 3m x 3.3m plots in randomized complete block design with three replications
[b]Values followed by the same letter are not significantly different by Duncan's multiple range test (5% level)

Mungbean depodding study

To assess the mungbean yield loss which results from the pod boring or pod feeding activities of mungbean insect pests, a depodding experiment was conducted in spring 1980. Plants were grown in 5m x 1m plots arranged in a randomized complete block design with three replications. The crop was raised using standard cultural practices (AVRDC Guide 78-63) including the use of insecticides to reduce insect damage interfering with the intentional depodding treatments. Depodding was initiated at the podfilling stage.

A single 10% depodding at any stage did not significantly reduce mungbean yield. Higher levels of depodding, except a 20% depodding at 30 days after initiation of podfilling, and multiple stage depodding at all levels, reduced yields significantly.

Characterization of bruchid resistance in mungbean

Blackgram accession VM 2011 rated highly resistant in 1978 to a bruchid (*Callosobruchus chinensis*) that attacks mungbean and several other beans in storage. In 1979, another blackgram accession, VM 2164, rated highly resistant. The modes of resistance of these materials appear to be distinctly different and were therefore studied in 1980. VM 2011, VM 2164 and susceptible mungbean accession V 2184 were each planted in ten clay pots in the greenhouse. Large numbers of bruchid adults were released on the plants twice a week beginning at flowering and continuing until harvest. Pods were collected, observed for oviposition and then stored in plastic containers for ten weeks. Adult insect emergence was then recorded. Insects laid significantly fewer eggs on the pods of VM 2011 than on those of VM 2164 or V 2184. Adult emergence was also considerably lower from VM 2011 than from V 2184.

The patterns of adult emergence and oviposition were almost identical on VM 2164 and V 2184. When bruchid adults were confined on the seeds of these three accessions, fewer eggs were laid on seeds of VM 2164 and significantly fewer adults emerged from these seeds for up to six months of incubation (Figure 2).

While the pods of VM 2164 and V 2184 are relatively smooth, those of VM 2011 have dense hairs, making it difficult for the adult bruchids to move over the pods. This probably accounts for the reduced number of eggs and adult emergence from the pods of VM 2011. The mechanism of resistance in the seeds of VM 2164 is still unidentified but it is likely that seedcoat hardness or antibiosis in the seed is responsible.

PLANT PHYSIOLOGY

Effects of Chinese cabbage and mungbean crops on succeeding mungbean crops

The harmful effects of Chinese cabbage and mungbean cropping on the performance of subsequent mungbean crops were studied in a greenhouse ex-

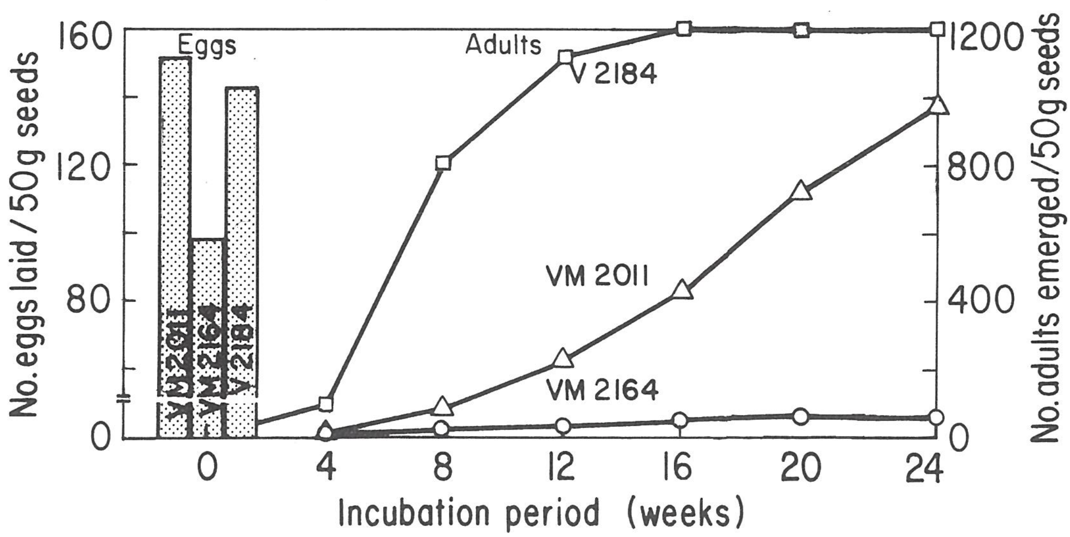


Fig. 2. Bruchid oviposition and adult emergence from seeds of one mungbean and two blackgram accessions, 1980, AVRDC

periment in 1980. A 1000 m^2 field on the experimental farm was divided into three parts to be cropped with either mungbean or Chinese cabbage, or left fallow. After both crops were harvested, soil at a depth of 5 cm was collected from each of the three plots. Half of each soil lot was steam-sterilized, and the resulting six soil treatments were then placed in 25cm ID clay pots. Ten grams of *G. mosseae* mycorrhizae were incorporated into each pot at sowing, and two seedlings per pot were maintained after emergence.

Both mungbean seed yield and plant growth were significantly reduced in those soils previously cropped with Chinese cabbage and mungbean. VA mycorrhizal inoculations with *G. mosseae* enhanced plant growth and yield of mungbean in sterilized soil, but could not overcome the detrimental effects of non-sterilized mungbean or Chinese cabbage cropping soil.

No tillage, rice-stubble soybean cultivation enables farmers in southern Taiwan to harvest two rice crops and one soybean crop from the same piece of land in one year

SOYBEAN

PLANT BREEDING

Germplasm collection and hybridization

The addition of 126 soybean accessions from Indonesia, Japan, Thailand and the United States brought the total soybean germplasm collection to 9273 accessions in 1980. The accessions from Thailand are potential sources of tolerance to low pH and high soil aluminum content.

One hundred sixty-seven crosses were made to combine early maturity, high yield, photoperiod insensitivity, resistance to soybean rust and high protein content. An additional 12 crosses were made at the request of cooperators from Malaysia and Pakistan.

Advanced trials for high yield and early maturity

Drought conditions during the 1980 February-June season harvest were highly favorable for high yields and excellent seed quality from

Table 2. AVRDC soybean selections with high yield potential and adaptability to three seasons, 1980, AVRDC

AVRDC selection no.	Yield (t/ha) sowing date February	July	September
AGS 19	2.6	2.8	2.2
AGS 66	3.4	3.1[b]	-
AGS 129	4.0	3.4	2.6
AGS 130	3.8	3.0	2.5
AGS 131	3.8	2.9	-
AGS 133	3.5[a]	3.3[a]	-
AGS 135	3.8	3.0	2.5[a]
AGS 144	4.3[b]	3.0	2.2

[a]Early maturing
[b]Late maturing
All other cultivars demonstrated intermediate maturity

Table 1. Performance of AVRDC soybean selections in advanced yield trials, 1980, AVRDC

Season	AVRDC selection or (accession) no.	Cross no.	Yield (t/ha)	Yield/day (kg/ha)	Days to maturity
Spring[a]	AGS 144	Selection from T 17	4.3	41	103
	AGS 59	GC 30187-10-9	4.2	41	103
	AGS 129	GC 30229-8-7	4.0	40	101
	(G 38)	Shih Shih	3.2	33	97
	(G 2261)	Tainung 15	2.9	30	96
	(G 2043)	Kaohsiung No. 3	3.0	29	101
Summer[b]	AGS 129	GC 30229-8-7	3.4 a	37	93
	AGS 133	GC 30243-10-8	3.3 ab	37	89
	AGS 140	GC 40359-1-91	3.2 ab	35	92
	(G 38)	Shih Shih	2.7 d	33	85
	(G 2261)	Tainung 15	2.7 d	31	84
	(G 2043)	Kaohsiung No. 3	2.8 d	30	92
Fall[c]	AGS 129	GC 30229-8-7	2.6 a	29	91
	AGS 130	GC 30104-2-56	2.5 ab	27	91
	AGS 93	GC 30187-10-15-2	2.5 ab	27	93
	(G 38)	Shih Shih	2.2 b	27	82
	(G 2261)	Tainung 15	2.0 b	23	86
	(G 2043)	Kaohsiung No. 3	1.9 b	21	93

[a]Sown February 8, 1980 [b]Sown July 15, 1980 [c]Sown September 4, 1980
Values followed by the same letter are not significantly different according to Duncan's multiple range test (5% level)

spring advanced yield trials. AVRDC selections yielded up to 4.3 t/ha with maturities comparable to those of the early maturing check cultivars. Selections AGS 62 and AGS 66, the highest yielders in 1979 spring trials, yielded 2.9 t/ha and 3.5 t/ha respectively in the 1980 spring trials. AVRDC selection AGS 129 was the top yielder in both summer and fall advanced yield trials, producing yields of 3.4 t/ha and 2.6 t/ha respectively (Table 1).

High yielding selections with wide adaptability

From the advanced yield trials, five AVRDC soybean selections were identified with high yield potential across all three seasons at AVRDC. Three others showed adaptability to both spring and summer plantings (Table 2). Cultivars which have been released or are in advanced stages of testing were obtained from breeders in Australia, Thailand, Indonesia, the Philippines and Zimbabwe and evaluated across all three seasons. Two cultivars, Santa Rosa from Argentina and Kudu from Zimbabwe, demonstrated adaptability to all three seasons.

Photoperiodic response of advanced yield trial selections

All advanced yield trial selections were evaluated in pot culture for response to 10 hr, 12 hr, 14 hr and 16 hr photoperiods. Each selection was rated for photoperiod sensitivity based on the difference in the number of days to flowering between different photoperiods. Selection AGS 62 and accession G 215 rated photoperiod insensitive regardless of the photoperiods compared.

Vegetable soybeans with wide adaptability

Four accessions and three cultivars were evaluated for yield and acceptability as vegetable soybean genotypes in February, July and September sowings. Accession G 8285 yielded the highest average of 8.2 t/ha over all three plantings and had acceptable seed size but matured later. Seeds of G 8285 will be multiplied along with accessions G 9948 (Zen Wu #2) and G 9053 (Tzuzunoku) for evaluation in different countries. In July-October season intermediate yield trials of vegetable soybeans, AVRDC selections yielded up to 14 t/ha against 5 t/ha and 11 t/ha from the local checks (Table 3).

Genotypic response to management and no management

In the tropics grain legumes are generally grown on marginal lands or following cereal crops in the off-season with minimum or no input. In order to assess the differences in yield attributable to season or management, as well as to identify potential genetic sources of high yield under no management situations in specific seasons, advanced yield trials were conducted with and without management in all three seasons. Management increased yields by 170%, 115% and 36% respectively in fall, spring and summer crops (Figure 1). Even with management, however, seasonal factors have tremendous influence on yields. The well managed fall crop yielded 36% and 78% less than the well managed summer and spring crops respectively. In the no management trial, however, spring and summer yields were almost

Table 3. Performance of AVRDC large seeded vegetable soybean selections in intermediate yield trials, summer 1980[a], AVRDC

Cross no.	Days to harvest	100 seed weight (g)	Yield (t/ha)[b]	Yield/day (kg/ha)
GC 50062-5-10-7	83	40	14.2 a	172
GC 50232-2-17-7 E	83	41	13.3 ab	160
GC 50126-1-4-7	83	51	13.2 ab	159
GC 50137-6-1-7	84	43	12.1 ab	144
Tzuzunoku	75	58	4.6 c	61
Shih Shih	71	36	11.3 ab	159

[a]Twelve entries sown on July 12, 1980
[b]at 90% moisture content. Values followed by the same letter are not significantly different by Duncan's multiple range test (5% level)

the same while the fall crop yielded about 70% less. The selections used in this experiment responded better to management in the fall and spring crops than in the summer planting. In the summer planting, some of the highest yielding selections performed equally well in both management and no management trials (Table 4). All, however, responded well to management in spring and fall plantings.

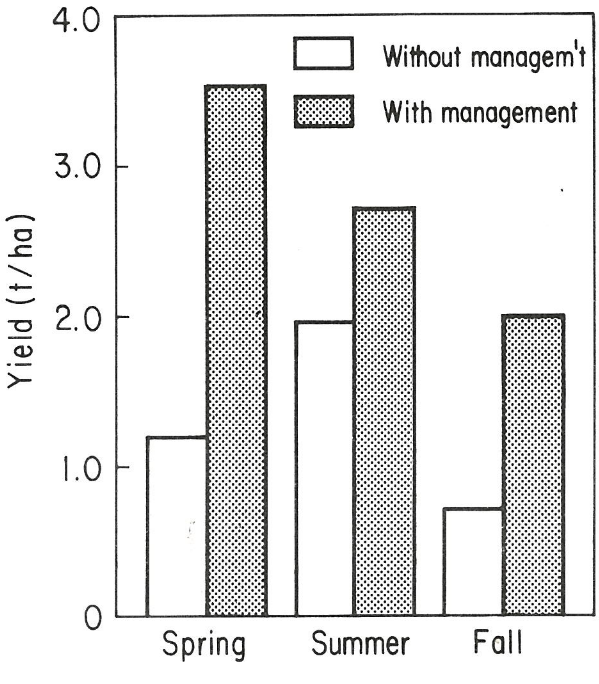


Fig. 1. Soybean yield response with and without management, 1980, AVRDC

Table 4. Performance of AVRDC soybean selections under management and no management in summer plantings[a], 1980, AVRDC

AVRDC selection no.	Cross no.	Yield (t/ha)		Days to maturity	
		management	no management[b]	management	no management
AGS 66	GC 30257-2-0-1	3.1 a	3.0 a	89	89
AGS 62	GC 40359-1-55	2.9 bc	2.6 b	89	90
AGS 85	GC 30295-6-6-1	3.0 b	2.4 bc	88	84
AGS 71	GC 30299-29-6-3	2.6 c	2.1 c	96	94

[a]Sown July 15, 1980
[b]No fertilization, herbicide or fungicide applications
Mean separation within columns by Duncan's multiple range test (5% level)

Plant population densities and soybean yields

A plant population density experiment was conducted to determine suitable plant densities and planting arrangements for AVRDC soybean selections AGS 62 and AGS 66 in summer and fall plantings. Inter-row spacings of 25 cm and 50 cm were studied, and intra-row spacings were adjusted to accomodate plant populations of 2,000,000 plant/ha, 1,000,000 plant/ha, 400,000 plant/ha and 200,000 plant/ha. With a given plant population, therefore, planting arrangement varied in inter- and intra-row spacings.

Yield of AGS 62 was significantly affected by planting arrangement in the summer crop. With inter-row spacings of 50 cm, yield continued to increase up to a plant density of 2,000,000 plant/ha. At a given plant density of 1,000,000 plant/ha, however, yield was significantly greater with 25 cm inter-row spacings (4 cm intra-row) than with 50 cm inter-row spacings (2 cm intra-row). In the fall planting at a 1,000,000 plant/ha density, the results were reversed with the 50 cm inter-row spacing producing larger yields for both selections than the 25 cm inter-row spacing. The results also suggest that for selection AGS 66, a planting arrangement of 25 cm between rows and a plant density of 400,000 plant/ha will yield similarly to an arrangement of 50 cm between rows and 1,000,000 plant/ha regardless of the season (Figure 2).

Day-neutral soybean flowering

In 1979 it was reported that the ability of day-neutral accession G 215 to flower without trifoliolate leaves might be unique to day-neutral soybeans, and therefore useful as an indicator of photoperiodic response without requiring time-consuming screening under different photoperiod regimes. In 1980, 103 day-neutral soybean materials were evaluated under natural photoperiod for their potential to flower when stripped of trifoliolate leaves. All except photoperiod sensitive accession G 2120 flowered with only cotyledonary and unifoliate leaves. Varietal differences were observed, however in total flower and pod production with

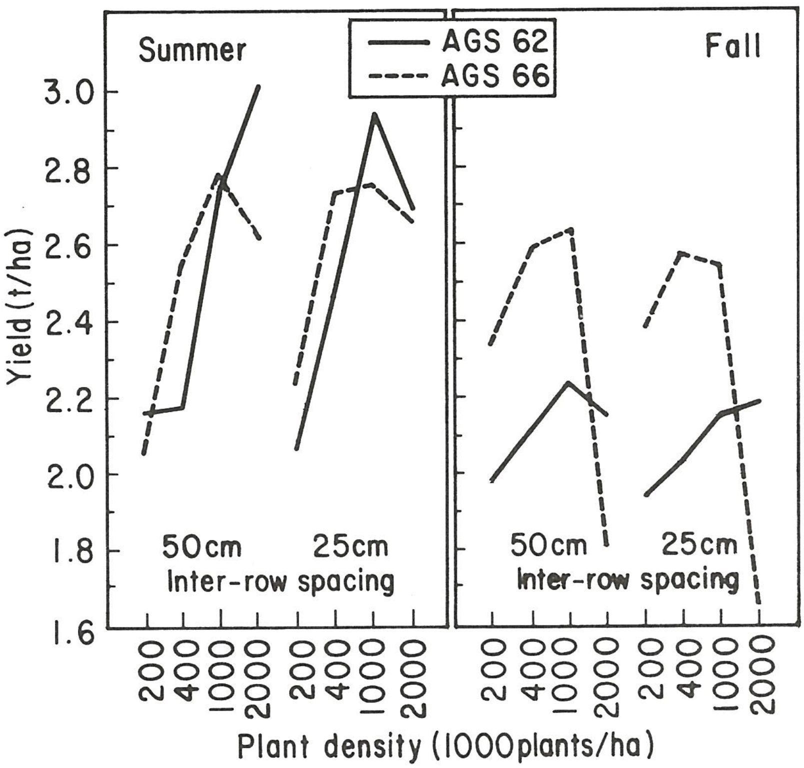


Fig. 2. Influence of planting arrangement and plant density on the yields of two cultivars in summer and fall, 1980, AVRDC

and without trifoliolate leaves. Varieties varied in the number of trifoliolate leaves needed to complete the flowering, pod forming and seed forming processes. Photoperiod sensitive G 2120 differed distinctly from the day-neutral soybeans.

PLANT PATHOLOGY

Resistance to soybean rust (*Phakopsora pachyrhizi*)

A total of 1988 F_2 plants (13 crosses), 559 F_3 (10 crosses), 1516 F_4 (11 crosses), and 11 F_6 and F_7 lines (2 crosses) were field-screened for soybean rust resistance in the spring. Lines showing promising resistance were advanced to the next generation and rescreened in fall plantings together with an additional 52 F_2 lines from 24 crosses. From the rescreening, 205 F_3 lines, 8 F_4 lines, 25 F_5 lines, and 6 F_7 and F_8 lines were selected for further testing in 1981.

Resistance to root-knot nematode (*Meloidogyne incognita*)

Five accessions rated highly resistant to root-knot nematode (0 to 2 galls per root system) after four field tests, and ten breeding lines rated highly resistant after three field tests. An additional 16 accessions and 66 breeding lines rated highly resistant after two field tests and another two accessions and ten breeding lines were rated highly resistant after a preliminary field test.

Teliospore formation by *Phakopsora pachyrhizi*

A method utilizing controlled environment conditions was devised to induce teliospore production on plants susceptible to soybean rust. Host plants were inoculated with a uredospore suspension and placed in a plastic moist chamber located in a growth room programmed for 12-hour photoperiods (2060 Lux) and 24$\pm$1^{o}C maximum day temperature and 15$\pm$1^{o}C minimum night temperature. The plants were removed from the moist chamber after two weeks and kept in the growth room. Telia were observed 30 to 60 days after inoculation depending on the host species. This method is useful for identifying and determining the host range of *P. pachyrhizi*. Telia and teliospore production was reported for the first time on *Cajanus cajan, Glycine canescens, G. wightii, Phaseolus lunatus, P. vulgaris* and *Vigna unguiculata*. Telia and teliospores were also induced on *Pachyrhizus erosus* and *Glycine max*.

Environment and soybean rust development

The interaction between environment and soybean rust development was studied in the field using cultivar Taita Kaohsiung No. 5 planted at weekly intervals. Disease progress based on percent affected foliage was assessed weekly and the apparent infection rates between assessments were calculated. Mean daily temperatures were calculated from readings every two hours, and daily dew periods were based on 24 hr periods beginning at 1200 hours.

Regression analyses were conducted between weekly apparent infection rates and either weekly total dew periods or weekly mean temperatures. The apparent infection rates were correlated with temperature and dew data from the same week, and from one and two weeks prior to the infection rate data.

Low correlation coefficients between infection rates and dew period indicate that dew period by itself did not significantly influence the weekly fluctuations of infection rates. However, weekly mean temperatures were closely correlated with apparent infection rates, especially mean temperatures two weeks prior to apparent infection rates (Table 5). Disease progress thus appears to have been strongly influenced by mean temperature two weeks before, suggesting that temperature had the greatest influence on initial infection processes and not on lesion expansion.

Rust development and planting date

An experiment was conducted in the spring season to assess the effects of planting and maturity dates of soybean on rust development, and to clarify the characteristics of specific and general rust resistance. Three cultivars, Taita Kaohsiung No. 5 (TK 5), Tainung No. 4 (TN 4) and G 8587, were planted on March 17, and an earlier crop of G 8587 (EG 8587)

Table 5. Correlation of weekly mean temperature with weekly apparent infection rates (AIR), 1980, AVRDC

Temperature comparison	Equation[a]	Correlation coefficient
Same week as AIR	y = 0.0121x - 0.0948	.6996
One week before AIR	y = 0.0133x - 0.1127	.7069
Two weeks before AIR	y = 0.017x - 0.1847	.8519

[a]y = weekly AIR
x = weekly mean temperature (^{o}C)

was sown on March 3. TK 5 matures from 0 to 1 week earlier than TN 4 which, in turn, matures 1 to 3 weeks earlier than G 8587. Disease assessment data were converted to logits according to the formula, log e (x/(1-x)) where x is percent rusted foliage, and regressed on time.

The rate of disease increase from April 22 to June 10 for each planting was highly correlated with time, with correlation coefficients ranging from .95 to .99 (Figure 3). TN 4 had a lower rate of disease

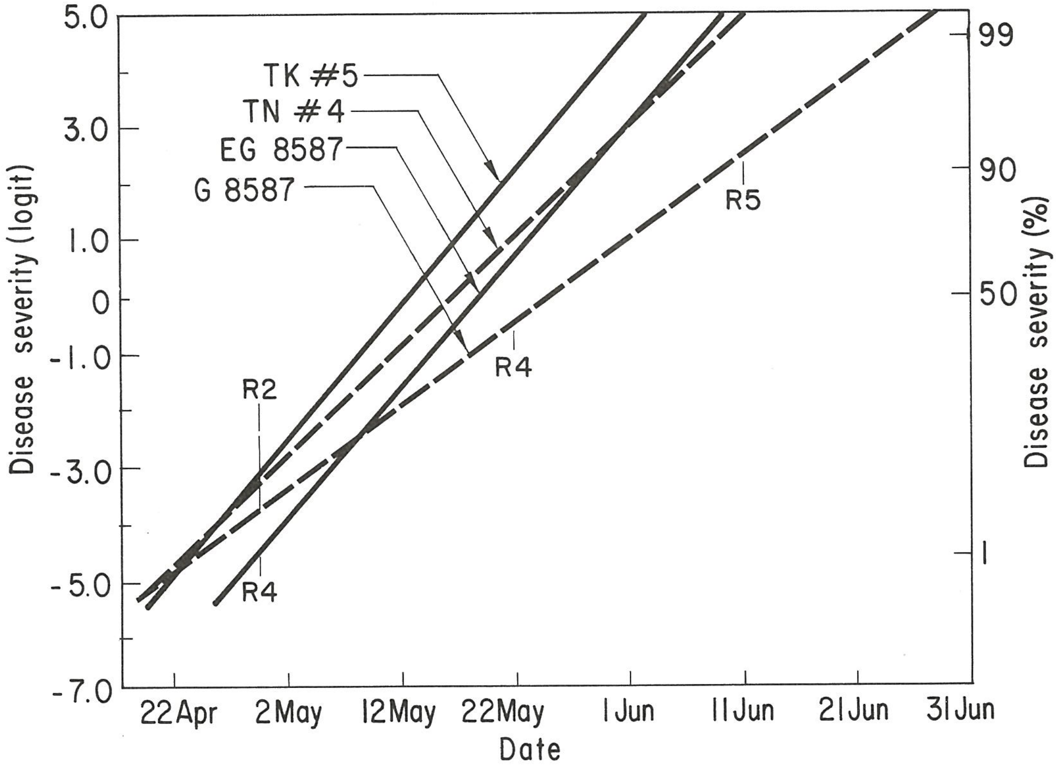


Fig. 3. Correlation of disease severity with time in cultivars planted on two different dates. R2 = full bloom growth stage, R4 = full pod growth stage, R5 = beginning seed stage. 1980, AVRDC

increase than either TK 5 or EG 8587, indicating its general resistance. The delay of six days in the disease development of EG 8587 when compared with TK 5 indicates that the propagules to which G 8587 is susceptible numbered few in the overall pathogen population, and therefore suggests specific resistance.

Although the rates of disease increase in TK 5 and EG 8587 are similar, this does not necessarily indicate a similar degree of disease susceptibility. Previous studies have shown that if the initial infection occurs later in the plant's life cycle, the subsequent development of the disease is much more rapid (Table 6). Thus the rate of disease increase in EG 8587 should have been lower than that of TK 5 (indicating general resistance) if the two cultivars were infected at the same growth stage. The existence of both specific and general resistance in the same cultivar and in varying levels between cultivars will seriously complicate the development of suitable levels of soybean rust resistance.

The yield of LG 8587 was only 37% of the EG 8587 yield even though the rate of disease increase was lower and the days to maturity longer (143 days after planting v. 107 DAP). It appears that the intensity and duration of the epidemic rather than the rate of disease increase are more closely related to yield loss.

Table 6. Effect of plant age at initial infection on subsequent soybean rust development in cultivar Taita Kaohsiung No. 5, 1979-80, AVRDC

Date		Planting date		
		10/8/79	10/15/79	10/22/79
November	9	0	0	0
	20[a]	.001[b]	.001	.001
	29	.001	.001	.001
December	6	.001	.001	.001
	13	.080	.003	.001
	20	8.3	4.8	2.3
	27	30.0	17.5	5.2
January	3	70.0	60.0	50.0

[a]Date of initial infection
[b]Disease severity is expressed as percent affected foliage

Soil moisture and rust development

The effects of soil moisture on rust development on soybean cultivar Taita Kaohsiung No. 5 were assessed using three irrigation schemes: no irrigation (NI), furrow irrigation (FI) and overhead irrigation (OI). Weekly disease assessments were converted to logits and regressed on time. Since heavy rainfall at 57 days after planting altered disease development, rust development curves were separated into two stages, before 55 DAP and after 55 DAP.

The rate of disease development before 55 DAP was the same in all three treatments, but the onset of the disease was delayed in the NI plots (Figure 4a). This delay in disease development in the NI plots should have been associated with an increase in the rate of disease development since initial infection occurred at a later growth stage. After the rainfall at 55 DAP, however, the rate of disease development in the NI plots did increase and was greater than that of the OI and FI treatments (Figure 4b). It appears that low soil moisture not only delays rust development but also decreases the rate of rust development.

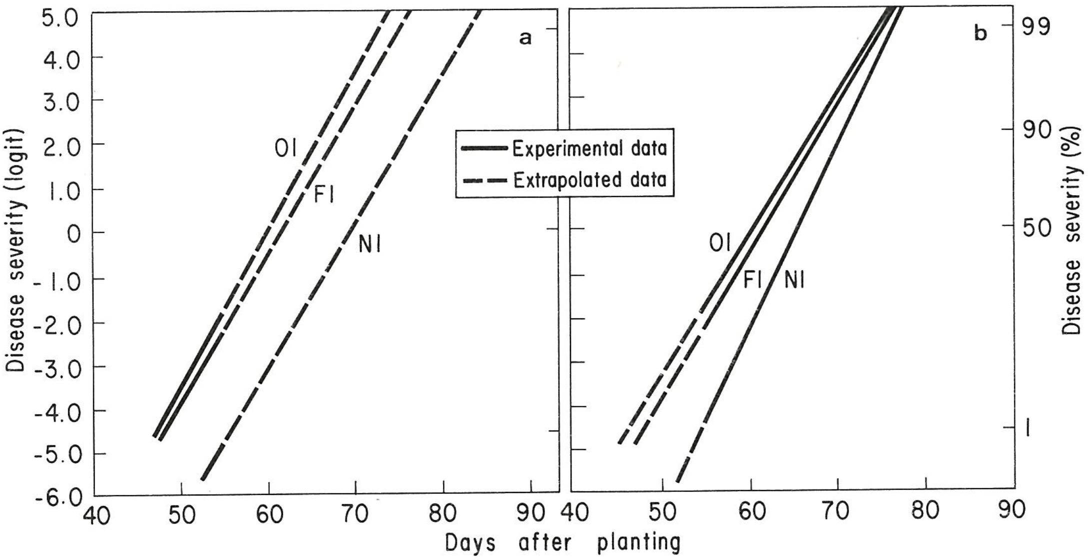


Fig. 4. Rust development in soybeans under overhead irrigation (OI), furrow irrigation (FI) and no irrigation (NI) at a) before 55 DAP and b) after 55 DAP, 1980, AVRDC

Rust severity and yield loss

Rust severity and yield data from several experiments grown under different environments were analyzed to determine how rust severity is correlated with yield loss. Two rust severity parameters, mean disease severity based on days after planting and mean rust severity based on the highest rust severity attained at each growth stage, were correlated with yield loss expressed as a percentage of the yield from a fungicide-protected plot. Mean rust severity based on growth stage was more closely correlated with yield loss (correlation coefficient = 0.9090 for data from six cultivars).

Soybean mosaic virus (SMV)

Thirty samples of SMV have been collected from Taichung, Hualien, Pingtung, Chiayi and AVRDC fields. The sample from AVRDC was strain typed and identified as strain SMVG-1.

Seed transmission of SMV was studied in the greenhouse on cultivar Tainung No. 4 which was artificially inoculated with strain SMVG-1 at the primary leaf stage. The resulting harvest of discolored and normally colored seed was then planted and observed for SMV symptoms. Total seed transmission of the virus was 5.3%, with 15.3% for discolored seed and 0.64% for normal colored seed. A Chi-Square test ($X^2 df_1 = 105.4$) indicated a strong association between seed discoloration and SMV transmission.

ENTOMOLOGY

Beet armyworm resistance screening

A total of 1871 soybean accessions were screened for resistance to beet armyworm (*Spodoptera exigua*) in a non-replicated preliminary screening in spring 1980. Accessions G 50, G 82, G 1259, G 1715, G 1767 and G 1970 rated highly resistant based on percent plant damage. Accessions G 1743, G 1746, G 1761, G 1772, G 1818 and G 1917 rated only slightly less resistant. These accessions will be screened further in replicated experiments in spring 1981.

Defoliation and depodding studies

A number of polyphagous insect pests feed on soybean leaves, causing damage which ranges from insignificant to severe depending on season. The extent to which their damage affects soybean yields, however, is as yet undetermined. Varying levels of intentional defoliation were therefore studied to determine the effects on grain yield and yield components.

In a late January planting, soybean was cultivated using standard cultural practices (AVRDC Guide 78-112), including insecticide sprayings to prevent insect defoliation. Plants were progressively defoliated beginning 20 days after emergence (DAE). At harvest, yield, number of pods/plant, number of seeds/pod, 100-seed weight and fat content were recorded.

A single defoliation of up to 50% at any stage before 50 DAE did not reduce yield significantly, nor did a 10% defoliation at each 20, 40, 60 and 80 DAE. Yield reductions from more frequent or heavier defoliation were mainly due to significant reductions in the number of pods/plant, number of seeds/pod and 100-seed weight. Fifty DAE thus appears to be critical period which will be investigated further in spring 1981.

A similar study was conducted to determine the extent to which damage caused by pod-feeding insects affected soybean yields. Soybean was sown in the spring and depodding was initiated when plants reached the R3 growth stage (early podding). A single depodding of up to 40% at the R3 growth stage did not significantly reduce yields, nor did 10% depodding at each R3, R4 (full podding), R5 (beginning seed) and R6 (full seed) growth stages.

Podborer resistance

Seven soybean accessions (G 2102, G 2105, G 3473, G 3517, G 3818, G 8448 and G 8506) previously identified as potentially resistant to pod-

Table 7. Podborer damage to selected soybean accessions previously identified with high levels of resistance[a], 1980, AVRDC

AVRDC accession no.	Podborer damage (%)	AVRDC accession no.	Podborer damage (%)
G 2102	5.1 c[b]	G 8448	8.6 c
G 2105	8.1 c	G 8506	7.7 c
G 3473	4.9 c	G 1911[c]	18.0 b
G 3517	5.3 c	G 6725[c]	29.1 a
G 3818	3.7 c	G 6[c]	32.8 a

[a]Sown September 4, 1980, harvested December 1, 1980; plot size: 2m x 1m with three replications
[b]Values followed by the same letter are not significantly different according to Duncan's multiple range test (5% level)
[c]Susceptible check

borer (*Etiella zinckenella*) were rescreened with three susceptible checks in fall 1980. Podborer damage was assessed at harvest based on 500 pods per plot. All seven accessions were significantly less damaged than the susceptible checks (Table 7). These seven have shown consistent high levels of resistance in four tests over a three year period and will be used for podborer resistance breeding in 1981.

Chemical control

Chemical control experiments were conducted in spring to control beet armyworm and in fall to control beanflies. The experimental design and other details were the same as described in the AVRDC publication "Vegetable Pest Control: Insecticide Evaluation Tests".

Except for aldicarb and terbufos, the insecticides screened significantly reduced insect damage. Carbofuran 3G incorporated into the soil at 2 kg a.i./ha, and decamethrin 2.8EC sprayed at 0.025 kg a.i./ha gave the most effective control. Carbofuran soil incorporation, however, was effective only up to three weeks after planting.

Five new insecticides were screened for beanfly control in fall 1980. Omethoate, AVRDC's standard insecticide, produced better beanfly control and yield response than Marshal, chlorpyrifos, BAS 26302, BAS 26801, and bendiocarb.

Soybean tolerance to beanfly

In 1978 four soybean accessions were identified with high levels of resistance to beanfly infestations. These accessions, however, belong to *Glycine soja* with thin stems and a viny growth habit, making it difficult to incorporate beanfly resistance into cultivated *Glycine max*. Therefore, 163 accessions of *Glycine max* were screened for tolerance to

Table 8. Beanfly damage and yield of selected beanfly tolerant soybean accessions with and without insecticides[a], 1980, AVRDC

AVRDC accession no.	No. beanfly larvae+ pupae/plant		Damaged plants[b] (%)		Yield (g/plot)		Yield reduction(%)
	insecticide	check	insecticide	check	insecticide	check	
G 798	0.05	1.7	5	100	232	222	4.3
G 1992	0.00	1.5	0	100	478	464	2.9
G 2121	0.00	1.3	0	100	457	525	0.0
G 3496	0.00	1.4	0	95	429	409	4.7
G 4556	0.00	1.6	0	95	349	385	0.0
Average[c]	0.02	1.6	2.4	98.4	296	204	31.1

[a]Sown September 4, 1980; harvested December 1-15, 1980
[b]Assessed on October 15, 1980
[c]Average of 163 entries

beanflies. Entries were planted in 4m x 1m plots with four replications arranged in a randomized complete block design. Two replicates were treated with the insecticide monocrotophos 60EC (0.5 kg a.i./ha) at 3, 7, 14, 21, and 28 days after germination and two replicates were left untreated. At four weeks after planting, each plot was thinned to an equal number of plants. From this time onwards the crop was protected against other insect pests by monocrotophos sprays when necessary.

Yields of accessions G 798, G 1992, G 2121, G 3496 and G 4556 were not reduced by more than 5% due to beanfly infestations (Table 8). These five accessions have the potential to be cultivated with reduced requirements for chemical beanfly control. The tolerance mechanism will be further studied in 1981.

PLANT PHYSIOLOGY

VA mycorrhizal inoculation and soybean performance

The effect of vesicular-arbuscular (VA) mycorrhizal inoculations on soybean performance was investigated under greenhouse conditions in 1980. Five species of VA mycorrhizal fungi were isolated from the AVRDC experimental farm and multiplied on corn culture. The soybean soil medium consisted of steam-sterilized sandy loam soil with 12.4 ppm available phosphorus extracted with 0.5 N $NaHCO_3$. Four kg was filled into each 2 x 10^{-4} acre Wagner pot, and 10 g fresh VA mycorrhizal inocula from the corn culture were incorporated into each pot. Four seeds of AVRDC soybean selection AGS 59 were sown per pot and thinned to two seedlings after emergence.

Of the five VA mycorrhizal fungi tested, inoculation by all species of *Glomus* and *Acaulospora* significantly increased total dry weight and seed yield (Table 9). *Glomus fasciculatus* and *Glomus mosseae* demonstrated the highest potentials for increasing soybean growth and yield. Yield increases over that of the control were attributed mainly to increases

Table 9. Effect of VA mycorrhizal fungi on growth, yield and yield components of soybean selection AGS 59 in pot culture[a], 1980, AVRDC

Inoculant	Seed yield (g)	Pod no.	Seed/pod	100-seed weight (g)	Total dry weight (g)
Glomus fasciculatus	9.1 a[b]	36 a	1.96	12.8 a	29.8 a
Glomus mosseae	8.1 a	36 a	1.95	11.5 ab	25.3 ab
Glomus etunicatus	6.3 b	31 ab	1.83	11.1 b	20.0 bc
Acaulospora scrobiculatus	6.3 b	28 b	1.89	11.9 ab	20.8 bc
Gigaspora pellucida	5.1 bc	26 b	1.84	11.0 b	17.7 c
Control	3.9 c	26 b	1.86	8.1 c	14.2 d

[a]Two plants per pot
[b]Mean separation within columns by Duncan's multiple range test (5% level)

in pod number and average seed size. The data in Table 9 also indicate that VA mycorrhizal inoculation increased seed yield through production of total dry matter rather than influencing dry matter partition.

The best VA mycorrhizal fungi from the pot experiment were then studied in the field on no-tillage, rice stubble soybean. The field had a VA mycorrhizal population of 0.9 to 1.9 spores/g soil at a depth of 10 cm, and 9.4 ppm available P before sowing and fertilization. Two weeks after the rice harvest, local soybean cultivar Tainung 15 was sown at 3-4 seeds per rice stubble hill and later thinned to two seedlings per hill. The plants were subjected to the following four treatments: no P fertilization or VA inoculation: P fertilization at 60 kg P_2O_5/ha; VA mycorrhizal mixture of *Glomus mosseae*, *G. fasciculatus* and *Acaulospora scrobiculatus* inoculated at 15 g/rice stubble hill; and both mycorrhizal

Table 10. Effect of VA mycorrhizal inoculation and phosphorus fertilization on yield and yield components of no-tillage, rice stubble soybean[a], 1980, AVRDC

Treatment	Seed yield (t/ha)	Pod/plant	Seed/pod	100-seed weight (g)
P fertilization	2.65 ab[b]	33.8 ab	1.5	14.1
VA inoculation	2.90 a	36.0 a	1.6	14.4
P fertilization + VA inoculation	2.81 a	37.1 a	1.5	14.2
Control	2.33 b	28.1 b	1.5	14.4

[a]3m x 5m plots arranged in randomized complete block design with four replications
[b]Mean separation within columns by Duncan's multiple range test (5% level)

inoculation and P fertilization. All treatments were fertilized with 20 kg N/ha and 80 kg K_2O/ha. VA mycorrhizal inoculation alone resulted in the greatest yield enhancement of 24% over that of the control, and the combined P fertilization and VA mycorrhizal inoculation gave comparable seed yield enhancement (Table 10).

The field potential of *G. fasciculatus* was evaluated in another experiment using both fresh and air dried inocula on no-tillage, rice stubble soybean. The field contained 12.0 ppm available P, and the inoculum was incorporated into the soil at 15 g/rice stubble. The results confirmed the findings of the pot culture experiment, with the seed yield of the fresh inoculum treatment 20% greater than that of the control.

In spite of the demonstrated potential of VA mycorrhiza on the growth and yield of soybean, it should be noted that the soil conditions under which that potential is maximized have not yet been determined.

<u>Mycorrhiza and soybean as affected by soil properties and host specificity</u>

Several pot experiments were conducted to evaluate the efficiency of VA mycorrhizae as influenced by host specificity, soil pH, available P, and other soil properties.

Seed of soybean selection AGS 62 was sown in pots with a soil pH of 5.30, 6.35 or 7.65. Inocula of *Glomus etunicatus* were incorporated into the soil at 10 g/pot. Inoculation was equally efficient at all three soil pH levels in terms of total dry matter production, although inoculation at soil pH 6.35 yielded the highest number of pods.

The performance of mycorrhized and nonmycorrhized soybeans as affected by various soil P levels was examined, since VA mycorrhizae is reported to play a significant role in the absorption of phosphorus from phosphorus-deficient soils. Seed of AGS 62 were sown in pots and inoculated with fresh *G. mosseae*. Calcium superphosphate was added to each pot at 0, 0.25, 1, 2 and 3 g/kg soil. After P fertilization, available P levels were determined. Ten weeks after emergence, increases in growth and yield of nonmycorrhized plants in response to phosphate fertilization was greater than that of mycorrhized plants; however, the beneficial response of yield to VA mycorrhizae was greatest in plants grown at low soil P levels (Table 11). Differences in plant dry weight and seed yield between mycorrhized and nonmycorrhized plants decreased as soil P levels increased. The results lend support to the hypothesis that phosphorus utilization by mycorrhized soybean is better in soils with low phosphorus levels than in phosphorus-rich soils.

The efficacy of *G. fasciculatus* inoculations as affected by soybean variety was evaluated with eight cultivars grown on sterilized soil with 8.7 ppm available P. Table 12 shows that although yields of nonmycorrhized plants were less than those of mycorrhized plants for all varieties, there were differences in the efficiency with which each variety responded to the inoculation.

Table 11. Effects of soil P levels on performance of mycorrhized and nonmycorrhized soybean, 1980, AVRDC

Treatment	Available P (ppm)	Seed yield (g/plant)	Pod/plant	Shoot dry weight (g/plant)
VA inoculated	21	3.2 b[a]	9.7 bc	1.8 bc
	55	4.4 a	12.2 ab	2.9 a
	76	4.4 a	12.5 ab	2.5 ab
	131	4.1 ab	14.5 a	2.6 a
	165	4.3 a	12.3 ab	3.1 a
Non-inoculated	21	0.1 c	3.3 d	0.7 d
	55	0.1 c	7.0 c	0.8 d
	76	1.0 c	11.7 ab	1.4 cd
	131	3.2 b	11.7 ab	2.5 ab
	165	3.7 ab	12.2 ab	2.6 a

[a]Mean separation within columns by Duncan's multiple range test (5% level)

Table 12. Dry matter production (g/plant) of eight soybean entries as affected by *Glomus fasciculatus* inoculations[a], 1980, AVRDC

Entries	Inoculated	Non-inoculated	Efficiency (inoculated/ non-inoculated)
AGS 2	4.6 a[b]	1.0 d	4.6 a
AGS 66	4.4 a	1.7 cd	2.9 b
AGS 59	4.1 a	1.9 c	2.4 bc
AGS 143	4.6 a	2.1 c	2.1 bc
AGS 62	4.0 a	2.0 c	2.0 bc
G 9053	4.0 a	2.0 c	2.0 bc
G 2	2.3 c	1.6 cd	1.7 cd
G 9948	3.1 b	3.0 b	1.1 d

[a]Sown November 11, 1980 and harvested January 10, 1981
[b]Mean separation within columns by Duncan's multiple range test (5% level)

A preliminary experiment with the most responsive selection AGS-2 also indicated that the utilization of *G. fasciculatus* was less efficient with the simultaneous incorporation of an inefficient VA mycorrhizal fungus, *Gigaspora pellucida,* suggesting competition between those two VA mycorrhizae in invading the host root.

The efficiency of VA mycorrhizae as influenced by soil properties was evaluated in soils collected from 17 sites on the AVRDC experimental farm. Soil samples were sterilized and measured for pH; electrical conductivity; Olsen's P; Bray-1 P; total N; organic matter; cation exchange capacity; exchangeable Ca, K and Mg; Fe, Zn and Mn. The soils were then filled into plastic pots, inoculated with *G. fasciculatus*, and sown with soybean selection AGS 62. VA inoculation enhanced yields significantly (average 6.3 g/mycorrhized plant versus average 3.0 g/nonmycorrhized plant) regardless of soil properties. The best mycorrhizal response, however, occurred in soils with low available P, high cation exchange capacity and high exchangeable Ca according to a stepwise mode of the regression analysis (mycorrhized yield-nonmycorrhized yield = 0.45 - (0.05·Olsen's P) + (0.62·CEC) + (0.02·exch Ca)); R^2 = 0.84

The AVRDC NEM Garden Program is developing transferable home, school and market garden technologies, with an emphasis on vegetables with the potential to address particular nutritional deficiencies, supplement family diets or generate cash income

Nutrition, Environment and Management

The Nutrition, Environment and Management Program (NEM) uses an interdisciplinary approach to enhance the nutritional quality of vegetable crops and increase crop production by adapting and developing appropriate crop management techniques and technologies. The effort involves research into nutrition, nutrition chemistry, the environment, soil science, crop management, agricultural economics and other disciplines.

BIOCHEMISTRY AND NUTRITION

Tofu making quality of soybean lines

Twenty soybean varieties were evaluated for their 'tofu' (soybean curd) making qualities and yields (Table 1). The chemical and physical properties of the soybean seed, tofu and soybean sheets were also analyzed to determine those factors affecting tofu quality and yield. A stepwise correlation revealed that the color of soybean sheet powder (Hunter brightness scale) was most closely correlated with tofu yields (R^2=0.776)

Table 1. Yield and quality of tofu made from different varieties of soybean for commercial scale production, 1980, AVRDC

Selection or accession no.	Cross or name	Yield (kg)[a]	Tofu quality[b]
AGS 2	G 2120	11.1	Poor
AGS 8	GC 30293-6-10	12.7	Medium
AGS 17	GC 30050-2-17	13.9	Poor
AGS 19	GC 30229-8	15.7	Medium
AGS 22	GC 30170-0-14	14.8	Good
AGS 27	GC 30238-1-14	15.7	Good
AGS 34	GC 30271-1-14	15.7	Good
AGS 62	GC 40359-1-55	13.3	Medium
AGS 66	GC 30257-2-0-1	14.1	Medium
AGS 85	GC 30295-6-6-1	15.6	Excellent
AGS 94	GC 30187-10-16	14.3	Medium
AGS 96	GC 30299-17-9-1	15.5	Excellent
AGS 109	GC 30178-0-8	14.9	Good
G 38	Shih Shih	15.1	Good
G 2048	Wakajima	14.0	Medium
G 2050	KS #3	15.6	Excellent
G 5136	Palmetto	12.6	Medium
G 5290	Calland	11.3	Poor
G 5455	Williams	14.3	Medium
G 9951	Talien Tou	14.7	Good

[a] Amount produced from 3.2 kg soybean
[b] Judged by a tofu manufacturer

Improvement of the protein quality of mungbean

Previous studies have shown that although mungbean protein is high in digestibility, low levels of methionine reduce its overall protein value. A project is presently underway in cooperation with the Institute of Agricultural Chemistry of National Taiwan University and the Institute of Biochemistry of the Academia Sinica in Taiwan to improve the protein quality of mungbean through interspecific hybridization with methionine-rich blackgram. A rat-feeding experiment and an *in vitro* digestion system have both shown that the digestibility of isolated blackgram protein is as good as that of mungbean, indicating that the low digestibility of blackgram is not due to its primary protein structure.

The major dipeptides of mungbean and blackgram are γ-glutamyl-S-methyl-cysteine and γ-glutamyl-methionine. The exact quantity and nature of these peptides and free sulfur-containing amino acids were determined for ten mungbean and blackgram cultivars using High Performance Liquid Chromatography (HPLC), a reverse phase separating technique. The peptide standards were synthesized at the Institute of Biochemistry.

Mungbean is rich in γ-glutamyl-S-methyl-cysteine and S-methyl-cysteine, and blackgram is rich in γ-glutamyl-S-methionine and methionine. Although the F_1 progeny of an interspecific cross (VC 2727 x VMC 2730) were similar to mungbean, a segregation was evident in the F_2 progeny. Some of the seeds were similar to blackgram with high contents of methionine, suggesting that interspecific hybridization is a possible technique for improving the protein quality of mungbean.

Whole utilization of mungbean through air classification

Mungbean starch noodle has been made traditionally by a 'wet process' involving lactate formation. With this process, however, the mungbean protein is lost and pollution problems result from discarding the steeping liquor wastes. Air classification, a 'dry process' for separating starch and protein, can potentially produce starch for starch noodle manufacturing, minimize pollution problems and recover the mungbean protein for further utilization.

To evaluate the air classification process, dehulled and whole mungbeans were pin-milled and air-classified into starch-rich fractions (SRF-I) and protein-rich fractions (PRF-1). The SRF-I was further pin-milled and air-classified into SRF-II and PRF-II to remove impurities. Both SRF-I

Table 2. Carbohydrate components of selected local and AVRDC summer Chinese cabbage lines[a], 1980, AVRDC

Entry	Dry matter (%)	pH	Soluble solids (°Brix)	Titratable acidity (% citric acid)	Crude fiber (%)	Pectic Substances (%)	Sugar (%)	Vitamin C (mg/100 g)
77 M(2)-25	4.16	6.44	3.50	0.080	0.399	0.162	1.27	31.0
77 M(3)-26	4.45	6.42	3.83	0.079	0.422	0.181	1.68	27.5
77 M(3)-27	4.54	6.48	3.93	0.078	0.392	0.190	1.34	26.9
77 M(3)-33	4.42	6.49	3.98	0.084	0.409	0.198	1.64	26.8
77 M(3)-35	4.74	6.44	4.10	0.096	0.443	0.178	1.44	34.0
77 M(3)-38	4.67	6.44	3.95	0.087	0.441	0.176	1.39	29.7
77 M(2/3)-43	4.29	6.43	3.68	0.073	0.445	0.152	1.51	32.1
77 M(2/3)-44	4.52	6.44	3.93	0.079	0.415	0.178	1.36	29.8
77 M(2)-46	4.19	6.50	3.76	0.072	0.401	0.172	1.27	32.7
Hybrid #58	4.54	6.41	3.73	0.079	0.430	0.225	1.43	34.6
Hybrid #59	4.55	6.46	3.85	0.075	0.460	0.190	1.29	31.4
Hybrid #62	4.36	6.41	3.80	0.078	0.475	0.214	1.35	33.9
B 189 C	4.16	6.40	3.73	0.089	0.387	0.138	1.24	33.3
S. L. #2	4.25	6.39	3.88	0.093	0.380	0.146	1.23	34.1
Mean	4.42	6.44	3.83	0.082	0.421	0.179	1.39	31.3
Feng Luh	3.83	5.85	2.70	0.076	0.497	0.148	1.38	-

[a]Planted August 26 and harvested October 8, 1980

and SRF-II, however, produced green-colored starch noodles with high cooking losses and bitter taste. When the SRF's were further purified in a 0.1 N NaOH solution, they produced starch noodles of a quality comparable to that produced from wet-milled starch.

Chinese cabbage carbohydrate analysis

Selected characteristics of Chinese cabbage including soluble solids, pH, titratable acidity, crude fiber and pectic substances, were analyzed for AVRDC breeding lines and compared with those of local cultivars (Table 2).

The quality of AVRDC Chinese cabbage breeding lines was comparable to that of local summer cultivars B 189C and Summer Light #2. Although the sugar contents of AVRDC lines and popular cultivar Feng Luh are similar, the former have much higher dry matter and soluble solid contents. This indicates that AVRDC lines may be rich in protein and other soluble substances. The low crude fiber contents and high pectic substance contents of some of the summer lines suggest less fibrous, crisper leaves, resulting in better eating quality.

Carbohydrate components of sweet potato lines

Seven sweet potato lines with different sugar contents were analyzed for their carbohydrate components. Dry matter content was negatively associated with sugar content (Table 3). Starch was the major component of dry matter in the low sugar lines. The low cellulose and lignin contents of the low sugar lines also suggest better eating quality. Although the significance of hemicellulose to eating quality is not known, it is suspected of being associated with flatulence.

Correlation studies showed significant negative correlations between sugar and dry matter contents, but only low positive correlations between sugar content and protein content, and sugar and β-carotene contents.

Table 3. Distribution of the carbohydrate components of sweet potato roots, 1980, AVRDC

AVRDC cross or selection no.	Dry matter (% fresh weight)	Free sugar	Starch	Cellulose	Hemi-cellulose	Lignin
		(% dry weight)				
CI 830-5	13.6	36.7	34.0	5.0	6.1	3.3
CI 608-127	17.0	32.6	37.9	4.6	6.1	2.8
AIS 0122-2	19.6	29.0	48.2	4.6	6.2	2.5
AIS 35-2	25.0	24.1	52.4	3.8	6.3	1.7
CI 412-2	27.3	20.2	61.1	3.5	6.3	1.7
CI 57	30.1	13.5	68.6	3.1	6.3	1.6
CI 935-35	35.1	4.7	73.3	2.6	7.7	1.5

These findings indicate that it is possible to develop a low sugar, high dry matter sweet potato that still retains good protein and β-carotene contents.

NON-COMMODITY NUTRITION PROJECT

A nutritionist joined AVRDC on a two-year USAID seed grant to examine nutritional needs in southeast Asia and link AVRDC's activities with nutrition intervention projects in selected developing countries. Initial linkages have been made in Indonesia, Thailand and the Philippines, all of which include gardening in their national development plans. To assist with the planning and development of these garden activities, AVRDC has begun a program to develop home, school and market garden technologies that can be transferred to these countries.

AVRDC's nutrition group began studies in food fortification involving high β-carotene sweet potato flour as a partial substitute for imported wheat flour in various baked goods. Such products can be valuable sources of vitamin A.

SOCIAL ANTHROPOLOGY

The department of social anthropology was created in late 1980 to study the sociocultural factors involved in the production, distribution and consumption of vegetables on Taiwan and in other Asian countries, and to identify the problems of technology transfer related to agricultural development. Labor shortage and small, fragmented landholdings were identified as the major agricultural problems for farmers on Taiwan. A study was initiated to examine these issues and possible solutions, particularly individual and group farming approaches to farm management among vegetable farmers in several villages on Taiwan.

SOIL SCIENCE

Rice hull as a seedling culture medium

Smoked rice hull was evaluated for its adaptability as a seedling culture medium for tomato in order to minimize the threat from pathogens and insect pests associated with soil mediums. Tomato seeds were sown in flats in three culture mediums of smoked rice hull treated with a nutrient solution, sterile or non-sterile fertilized soil. Tomato seedlings grew much more rapidly on the rice hull medium and were ready for transplanting 4-5 days earlier than seedlings sown in the other mediums (Table 4). Practical seedling culture techniques using smoked rice hulls in 6cm pots instead of flats have been developed for both tomato and Chinese cabbage.

Phosphorus concentration and growth and yield of soybean

Previous studies indicated that soybean planted in soil with 20 ppm

Table 4. Seedling culture medium and tomato seedling growth, 1980, AVRDC

Treatment		Cotyledon length (cm) (7 DAS)	Plant weight (g) (27 DAS)	Plant height (cm) (27 DAS)	No. of seedlings ready for trans-planting (%)
Sterilized soil + NPK[a]	$\bar{x}$	1.19	2.46	16.35	95.8
	cv	12.6	35.3	15.0	
Non-sterile soil + NPK	$\bar{x}$	1.29	1.75	13.63	75.0
	cv	9.9	31.4	12.4	
Smoked rice hull[b]+ nutrient solution[c]	$\bar{x}$	1.60	10.31	30.49	95.8
	cv	5.7	21.2	9.3	

[a]NPK fertilizer was supplied by 1.8g ammonium sulfate, 5.6g calcium superphosphate and 3.4g potassium chloride applied per flat
[b]Rice hulls were smoked, washed clean of all ashes, treated with diluted H_2SO_4 and then washed again
[c]Nutrient solution was a mixture of the following two solutions:
1) 81g KNO_3, 95g $Ca(NO_3)_2$, 50g $MgSO_4 \cdot 7H_2O$, 15.5g $NH_4H_2PO_4$ and 2.0g Fe chelate dissolved in 100 ℓ water
2) 29g $MnSO_4$, 0.22g $ZnSO_4$, 0.05g $CuSO_4 \cdot 5H_2O$, 0.02g $NaMoO_4$ and 3g H_3BO_3 dissolved in 1 ℓ water. 100 ml solution (2) is mixed with 100 ℓ solution (1)

P_2O_5 showed no response to additional P applications. A sand culture experiment was then conducted to determine the appropriate P concentration for optimum soybean growth. Nutrient solutions were prepared with various P concentrations and applied to soybean planted in sand culture at two plants per 1/2000 acre Wagner pot. Soybean yields were highest with a P concentration of 12.5 ppm (Table 5), but further studies are needed to determine whether or not this is the optimum concentration.

Chinese cabbage response to fertilization in acidic and alkaline soils

The response of Chinese cabbage to different fertilizer treatments was evaluated in acidic (non-fertile) and alkaline (fertile) soils on

Table 5. The effect of different concentrations of phosphorus in sand culture on the growth, yield and yield components of soybean[a], 1980, AVRDC

Phosphorus concentration (ppm)	Plant height (cm)	Pod no/plant	Seed no/pod	100-seed weight (g)	Yield (g/plant)
0	27 a[b]	3 a	1.42 a	8.9 a	0.4 a
12.5	78 b	165 b	1.91 b	21.8 b	68.5 b
25	61 c	185 b	1.89 b	19.2 bc	66.1 b
50	68 c	168 b	1.86 b	16.1 c	50.6 b

[a]Local variety Shih Shih was sown May 23, 1980 and harvested August 26, 1980
[b]Mean separation within columns by Duncan's multiple range test (5% level)

Table 6. Fertilizer applications and summer Chinese cabbage yields in alkaline and acidic soils, 1980, AVRDC

Treatment	Marketable yield (t/ha)	
	Acidic field soil	Alkaline field soil
No fertilizer	4.3 b[a]	27.6 a
P + K	4.8 b	28.7 a
N + P	16.0 a	30.5 a
NPK	15.6 a	30.7 a

[a]Mean separation within columns by Duncan's multiple range test (5% level)

the AVRDC experimental farm. The treatments consisted of no fertilization, P + K fertilization, N + P fertilization, or NPK fertilization where application rates were 120 kg N/ha, 80 kg P_2O_5/ha and 100 kg K_2O/ha. The absence of N significantly affected Chinese cabbage yields in the acidic soil, while no significant differences were found between treatments in the alkaline soil (Table 6).

Nitrogen applications, soil amendment materials and tomato growth

Pot experiments with three soil types showed that whereas soil amendment materials like rice hull and sand had no effect on tomato growth, increased nitrogen applications significantly promoted tomato growth (Table 7). The experiment followed an $L_{27}(3^{13})$ orthogonal factorial design ('3' refers to the number of levels and '13' is the number of possible arrays) with three levels of nitrogen (0.6, 0.4 or 0.2 g/pot), sand (3.0, 1.5 or 0 kg/pot) and rice hull (250, 125 or 0 g/pot) mixed with the soils.

Table 7. Effects of increasing levels of nitrogen, sand and rice hulls on tomato growth and soil components in pot culture[a], 1980, AVRDC

	Plant height (cm)	Cluster number	Fruit number	Yield[c] (g/pot)	Dry weight (g)	pH in dry soil	EC in dry soil
Factor[b]	F	F	F	F	F	S	S
L_1[d]	48.8 a	29.7 a	61.0 a	1233 a	158 a	7.87 a	0.31 c
L_2	45.7 b	25.2 b	55.2 a	1105 b	137.5 b	7.62 a	0.39 b
L_3	46.4 b	23.4 b	30.4 b	594 c	112.0 c	6.53 b	0.47 a
LSD (.05)	2.22	3.826	8.386	96.711	15.75	0.196	0.052
Significance[e]	*	*	**	**	**	**	**

[a]$L_{27}(3^{13})$ orthogonal factorial design (OFD)
[b]Factors were nitrogen (F), sand (S) and rice hull (H)
[c]One tomato plant/pot
[d]$L_1 > L_2 > L_3$ in reference to the three levels of each of the three factors
[e]*5% level, **1% level

Soil amelioration and soybean yields

In evaluations of various soil ameliorants for pot-grown soybean, standard NPK fertilization plus either powdered sun hemp (10 t/ha) or compost (60 t/ha) significantly increased yields over that of plants treated with NPK alone. Fused phosphate, an ameliorant for volcanic ash soil, did not significantly improve yields from AVRDC soils.

A second pot experiment was conducted to evaluate the effectiveness of organic material applications with and without nitrogen fertilization on soybean. Sun hemp, compost and mungbean stalks increased yields over that of the control when applied with or without nitrogen (Table 8). The addition of nitrogen, however, increased yields in all treatments by 18% to 43.5%.

Table 8. Effects of various organic materials applied with or without nitrogen fertilizer on pot grown soybean[a], 1980, AVRDC

Organic material	Yield (g/pot) -N	Yield (g/pot) +N	Yield increase(%)
Control	13.6 (100) ef[b]	16.2 (100) cd	19.1
Sun hemp	18.9 (139) b	22.3 (138) a	18.0
Compost	14.7 (108) edf	17.5 (108) cb	19.0
Mungbean	14.3 (105) edf	17.4 (107) cb	21.7
Starch	11.7 (86) gh	15.2 (94) edf	29.9
Rice straw	10.8 (79) h	15.5 (96) ed	43.5
Sawdust	10.4 (76) h	13.2 (81) fg	26.9

[a]Soybean selection GC 30293-6-10 planted at two plants/pot
[b]Mean separation within columns by Duncan's multiple range test (5% level)

CROP MANAGEMENT

Plant arrangement studies for mungbean and soybean

Previous studies have shown that the optimum population density for mungbean is 400,000 plants/ha. Experiments were then conducted to determine the optimum mungbean planting arrangement at this population density. Three between-row spacings (25cm, 50cm and 75cm) and three within-row spacings (10cm, 20cm and 30cm) were combined factorially for a total of nine treatments carried out in both fall and spring plantings (Table 9). Dry bean yields were significantly affected by between-row spacing but not by within-row spacing. A plant spacing of 10cm x 25cm and one plant/hill gave the best yields across both seasons. Correlation analysis showed that yield differences were due to plant survivability.

Table 9. The effects of plant arrangement at a constant density of 400,000 plants/ha on mungbean yields, 1980, AVRDC

Spacing (cm)	No. of plants/hill	Seed yield (kg/ha)	
		Spring	Fall
10 x 25	1	1640	2272
10 x 50	2	1390	2199
10 x 75	3	1110	2135
20 x 25	2	1340	2268
20 x 50	4	1480	2253
20 x 75	6	940	1890
30 x 25	3	1420	2325
30 x 50	6	1310	2146
30 x 75	9	910	2050
LSD (.05)	between-row	192.5	123.3
	within-row	ns	ns
	between x within	ns	ns

Table 10. Soybean yield as affected by between-row spacing, 1980, AVRDC

Spacing (cm)	Seed yield (kg/ha)	
	Spring	Fall
25	2950	2465
50	3002	2322
75	2675	2017
LSD (.05)	196	121

An identical experiment was conducted for soybean in spring and fall. Yields from both plantings were significantly affected by between-row spacings, with a 50cm separation resulting in the highest yields in spring and a 25cm separation producing the highest in the fall (Table 10). Yields were not significantly affected by within-row spacing although yields tended to increase as spacings grew smaller. The best spacings were 10cm x 50cm (two plants/hill) in the spring and 10cm x 25cm (one plant/hill) in the fall.

Weed interference studies

Experiments were conducted to determine the 'critical period of weed competition' (during which weed interference significantly reduces yields) for mungbean, soybean and tomato. In a spring 1980 planting, mungbean was kept weed-free, or allowed to be infested with weeds, for periods ranging from 15 days after planting up to the duration of crop growth. Mungbean kept weed-free for 60 days after sowing (DAS) yielded as high as the weed-free check, while weed infestations for periods longer than 30 DAS significantly reduced yields (Table 11). Yields were highly correlated with the number of seeds per pod. The results indicate that the critical period of weed competition for mungbean is between 30 and 60 DAS.

In fall 1979 plantings, rice-stubble soybean demonstrated weed tolerance for up to 45 days after sowing without significant yield loss. The experiment was repeated in spring 1980. Significant yield loss resulted from weed competition lasting more than 60 days after sowing, while keeping the plots weed-free for any duration of time did not significantly affect yields (Table 12).

Table 11. Effect of weed interference on the growth and yield of mungbean[a], spring 1980, AVRDC

Duration of interference (DAP)	Total yield (kg/ha)	Plant height (cm) 30 DAS	Plant height (cm) 50 DAS	100-seed weight (g)	No. of seeds/pod
Weed-free					
15	674 e	7.1	16.4	6.2	9.4 abc
30	687 de	6.4	18.4	6.2	8.6 bcd
45	1499 c	5.6	16.9	6.1	10.0 a
60	2131 a	6.6	14.3	6.2	9.8 a
75	2296 a	6.1	17.3	6.3	9.7 ab
to harvest	1935 ab	6.1	16.9	6.2	9.5 ab
Weed-infested					
15	1996 ab	6.3	16.3	6.2	9.6 ab
30	2140 a	6.4	15.7	6.2	9.7 ab
45	1676 bc	6.1	19.6	6.1	10.0 a
60	1005 d	5.5	15.6	6.2	9.7 ab
75	559 e	6.4	18.2	6.0	8.5 cd
to harvest	378 e	6.3	15.6	6.1	8.1 d

[a]Mean separation within columns by Duncan's multiple range test (5% level)

Table 12. Effect of weed interference on growth and yield of soybean[a], spring 1980, AVRDC

Duration of weed interference (DAP)	Seed yield (t/ha)	Pods/plant	Seeds/pod	100-seed weight (g)
Weed-free				
15	2.71 abc	27.98	1.97	15.18
30	2.93 a	30.15	1.94	15.20
45	2.90 ab	29.38	1.92	15.38
60	2.89 ab	29.08	1.88	15.60
75	2.88 ab	30.25	1.90	15.02
to harvest	2.89 ab	29.05	1.91	15.07
Weed-infested				
15	2.74 ab	28.35	1.86	15.38
30	2.84 ab	29.20	1.84	15.50
45	2.79 ab	26.50	1.97	15.10
60	2.72 abc	26.80	1.90	15.38
75	2.63 bc	26.22	1.85	14.10
to harvest	2.44 c	26.75	1.84	14.92

[a]Mean separation within columns by Duncan's multiple range test (5% level)

Weed competition experiments were conducted for transplanted tomatoes in winter 1979 and spring 1980. In the winter planting, it was necessary to keep the tomato plants free of weeds for at least 42 days to obtain yields equal to those of the weed-free check (Table 13). Yields were significantly affected if weeds were allowed to grow longer than 42 days after transplanting (DAT). In the spring planting, there was no signi-

Table 13. Effect of weed interference on growth and yield of transplanted tomato[a], 1979 and 1980, AVRDC

Duration of weed interference (DAT)	Total yield (t/ha)		Fruit weight (g/fruit)		Fruit no./plant	
	1979	1980	1979	1980	1979	1980
Weed-free						
14	18.5 d	26.1 ab	54.4	55.9 abcd	17.6 e	22.0 a
28	26.0 bcd	26.5 ab	55.7	58.5 abc	24.3 bcde	19.9 ab
42	32.3 ab	25.8 ab	60.5	57.2 abcd	28.0 abc	21.5 a
56	33.1 ab	29.0 a	58.5	59.0 abc	29.6 abc	21.6 a
70	37.5 a	26.4 ab	59.8	56.3 abcd	32.6 a	20.0 ab
to harvest	37.2 a	27.7 ab	61.5	59.9 a	31.6 ab	19.8 ab
Weed-infested						
14	36.1 a	27.5 ab	60.4	58.3 abc	31.1 ab	20.3 a
28	38.1 a	24.0 abc	62.2	53.5 abcd	31.8 a	19.0 abc
42	30.2 abc	22.7 bc	61.1	59.5 ab	25.6 abcd	16.6 c
56	24.5 cd	19.4 c	66.1	52.9 bcd	19.5 de	17.0 bc
70	22.5 cd	19.6 c	51.5	51.4 d	23.1 cde	16.3 c
to harvest	22.6 cd	19.4 c	58.3	52.6 cd	20.1 de	16.3 c

[a]Mean separation within columns by Duncan's multiple range test (5% level)

ficant yield difference whether the tomato plants were kept weed-free for only 14 DAT or throughout the duration of crop growth. On the other hand, weed infestations for more than 28 DAT significantly reduced yields. The difference between the winter and spring trials may be due to the type of competing weed. In the winter planting, the major weed was *Chenopodium album*, a fast-growing broadleaf weed, while grasses were dominant in the spring planting.

Herbicide screening for transplanted tomatoes

Eight herbicides at various application rates were evaluated for weed control in transplanted tomatoes in spring 1980. Metribuzin at 0.5 kg a.i./ha, oxyfluorfen at 1 kg a.i./ha, diphenamid at 6.0 kg a.i./ha, and alachlor at 2 kg a.i./ha were promising (Table 14). Only oxyfluorfen maintained good weed control until harvest. Higher herbicide rates were phytotoxic to tomatoes.

Irrigation and tomato fruit formation

Tomato yields are greatly affected by the competition between vegetative growth and flower or fruit formation. Suppressing vegetative growth through drought stress may therefore create favorable conditions for flower bud formation. To test this, four irrigation treatments bringing soil moisture up to field capacity when available soil moisture levels dropped to 80%, 60%, 40% or 20% were evaluated for tomato yields. Irrigating when available soil moisture levels fell to 40% resulted in the highest yield of 34.2 t/ha (Table 15). Irrigating when the soil was relatively wet (60%-80% available soil moisture) or relatively dry (20% available soil moisture) reduced yields. Yield differences were highly correlated with the number of fruits per plant.

Table 14. Effect of herbicides on weeds and tomato yields, spring 1980, AVRDC

Herbicide	Application rate (kg a.i./ha)	Total yield (t/ha)	Phytotoxicity (%)	Weed fresh weight (t/ha)	
				broadleaf	grasses
Alachlor	2	31.5	0	1.0	7.5
	4	29.2	33	0.1	7.9
Diphenamid	3	34.8	0	0.1	7.3
	6	35.8	2	0.3	3.9
Oxyfluorfen	1	46.2	10	0.0	2.2
	1.25	42.2	3	0.0	1.8
	1.50	37.7	17	0.0	1.3
Metribuzin	0.50	44.6	2	0.0	6.8
	0.75	42.2	0	0.3	8.0
Pendimethalin	1.0	22.4	12	0.3	9.3
	1.25	15.5	3	3.2	8.9
	1.50	11.2	30	6.9	10.6
Weedy check	-	23.7	0	2.4	8.1
Weed-free check	-	33.4	0	0.0	0.0

Table 15. Effect of irrigation on tomato fruit formation and yield, 1980, AVRDC

Available soil moisture at irrigation (%)	Yield (t/ha)		Fruit weight (g/fruit)	Fruit no./plant
	Total	Marketable		
80	28.4	27.5	54.5	22.9
60	31.0	29.7	54.7	25.3
40	34.2	32.4	56.1	27.3
20	31.0	29.4	57.1	24.1
non-irrigated check	20.7	19.8	35.5	17.4
LSD (.05)	5.4	5.2	NS	3.2

Soil compaction and sweet potato yield

Pot experiments were conducted in fall 1980 to determine the effect of soil compaction on sweet potato growth and yield. The highest root yields were attained in medium bulk density (1.3-1.5 g/cc) soil. Yields were reduced at higher or lower soil densities. The results indicate that low bulk density soil enhances vegetative growth but not root yield. A highly significant negative correlation between top growth and root yield was found.

Chinese cabbage response to fertilizer applications

Experiments were conducted in 1979 and 1980 to study the response of Chinese cabbage to various rates of nitrogen, phosphorus and potassium

Table 16. Chinese cabbage yield as affected by various rates of nitrogen, phosphorus and potassium fertilizer applications[a], 1980, AVRDC

Fertilizer application (kg/ha)		Total yield (t/ha)		Marketable yield (t/ha)	
		1979	1980	1979	1980
N	0	30.56 g	31.74	3.04 g	14.87
	70	60.47 e	48.70	21.88 f	24.73
	140	80.19 ab	53.95	40.03 ab	27.74
	210	86.73 a	50.81	45.33 a	26.77
P_2O_5	0	48.69 f	46.96	9.61 g	23.90
	40	63.07 de	47.34	25.36 ef	23.98
	80	73.96 bc	44.21	35.55 bc	22.52
	120	71.61 bcd	46.48	34.49 bcd	23.72
K_2O	0	70.09 bc	44.72	36.14 bc	23.44
	50	68.24 cde	47.71	31.10 cde	24.12
	100	66.63 cde	46.08	27.62 cdef	22.95
	150	64.40 cde	46.68	26.99 def	23.79

[a]Mean separation within columns by Duncan's multiple range test (5% level)

applications. In 1979, Chinese cabbage yields responded significantly to larger amounts of both N and P fertilizers, while greater K amounts reduced yields (Table 16). Nitrogen increased the marketable yield to 52% of the total yield (including outer leaves), up from the 10% marketable yield obtained from the plot without N application. In 1980, significant response was found only with N applications.

Chinese cabbage response to planting method

Direct-seeded Chinese cabbage produced higher total and marketable yields than transplanted Chinese cabbage (Table 17). Direct-seeded plants also matured earlier, and produced larger heads.

Table 17. Effect of transplanting and direct seeding methods on the growth of Chinese cabbage[a], winter 1979, AVRDC

Cultural method	Yield (t/ha)		Days to maturity (DAP)	Head circumference (cm)	
	Total	Marketable		equatorial	polar
Direct seeding	73.60 a	34.00 a	98.21 a	45.40 a	71.37 a
Transplanting	57.84 b	22.19 b	103.22 b	41.94 b	69.27 b

[a]Mean separation within columns by Duncan's multiple range test (5% level)

AGRICULTURAL ECONOMICS

Summer Chinese cabbage production in lowland central Taiwan

Data from a 1978 survey of 53 Chinese cabbage farmers in central Taiwan generated a fairly significant Cobb-Douglas function explaining about 67% of the variation in the logarithms of yield. The analysis showed that farmers used optimal amounts of seed and labor for mulching, and confirmed the preliminary results of 1979 which indicated inefficient use of nitrogen and pesticides. The major differences between the early and late summer harvests were identified and found to be closely related to two exogenous factors, weather and the price of Chinese cabbage.

Taiwan appropriate technology survey

The Taiwan appropriate technology survey was initiated to uncover and record traditional and contemporary technologies used in Taiwan for growing, marketing and processing farm crops and their by-products. Many areas outside Taiwan may find these technologies useful and appropriate for their needs as their agricultural systems develop.

Vegetable soybean study

The Agricultural Economics and Soybean Breeding programs have undertaken a cooperative study of the production, processing, marketing and consumption of vegetable soybean. The major growing areas are in Japan, Taiwan, Thailand, India and mainland China. Although soybean is reportedly consumed as a vegetable in Thailand and India, the major demand for vegetable soybean comes from Japan.

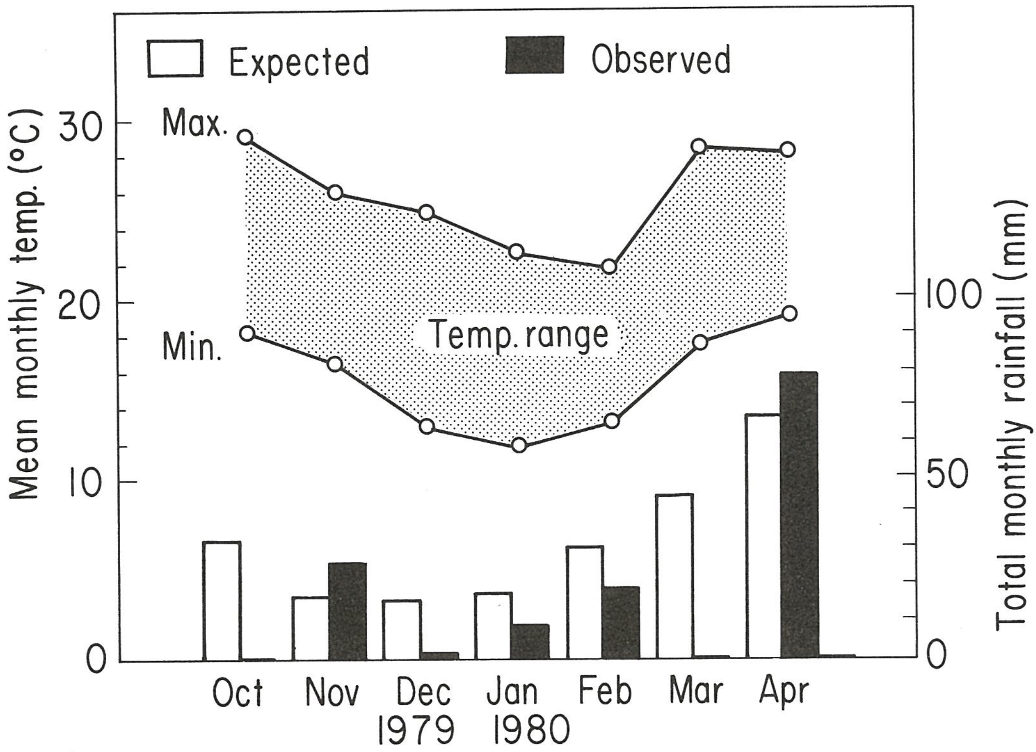


Fig. 1. Dry season rainfall and temperature, 1979-80, AVRDC

CROP ENVIRONMENT

The 1979-80 crop environment was one of the driest in Taiwan's history. Although the 1979-80 dry season deviated only slightly from normal patterns of precipitation, the 1980 wet season was extremely dry (Figures 1, 2 and 3). The rainfall total of 390mm was a record low for the wet season, the previous low being 601mm in 1923. Both temperature and solar radiation during the 1980 wet season were higher than that of 1979.

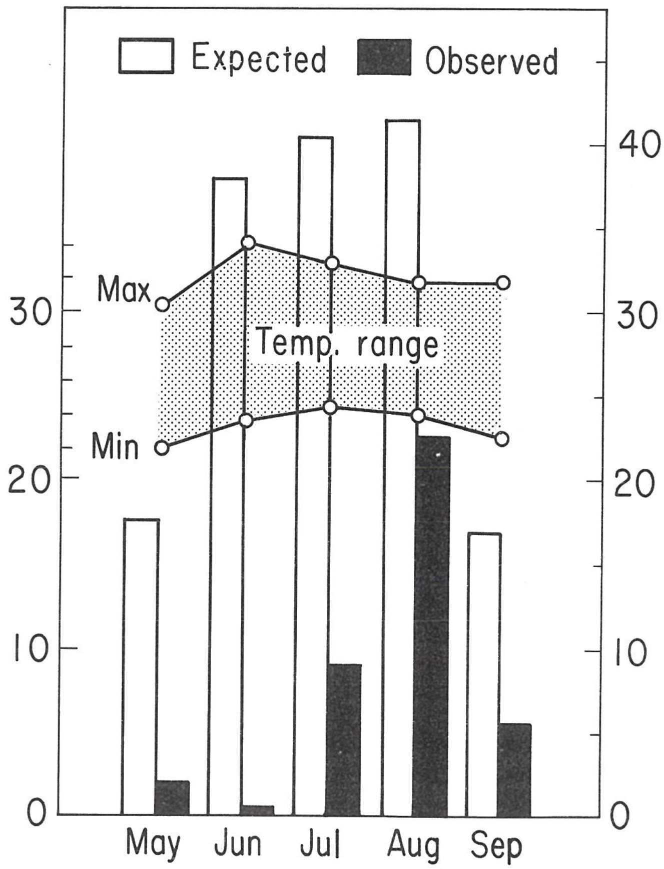


Fig. 2. Wet season rainfall and temperature 1980, AVRDC

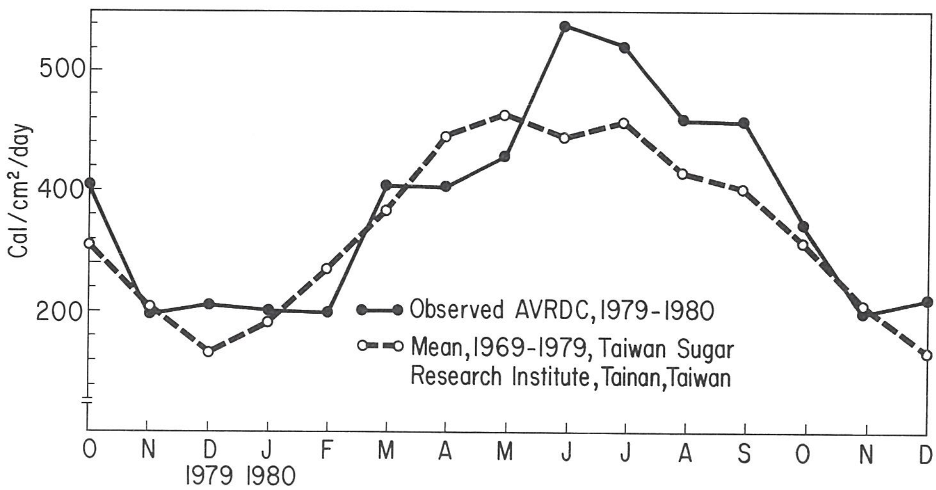
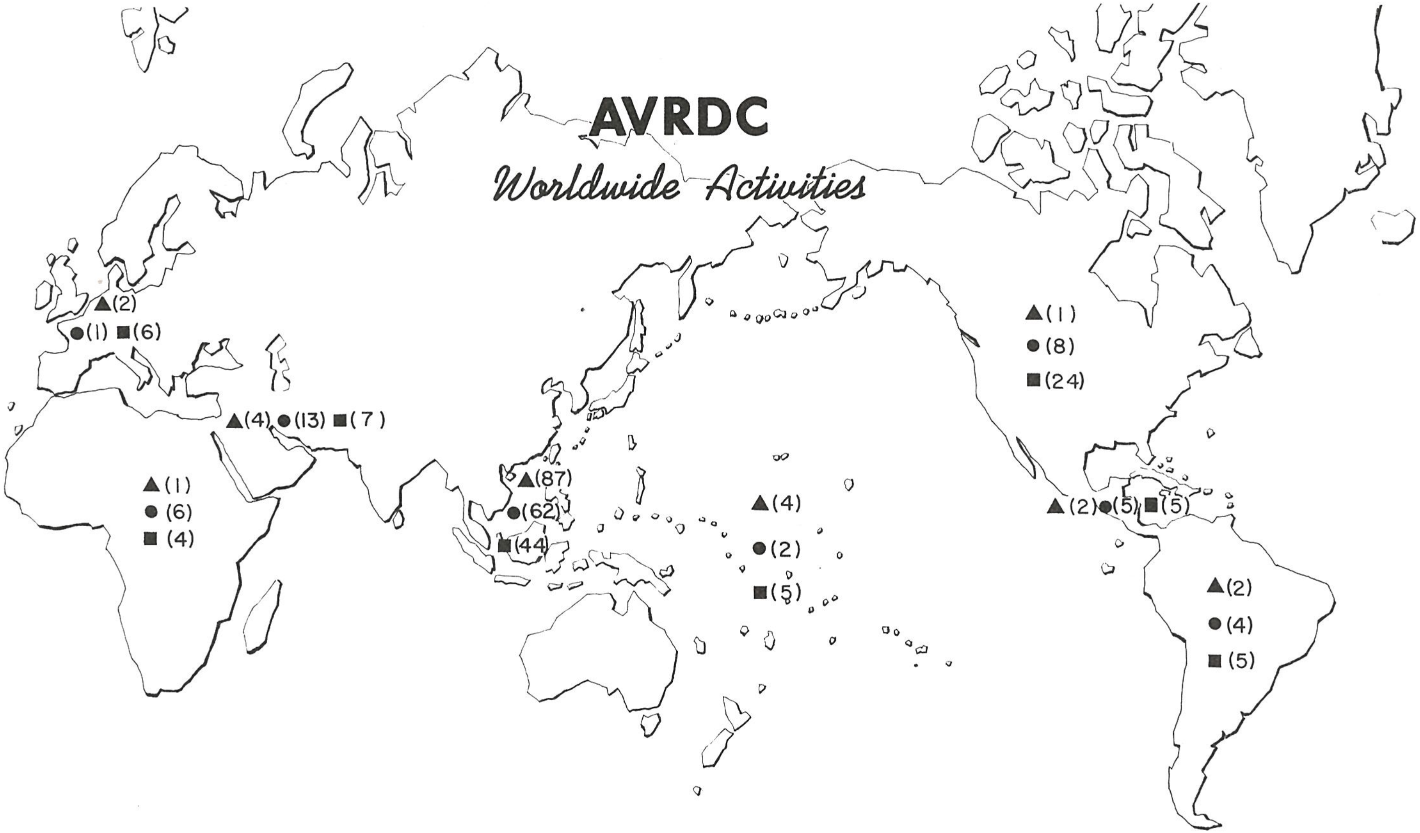


Fig. 3. Solar radiation, 1979-80, AVRDC



TRAINEES since 1973 ▲(% of Total)

SEED Packets Distributed since 1973 ●(% of Total)

PUBLICATIONS Distributed since 1973 ■(% of Total)

Outreach

Outreach is an essential element of AVRDC's research and training programs, facilitating germplasm and information exchanges, research coordination, and the development and testing of cultivars and management practices under a wide variety of agroclimatic conditions. In this effort, AVRDC's Seed Laboratory distributed in 1980 nearly 18,000 seed packets to researchers in 84 countries and territories, and more than 30,000 publications were despatched from the Center during the year. In March 1980, AVRDC joined with the International and Japanese Societies for Horticultural Science to sponsor the first international symposium on Chinese cabbage at Tsukuba Science City, Japan. More than 150 scientists from 15 countries attended the meeting.

The Center maintains close contact with cooperators in major universities, international and regional agricultural centers, and national agricultural programs in more than 20 countries. Extensive contacts have led to the establishment of formal Outreach Programs in the Philippines and Korea. A summary of the results obtained by cooperators in 1980 follows.

KOREA

The AVRDC Korean Outreach Program (KOP) operates from the Horticultural Experiment Station (HES) of the Office of Rural Development near Suweon.

Chinese cabbage

In 1980, two Chinese cabbage hybrids derived from AVRDC and HES germplasm were released to commercial seed companies after highly successful yield trials. The two hybrids, named Wonkyo 202 and Wonkyo 203, yielded an average 28.1 t/ha and 44.7 t/ha respectively in farmers' fields over four locations in 1980 trials.

Mungbean

An AVRDC mungbean accession from the Philippines (V 3476) was released to farmers in southern Korea under the local name Bangasa after two years of trials over nine locations. It was chosen for its high yield, lodging resistance and uniform maturity. In Korean regional mungbean yield trials, AVRDC mungbean line VC 1973 Sel A outyielded local checks by an average 20% over eight locations, showing insensitivity to long day conditions.

Soybean

For the past several years, AVRDC has worked through the KOP to assist the Korean national soybean breeding program by advancing generations and multiplying soybean seed in Taiwan. In 1980, the Center successfully completed a generation advance for multiplication of 48 F_2 soybean crosses in which 40 kg seed was returned to Korea. For F_3 and F_4 soybean lines, seed was multiplied from 4463 single plants for a total of 250 kg soybean seed which was sent to Korea for planting. The Korean soybean breeding program is also evaluating AVRDC germplasm, and AVRDC soybean selection AGS 62 shows promise with good growth and early maturity.

PHILIPPINES

The AVRDC Philippines Outreach Program (POP), based at the Economic Garden Experiment Station in Los Baños, has been fully incorporated with the Philippines national agricultural research program since 1977.

Soybean

In the POP's preliminary evaluations of AVRDC soybean breeding lines, AVRDC selections GC 50217-3-6-10 and GC 50121-7-8-7 yielded 2.42 t/ha and 2.21 t/ha respectively in the dry season against yields of 1.01 t/ha to 1.26 t/ha from check cultivars L 114 and Taita Kaohsiung No. 5. In wet season trials, AVRDC soybean selection GC 50188-7-8 yielded 2.27 t/ha. Of 26 soybean lines screened by the POP in the wet season for rust resistance, G 8587, G 8586 and GC 60061-8-9 rated resistant.

At the POP La Granja Experiment Station, three AVRDC soybean lines (GC 40061-4-0-5-7, GC 50136-7-7-4 and GC 40061-4-0-5-6) yielded from 1.42 t/ha to 1.77 t/ha compared with 1.12 t/ha from check Taita Kaohsiung No. 5 in wet season trials. GC 40061-4-0-5-6 was also the highest yielder in dry season trials, producing 2.29 t/ha.

Mungbean

Mungbean breeders at the POP Economic Garden evaluated 62 mungbean lines under heavily epiphytotic conditions for resistance to *Cercospora* leafspot. Accessions V 4574, V 4658, V 4679 and V 4799 showed a high level of resistance but they were low yielding and late maturing. AVRDC mungbean lines VC 1481 Sel B, VC 1089 Sel B and VC 1160-2B-14-2-2B-2-

2B were less resistant but had outstanding agronomic characters, leading to their selection for farmers' field trials.

In a trial of 100 promising AVRDC mungbean lines, 40 were selected for a 1981 preliminary yield trial on the basis of yield, seed coat color and plant appearance. Two of these lines, VC 1089 Sel B and VC 1519-B-4-1-1-3B, yielded more than 2 t/ha compared with 1.06 t/ha from check cultivar Pag-asa (V 3476). In dry season trials at the POP La Granja Experiment Station, AVRDC mungbean line VC 1160-54-C yielded 1.14 t/ha against 0.96 t/ha and 0.73 t/ha from seedboard cultivars CES 10-21 and MG 50-10A respectively.

Cooperators with the Philippines Atomic Energy Commission (PAEC) reported that AVRDC mungbean line VC 1560 Sel A yielded 2.91 t/ha in a February planting, and VC 1628 Sel A yielded 2.71 t/ha against 1.65 t/ha from local check PAEC 3 in an April planting.

Chinese cabbage

In a September planting of nine open-pollinated and four hybrid Chinese cabbage cultivars at the Economic Garden, AVRDC lines 77 M(2)-46 and hybrid #58 yielded 16.6 t/ha and 16.3 t/ha respectively compared with 8.4 t/ha from check cultivar B 189 C_1. In a November planting, hybrids #58, #59 and #62 yielded 17.6 t/ha, 19.2 t/ha and 18.8 t/ha respectively against 10.7 t/ha from B 189 C_1. The head weights of the three hybrids ranged from 0.77 kg to 0.80 kg, nearly twice that of the check.

In a 1979 wet season trial of open-pollinated Chinese cabbage cultivars conducted by the Bureau of Agricultural Extension, AVRDC line 77 M (2/3)-41 yielded 22.2 t/ha with a mean head weight of 0.77 kg, compared with 15.9 t/ha and 0.51 kg heads from B 189. The Institute of Plant Breeding reported that AVRDC Chinese cabbage lines 77 M(3)-35 and 77 M(3)-44 yielded 17 t/ha at Mount Banahaw in Quezon Province. The check cultivar, Nagaoka Tropicana, yielded only 7 t/ha.

Tomato

AVRDC tomato line CL 1529-0-0-5-1 gave a marketable yield of 29.22 t/ha in dry season preliminary yield trials conducted at the POP Economic Garden. AVRDC line CL 1094 F5-88 yielded 28.7 t/ha with an average fruit weight of 93.9 g, compared with 17.5 t/ha and 28.6 g fruits from check cultivar Pope. In preliminary yield trials at the POP Bicol Experiment Station, AVRDC tomato line CL 32d-0-1-25-0-0-0 yielded 16.3 t/ha and showed good resistance to bacterial wilt. Check cultivar Pope yielded 10.9 t/ha.

In preliminary dry season trials of AVRDC SSD tomato selections at the Misamis Oriental Horticultural Research Center in Claveria, four AVRDC crosses and one AVRDC accession yielded from 37.6 t/ha to 39.8 t/ha compared with 31.9 t/ha from local check BPI-TM-1. AVRDC lines CL 32d-0-1-25 and CL 32d-0-1-13 yielded more than 43 t/ha in wet season trials. BPI-TM-1 yielded 40.1 t/ha.

In POP evaluations of 13 SSD tomato lines over two dry seasons in Claveria, AVRDC tomato line CL 505-49 produced a mean yield of 51.8 t/ha, compared with mean yields of 40.9 t/ha and 30.9 t/ha for check cultivars Marikit and BPI-TM-1 respectively. In a similar trial over two wet seasons, AVRDC tomato line CL 505-1 had the highest mean yield of 38.2 t/ha.

In trials conducted by cooperators at the Bicol Experiment Station, AVRDC tomato selection CL 143-0-1-3 outyielded the check cultivar by 200%.

Sweet potato

A cooperator with the Agricultural Extension Service in Laguna evaluated nine AVRDC sweet potato breeding lines under rainfed conditions. AVRDC line CI 591-14 yielded 23 t/ha and six other AVRDC lines yielded from 17 t/ha to 20 t/ha compared with 11 t/ha from check cultivar Tinirining.

In preliminary sweet potato trials conducted at the POP Economic Garden, AVRDC sweet potato line CI 590-33 yielded 44.4 t/ha in the dry season and CI 580-1 yielded 25.6 t/ha in the wet season. The respective yields for check cultivar BNAS were 20.5 t/ha and 15.6 t/ha.

TAIWAN

Trials in cooperation with ROC national agricultural programs and other organizations in Taiwan were coordinated by the AVRDC Development Program.

Soybean

AVRDC soybean varieties performed well in ROC national program trials in 1980, demonstrating high yields, photoperiod insensitivity, wide adaptability and resistance to bacterial pustule. AVRDC soybean selection AGS 17, a high yielding cultivar suitable for slopeland cultivation, is being evaluated as a replacement for the currently used variety Palmetto. In summer trials at the Hualien District Agricultural Improvement Station (DAIS), AVRDC selection AGS 12 yielded 3.3 t/ha over two locations against 2.7 t/ha from check cultivar Kaohsiung No. 3. At the Tainan DAIS, AGS 12 again yielded well (2.2 t/ha), compared with cultivars H 15 (1.7 t/ha) and Kaohsiung No. 3 (1.5 t/ha). In spring trials at the Tainan DAIS, AGS 58 yielded 3.6 t/ha against 2.9 t/ha from check Shih Shih, and AGS 85 outyielded the check cultivar H 15 by 11% over three locations with an average yield of 2.8 t/ha.

In a fall 1980 planting by farmers in Lunyang, AVRDC selections AGS 62 and AGS 66 yielded 2.95 t/ha and 2.41 t/ha respectively compared with 2.22 t/ha from H 15, the locally recommended cultivar. These two selections together with AGS 85 will enter further evaluations by the Tainan DAIS throughout the Chianan area in 1981 spring and summer plantings.

Mungbean

In regional mungbean yield trials conducted in 1980 by Tainan DAIS, farmers were impressed by the high yields, uniform maturity and heavy top podding of AVRDC lines VC 1628 Sel A and V 3476.

Because of the drought conditions during 1980, many farmers in the Chianan area could not plant their traditional second crop of rice. Farmers at Liew Chia planted AVRDC mungbean line VC 1628 Sel A instead, and were able to obtain yields of 1.8 t/ha. By comparison, farmers planting local varieties of mungbean got little or no yield.

In yield trials conducted by Tainan DAIS over four locations in the Tainan area, VC 1628 Sel A again gave outstanding performance, yielding an average of 1.72 t/ha against 1.27 t/ha from the best local variety. VC 1628 Sel A and V 3476 have both been recommended by Tainan DAIS to the Provincial Department of Agriculture and Forestry (PDAF) for release and will be included in 1981 summer demonstration trials conducted by Tainan DAIS.

Tomato

AVRDC tomato lines L 33 and VC 8-1-2-1 were used as parent sources of heat tolerance and bacterial wilt resistance by the Taiwan Seed Service (TSS) to produce three tomato hybrids, TSS 1, 2 and 3. The superior bacterial wilt resistance of TSS 1 has led to its release by PDAF.

AVRDC's processing tomato lines continue to have significant impacts on commercial tomato production on Taiwan. During the 1980 cropping season, approximately 20% of the 6000 hectares planted to processing tomato were planted to tomato lines developed, selected or improved at AVRDC. Two new processing lines developed at AVRDC, CL 1561-6-0-5-1-3 and CL 1591-5-0-1-2-0, will be evaluated in fall 1981 trials conducted by Tainan DAIS.

Chinese cabbage

Experimental seeds of heat tolerant Chinese cabbage hybrids #58 and #62 were supplied to the Lunyang Cooperative Farm in Chiayi for summer 1980 plantings. Both hybrids outperformed the local variety under the drought conditions of 1980 summer, yielding from 22 t/ha to 23 t/ha, producing larger heads at a greater heading rate, and maturing earlier. These two hybrids and two other AVRDC Chinese cabbage lines will be included in 1981 regional yield trials conducted by PDAF over five locations throughout Taiwan.

Sweet potato

Despite AVRDC's selection pressure for minimum input sweet potato varieties, AVRDC lines performed comparably against check cultivars in trials conducted in 1980 by Taichung and Tainan DAIS's. In autumn plantings in Hualien, AVRDC materials outyielded the check cultivars although their eating quality was rated from poor to fair. These materials, however, may be useful as breeding materials for high yield potential.

AVRDC sweet potato lines were entered in regional yield trials conducted by Hsinchu DAIS, and in advanced yield trials at the Chiayi Agricultural Experiment Station. Under the low input, 120-day trial at Chiayi, AVRDC lines AIS 0122-2 and AIS 35-2 produced the second and third highest marketable yields of 17.79 t/ha and 16.74 t/ha respectively.

THAILAND

Soybean

In regional soybean yield trials over nine locations, AVRDC soybean selections GC 30229-12 and GC 30229-8 gave the highest mean yields over all locations with 2.1 t/ha and 2.0 t/ha respectively. Although the two selections are high yielding, their levels of resistance to anthracnose must be increased before they can be released.

Chinese cabbage

AVRDC hybrids #30 (LV) and #58 yielded about 12 t/ha each at trials near Bangkok, outyielding the check by four-fold. Semi-commercial plantings of AVRDC hybrids will begin in Thailand in 1981.

Sweet potato

Researchers at the Fang Horticultural Experiment Station in Chiangmai reported that seven AVRDC sweet potato lines outyielded check cultivar Tainung 57 by 27% to 89% in summer season evaluations. AVRDC line CI 590-33 was the highest yielder with 34 t/ha. All of the AVRDC lines had higher beta-carotene contents than the local checks.

INDONESIA

Soybean

Since 1979, the ROC Agricultural Technical Mission has worked in cooperation with the Agricultural Development Center in East Java, Indonesia, in evaluating AVRDC pure line soybean selection G 2120 in Desa Bulupasar. The cultivar has demonstrated high yields both as a monoculture and as an intercrop with sugarcane. The Mission multiplied seed of G 2120 for distribution to local farmers in 1980, and is currently working with ADC officials to expand the planted area to 1000 hectares.

Chinese cabbage

From two years of Chinese cabbage trials over three locations in Indonesia, researchers at the Horticultural Research Institute selected four AVRDC open-pollinated lines and AVRDC hybrids #58 and #59 for regional yield trials over six locations in 1981. The most promising entry from these trials will be prepared for release.

Tomato

After six years of evaluation, the demonstrated heat tolerance and bacterial wilt resistance of AVRDC tomato lines led to the release of two AVRDC pure line selections in 1980 by the Indonesian national agricultural program. Seed of these two cultivars, named Intan and Ratna by the Indonesian authorities, are being multiplied at AVRDC at the request of the national program for distribution to Indonesian farmers.

JAPAN

Soybean

Soybean lines collected and improved at AVRDC have been distributed to several breeding programs in Japan. In 1980, the Okayama Prefectural Experiment Station evaluated ten AVRDC soybean accessions and two breeding lines and reported that AVRDC accession Ta Lien Tou (G 9951) yielded 4.7 t/ha in 97 days compared with 3.0 t/ha in 91 days from the check cultivar Koganedaizu. In a second trial, AVRDC soybean breeding line AGS 17 (GC 30050-2-17) produced 5.7 t/ha in 110 days, outyielding the check Koganesiro by 2.0 t/ha. However, the seed size of AVRDC soybean is not yet suitable for the Japanese market.

Narrow-leaved soybean lines from AVRDC which are insensitive to daylength are presently being evaluated at the Ishigaki branch of the Tropical Agricultural Research Center in Okinawa, and AVRDC germplasm with resistance to purple seed stain disease has been sent to the National Tohoku Agricultural Experiment Station in Akita.

Tomato

AVRDC has supplied several tomato parent materials to Japan for bacterial wilt resistance screening, and scientists at the Vegetable and Ornamental Crops Research Station have identified two AVRDC tomato breeding lines, CL 32d-0-1-4-0 and CL 246-0-4B-2-0, with excellent resistance to Japanese bacterial wilt strains. The lines are being used to develop resistant Japanese tomato cultivars.

The Takii Seed Company in Japan has successfully incorporated the bacterial wilt resistance of tomato lines supplied by AVRDC into susceptible local cultivars and will begin conducting large-scale trials in 1981.

INDIA

Soybean

After five years of soybean trials over 26 locations, AVRDC pure line soybean selection G 2120 was released to farmers in Tamilnadu. Named Kudimiamalai 1 (KM 1) by Indian authorities, the cultivar yielded an average 1.7 t/ha in multilocation and multiseason trials.

Tomato

In preliminary plantings by cooperators at the University of Agricultural Science in Bangalore, AVRDC tomato selections CL 1591-5-0-1-6 and CL 1591-5-0-1-7 outperformed local cultivars and will be included in large-scale trials in 1981.

Researchers at Punjab Agricultural University screened 187 AVRDC tomato breeding lines for resistance to several diseases. Five lines showed a high level of resistance to *Septoria* leafspot, 25 lines showed no incidence of bacterial pustule, 19 lines were unaffected by root-knot nematode, four lines showed resistance to early blight, and two lines had a 25% incidence of late blight.

Sweet potato

In trials conducted over three seasons by cooperators at Tamilnadu Agricultural University, AVRDC sweet potato selection CI 210 produced an average 51 t/ha, a yield comparable to those of the checks Co 1 (45 t/ha) and W 13 (52 t/ha) and far superior to the national average of 7 t/ha.

BANGLADESH

Soybean

Thirty-five AVRDC soybean lines were evaluated in late kharif (September) and rabi (January) plantings. Five lines (GC 30217-2-2, GC 30156-8, GC 30098-1, GC 30094-2-4 and GC 30156-6) outyielded the check cultivar Bragg, producing 2.7 t/ha to 3.1 t/ha in the January planting, and 1.9 t/ha to 2.2 t/ha in the September planting.

Mungbean

Five of 16 mungbean lines provided by AVRDC performed well in spite of mungbean yellow mosaic virus (MYMV) infections, producing from 1.16 t/ha to 1.6 t/ha at Joydebpur against 0.72 t/ha from the local check. Cooperators with the Mennonite Central Committee reported that two mungbean lines introduced by AVRDC (ML-3 and 71-27) outyielded local checks by 75% at Char Bata, with ML-3 yielding 1.57 t/ha. Both lines showed resistance to MYMV.

Tomato

Four AVRDC tomato lines (CL 143-0-4B-1 and SSD lines 10, 29 and 40) have been recommended by the Mennonite Central Committee for large-scale trials after proving superior to local check cultivars. The AVRDC materials have yielded from 40 t/ha to 47 t/ha and all demonstrate resistance to bacterial wilt and virus diseases.

Sweet potato

AVRDC sweet potato lines AIS 35-2, AIS 230 and AIS 0122-2 have been selected for further testing after proving better than local varieties in low-management trials conducted by the Mennonite Central Committee.

OTHER ASIAN COUNTRIES

Malaysia

Cooperators at the Malaysian Agricultural Development Institute evaluated AVRDC Chinese cabbage materials at Jalan Kebun. Although yields for the hybrids and open-pollinated lines were low (11.7 t/ha to 12.5 t/ha), the advantage of their heat tolerance (89% - 98% heading rate) was evident when compared with heat sensitive check B 40 which failed to yield.

Nepal

In an initial soybean evaluation trial conducted in Khumaltar, AVRDC narrow-leaved soybean selection AGS 19 produced 2.5 t/ha in 113 days. Four other lines provided by AVRDC yielded from 2.0 t/ha to 2.3 t/ha.

Pakistan

AVRDC soybean breeding lines GC 30050-2-17 (2.08 t/ha) and GC 30257-1-7 (1.81 t/ha) outyielded local check cultivar Columbus (1.68 t/ha) in spring, and GC 30109-2-13 (2.10 t/ha) and GC 30067-0-8 (1.91 t/ha) outyielded Columbus (1.69 t/ha) in summer sowings at Tando Jam, Sind.

Sri Lanka

AVRDC soybean breeding lines GC 30090-1-8, GC 30120-38-55 and GC 30134-67 yielded from 3.8 t/ha to 4.0 t/ha in national program trials. The local check yielded 2.9 t/ha by comparison.

After five years of tomato trials conducted by the Central Agricultural Research Institute in Peradeniya, AVRDC tomato selection CL 32d-0-1-2 was released to farmers in Sri Lanka.

SOUTH PACIFIC

Guam

After conducting trials of AVRDC tomato materials for the past three years, the Guam Agricultural Experiment Station released two AVRDC tomato lines to Guam's farmers. The two lines, CL 143-0-6-9 UG and CL 143-0-4B-

1 UG, demonstrated excellent fruit set ability and resistance to fruit cracking and diseases. Named Lee's Plum and Royal Guam by Guam authorities, the two cultivars yielded up to 68 t/ha in trials prior to release.

Ponape

AVRDC sweet potato selections CI 551-3, CI 431-22 and CI 590-13 were reported promising.

Solomon Islands

A total of 170 sweet potato seeds derived from a cultivar found resistant to witch's broom disease in Taiwan were provided by AVRDC to cooperators in the Ministry of Agriculture and Lands. After an initial screening, 15 lines were retained for further testing on the basis of their low disease incidence and acceptable yields.

Tahiti

AVRDC sweet potato materials yielded up to 90% more than the local check in trials over two locations in Papeete. The orange flesh of the AVRDC lines, however, seems not to match local tastes.

Fiji

AVRDC mungbean breeding line VC 1160-1-213 has yielded well over two seasons, producing an average 1.5 t/ha and showing good disease resistance.

AFRICA

Zimbabwe

Eleven AVRDC soybean breeding lines and 48 accessions were sent to the Crop Breeding Institute in Causeway for photoperiod sensitivity evaluation. Three lines (GC 60020-18, GC 60058-13 and GC 60058-15-1) and 45 accessions rated photoperiod insensitive for both days to flowering and maturity.

Somalia

AVRDC mungbean lines VC 1209 Sel B and VC 1168 Sel B yielded 1.91 t/ha and 1.63 t/ha respectively compared with 0.63 t/ha from the local check. Both lines were highly resistant to *Cercospora* leafspot. Researchers have requested more seed for multiplication.

Tanzania

A total of 246 mungbean lines from AVRDC were screened for resistance to *Cercospora* leafspot, powdery mildew, mungbean scab and bacterial leafspot. Three lines (V 1276, V 1353 and V 1483) were free from infection by *Cercospora cruenta*. Twenty-five lines rated highly resistant to powdery mildew, and seven other lines showed only trace infections of the destructive disease. Sixteen AVRDC lines were resistant to bacterial leafspot.

Zambia

AVRDC mungbean accession V 2184 has outperformed local varieties on four hectares and is favored by local farmers because of its high yield and cooking quality.

At the National Irrigation Research Station in Mazabuka, AVRDC tomato lines yielded from 12 t/ha to 34 t/ha in summer observation trials. CL 123-2-4, CL 1561-6-0-22-4, CL 143-0-10-3 and L 387 each yielded at least 26 t/ha, compared with 13 t/ha and 14 t/ha from checks VF Roma and Moneymaker respectively.

Upper Volta

Cooperators at the Horticultural Center of the Adventists Mission planted AVRDC tomato materials during the hottest season of the year. Five AVRDC tomato lines yielded at least 28 t/ha and AVRDC selection CL 1591-5-0-1-6 produced a marketable yield of 59 t/ha compared with the national average tomato yield of 4 t/ha.

Togo

AVRDC tomato breeding lines yielded from 12 t/ha to 35 t/ha in trials in Lome. Outstanding entries were CL 123-2-4 (35 t/ha), CL 143-0-10-3 (29 t/ha), CL 1561-6-0-22-4 (26 t/ha) and CL 1591-5-0-1-6 (26 t/ha).

AMERICAS

Guatemala

AVRDC soybean selection AGS 62 yielded 1.8 t/ha in 83 days compared with 1.3 t/ha in 83 days from local check CES 23P. Four other AVRDC selections (AGS 143, AGS 124, AGS 66 and AGS 144) yielded from 1.6 t/ha to 1.7 t/ha in 80-84 days.

Honduras

AVRDC soybean selection AGS 29 (GC 30251-1-1) was released as Darco-1 after demonstrating high yields, early maturity and resistance to *Cercospora sojina* compared with local cultivars (Table 1). The national program is currently extending seed to three regions.

Three AVRDC tomato lines (CL 32d-0-1-1-9, L 1 and L 274) appear promising in the coastal lowlands of Honduras, and may be included in the Comite Evangelico de Desarollo y Emergencia Nacional Village development program.

Table 1. Yield and agronomic performance of AVRDC soybean selection GC 30251-1-1 in Honduras[a], 1980

Cross or cultivar name	Yield (t/ha)	Days to flower	Days to maturity	*Cercospora sojina* rating[b]	Yield/day (kg/ha)
GC 30251-1-1[c]	2.1 a	42	98	1.0	21
2523-F_2-1-20C	2.0 a	42	115	1.5	17
GC 50136-8-8	1.7 b	42	95	1.0	18
S-194	1.3 de	43	112	4.0	12
Siasta-44 (check)	1.0 e	42	96	3.5	10

[a]Sown July 21, 1979 in 10m x 7m plots with four replications
[b]1 = low disease incidence, 4 = high disease incidence
[c]Released as Darco-1
Mean separation within columns by Duncan's multiple range test (5% level)

Nicaragua

AVRDC soybean selection AGS 17 was the highest yielding entry with 2.9 t/ha and 2.6 t/ha in respective trials at Managua and Rivas. The selection was also identified as early maturing and disease resistant.

USA

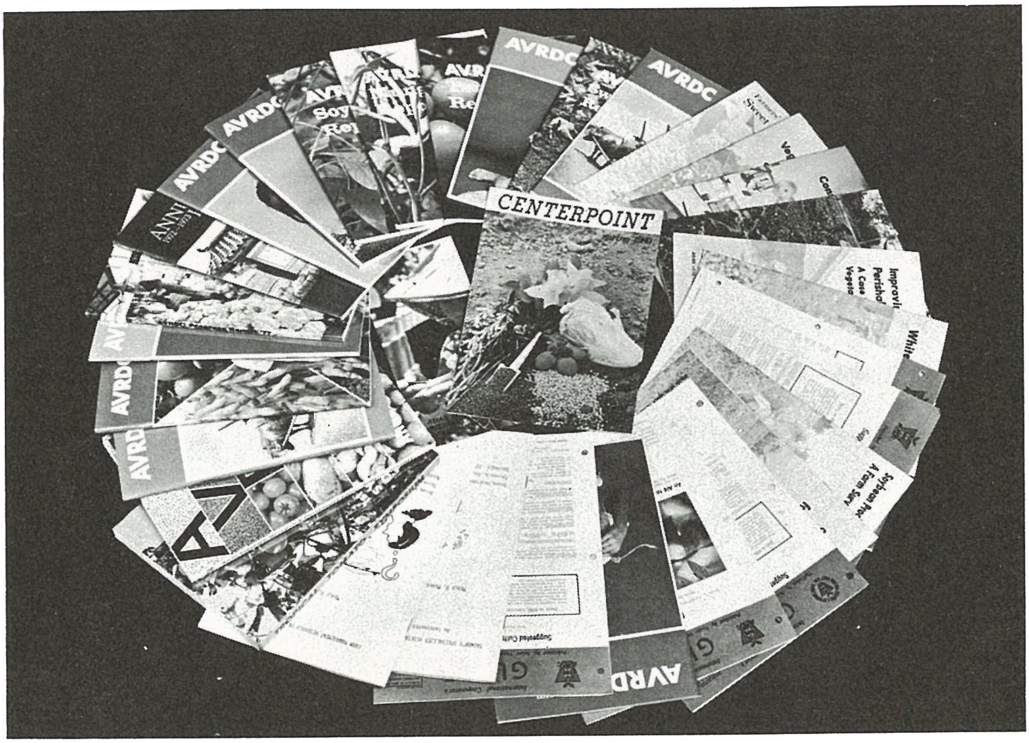
Initial soybean cooperation was established between AVRDC and the Land O'Lakes Seed Company to advance their single seed descent soybean lines in autumn and spring seasons.

AVRDC tomato lines are performing well in US trials, with CL 143-0-10-3, CL 9-0-0-1 and CL 123-2-4 rating among the four most promising cultivars in trials at the University of Arizona experimental farm at Marana. The three lines appear well-adapted to Arizona's extreme summer heat and solar radiation. The Catalina Heights Nursery in Arizona has been selling tomato seedlings of AVRDC accession L 245, a line popular with home gardeners. Scientists at Louisiana State University have been using AVRDC tomato breeding lines in their program to develop heat tolerant tomato hybrids. Researchers at the University of Illinois have made back-crosses with several tomato materials including CL 11d in an effort to produce seedless cultivars capable of bypassing the temperature-sensitive fertilization process.

Training

The AVRDC staff has trained 273 people from 25 countries in vegetable research and production techniques since the international training program was started in 1974. The program offers six kinds of training to students, scientists, extension workers and production specialists who are engaged in increasing vegetable production in their countries. It also provides opportunities and resources for individually tailored projects. All participants conduct their work under the guidance of AVRDC scientists. Classroom lectures in the basic sciences involved are provided by the Training and Development Office.

In 1980, a total of 44 people from 13 countries completed the training program, working on 56 projects in the legume and horticultural crops, communications, pest management, and crop and soil management. A PhD candidate from Louisiana State University worked on a multiple cropping project toward a dissertation on increasing rainy season vegetable production in Ilocos Norte, Philippines. Other Research Scholars included a student from the University of Illinois who studied soybean rust and purple seed stain disease, two students from the Agricultural University in Wageningen, the Netherlands, who conducted bed height studies for Chinese cabbage and tomato, and a student from National Taiwan University who analyzed the nutritional value of protein isolated from mungbean and blackgram.



Communications and Research Services

SEED TECHNOLOGY

During 1980, AVRDC seed technologists multiplied the seed of 2959 soybean, 2211 mungbean, 859 sweet potato, 408 tomato, 31 Chinese cabbage, 85 amaranth and 29 winged bean accessions. The Seed Laboratory distributed 17,968 seed packets to scientists in 84 countries and territories.

Cooperation is being maintained with the Taiwan Vegetable Gene Bank Project which was transferred from National Chung Hsing University to the Taiwan Agricultural Research Institute, Taichung, in 1979.

STATISTICAL SERVICES AND COMPUTING CENTER

A total of twelve research groups used the statistical services at AVRDC in 1980, with the departments of Plant Breeding and Agricultural Economics accounting for more than 60% of the demand. Through a grant agreement between AVRDC and IBM Taiwan Corporation, AVRDC scientists are provided with equipment, CPU time and access to the IBM System/370 Model 158 located at the IBM Data Center in Taipei.

OFFICE OF INFORMATION SERVICES

Publications

In 1980, the Office of Information Services produced fifteen publications of various kinds and assisted in the publication of six journal papers. Nearly 30,000 publications were despatched during the year.

More than 3200 people in 141 countries regularly received publications at the end of 1980, including the new quarterly magazine CENTER-POINT.

Photographic services

The photographic unit processed or handled 6500 black and white prints, 3000 color prints, 10,000 color slides and 3000 blue slides.

Contacts with the public and press

OIS mailed 18 press releases in 1980, and the research activities of AVRDC were featured in the media in several countries.

AVRDC staged two all-Chinese exhibitions, one at the Taichung provincial library and one at National Taiwan University in Taipei.

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    Yun-hua Lee, B.S., *research assistant***

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Hsien-yang Tien, B.S., *computer services assistant*

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Alfredo Palo, Ph.D., *affiliate horticulturalist, Philippines Outreach Program*

Soon Bum Hong, Ph.D., *affiliate horticulturalist, Korean Outreach Program*

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* Left during 1980
**Arrived during 1980
@ Sabbatical leave during 1980

Finances

Total income designated for AVRDC's 1980 budget was US$2,381,536 compared with a program budget calling for US$2,416,400. The Republic of China contributed US$1,036,060, and the United States Agency for International Development contributed US$600,000. The Republic of the Philippines and the Republic of Korea each contributed US$82,500, while Japan contributed US$75,000 and the services of a soil scientist. Miscellaneous grants for general purposes were received from USI Far East Corporation, United Polymers Corporation, Land O'Lakes Inc, Bima Industries Inc and Ms Rosita Chua. Special projects were supported by the United States Department of Agriculture, the United States Agency for International Development, the German Agency for Technical Cooperation (GTZ) and the ROC Council for Agriculture Planning and Development. A Post-Doctoral Fellowship was sponsored by the Rockefeller Foundation.

Publications Available

<u>Journal Papers</u>

JP 1 Mackenzie, Photoperiodism of mungbean and four related species

JP 7 Mew, Infectivity and survival of soft-rot in Chinese cabbage*

JP 8 Talekar, Persistence of some insecticides in subtropical soil*

JP 9 Mew, Effect of soil temperature on resistance of tomato cultivars to bacterial wilt

JP 11 Menegay, Crop intensity index: a research method of measuring land use in multiple cropping*

JP 13 Opeña, Derivation of maternals through pseudogamy and evaluation of their potential importance in Chinese cabbage breeding*

JP 24 Villareal, Heat tolerance in the genus *Lycopersicon**

JP 27 Kuo, Translocation of 14-C-photosynthate in *Vigna radiata* during the reproductive period

JP 29 Lim, Resistance in Chinese cabbage to TuMV*

JP 32 Villareal, The wild vegetables of southeast Asia*

JP 35 Calkins, Labor and input variability in determining vegetable production technology in Asia*

JP 39 Villareal, Variations in the yielding ability of sweet potato under water stress and minimum input conditions*

JP 40 Villareal, Selection criteria for eating quality in steamed sweet potato roots*

JP 44 Shanmugasundaram, Photoperiodic response of flowering in decapitated soybean plants*

JP 45 Opeña, Genetic control of heat tolerance in heading Chinese cabbage*

JP 48 Riley, Intensive agricultural practices in Asia

JP 50 Hubbell, The Germplasm Accession Information System at the Asian Vegetable Research and Development Center

JP 51 Tschanz, Soybean rust development and apparent infection rates at five locations in Taiwan

JP 53 Kuo, Physiological responses of different tomato cultivars to flooding

JP 54 Kuo, Tipburn of Chinese cabbage in relation to calcium nutrition and distribution

JP 55 Shanmugasundaram, Flower inducing 'potency' of different kinds of leaves in soybean

JP 58 Kuo, Variation in specific leaf weight and RuDPCase activity in mungbean

JP 59 Chiang and Talekar, Identification of sources of resistance to agromyzid beanflies in soybean and mungbean

JP 60 Kuo, Effect of high temperature on pollen grain germination, pollen tube growth and seed yield of Chinese cabbage

JP 61 Kuo, Flower initiation of *Brassica* species under total darkness

JP 62 Villareal, Cultivar responses of tomatoes to relay cropping

JP 63 Kuo, Effect of Chinese cabbage residue on mungbean

JP 64 Talekar and Lin, Two sources with differing modes of resistance to *Callosobruchus chinensis* in mungbean

JP 65 Shanmugasundaram, Varietal differences and genetic behavior for the photoperiodic responses in soybean

Technical Bulletins

TB 1 Menegay, Taiwan's specialized vegetable production areas

TB 2 Menegay, Farm management research on cropping systems

TB 3 Calkins, Four approaches to risk and uncertainty for use in farm management extension

TB 4 Calkins, Farmer's viewpoint on sweet potato production

TB 5 Calkins, Vegetable consumption in five Taiwan cities

TB 6 Huang, Summer tomato production in Taiwan

TB 7 Huang, Vegetable production in Taiwan: a survey of 300 farmers

TB 10 Calkins, White potato production in Taiwan: a farm survey*

TB 12 Riley, Evaluation of environmental parameters in the humid tropics for crop scheduling purposes

International Guide Sheets

78-63 Park, Suggested cultural practices for mungbean

78-64 Park, Procedures for mungbean evaluation trials

78-65 Villareal, Pollen collector

78-66 Riley, AVRDC crop environment

78-101 Villareal, Procedures to coordinate tomato evaluation trials

78-112 Shanmugasundaram, Suggested cultural practices for soybean

79-121 Hubbell, Suggested cultural practices for sweet potato

79-125 Shanmugasundaram, Procedures for soybean evaluation trials

79-127 Kuo, Suggested cultural practices for tomato

80-134 Villareal, Procedures for sweet potato evaluation trials

80-144 Opeña, Procedures for Chinese cabbage evaluation trials

80-150 Opeña, Cultural practices for Chinese cabbage at AVRDC

Annual Progress Reports

1972-73 Report*

1976 Report

1977 Report

1979 Report

1980 Report

Crop Reports

1975 Chinese cabbage

1976 Sweet Potato

Miscellaneous

Proceedings of the First International Symposium on Chinese Cabbage

Proceedings of the First International Symposium on Mungbean

Proceedings of the First International Symposium on Tropical Tomato

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