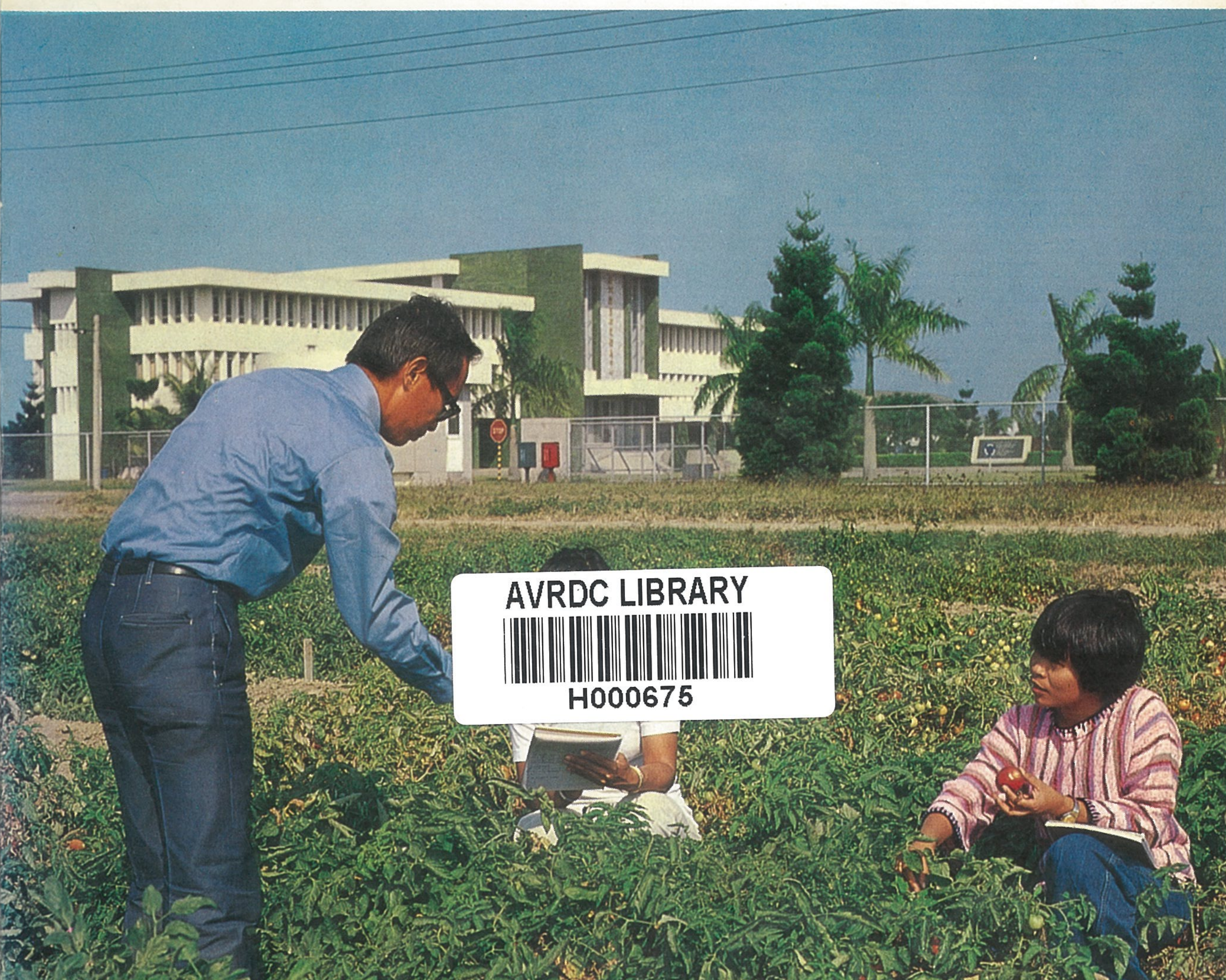
AVRDC

PROGRESS REPORT '78



ON THE COVER

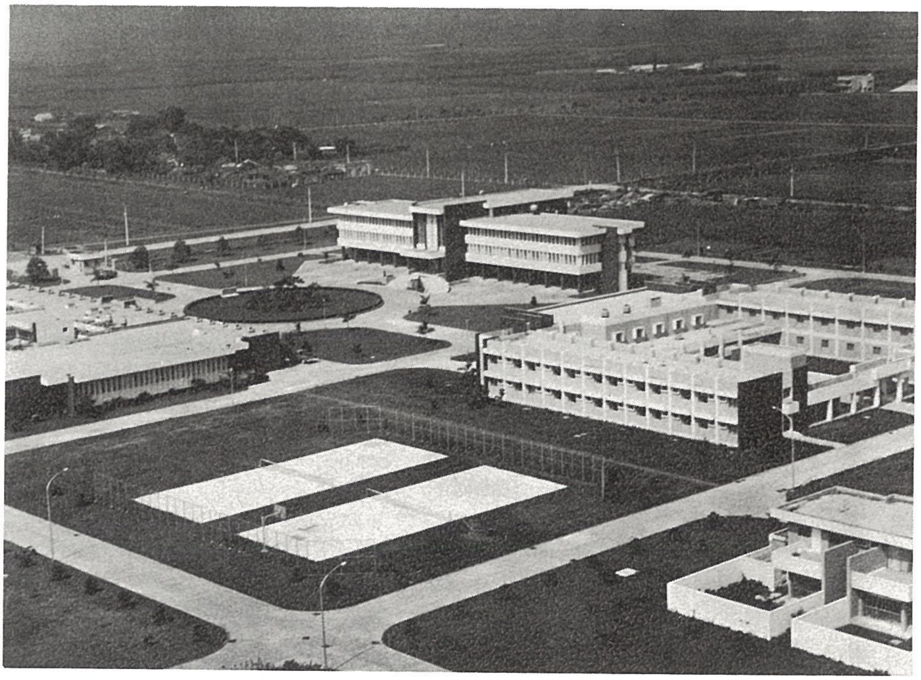
Lai Sen-Siung, assistant tomato breeder at AVRDC, discusses a project with trainees from Indonesia and the Philippines. The field is just outside the main gate and is reserved for use in the training program. The administration building is in the background.

For more information on the training program, see Page 154.

A group of trainees works on a soybean project.

The Asian Vegetable Reseach and Development Center

Progress Report for 1978



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 1978 Progress Report summarizes research, training, and outreach activities of the Asian Vegetable Research and Development Center (AVRDC). It is not intended to be definitive. For those interested in more detailed accounts of individual studies, technical bulletins are being planned that will provide details. These bulletins, when published, may be obtained by writing the Office of Information Services at AVRDC. Please be sure to give your complete mailing address. Scientists in other countries also are urged to correspond with AVRDC investigators regarding technical points and problems.

Data are presented in metric units. Monetary values are in U. S. dollars, unless stated otherwise. "Check" means an untreated experimental plot, unless otherwise stated. A single asterisk (*) means significant at the 5 percent level, a double asterisk (**) means significant at the 1 percent level. 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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Contents

Director's Foreword

The 1978 research year produced a substantial number of accomplishments in furtherance of our objectives to improve vegetable production potentials in the humid lowland tropics. The facts and their implications are discussed in detail in the following pages.

Our tropical tomato continued to perform well in many countries including Bangladesh, Philippines and Thailand. A significant event in the tomato research history was the convening of the First International Symposium on the Tropical Tomato. Supported by a grant from the US Agency for International Development, the Symposium brought together 140 participants from 20 countries who discussed technical problems of the past and projected future work. The Republic of China honored us with a commemorative stamp for the occasion.

Planning was initiated for future conferences on the Chinese Cabbage and Sweet Potato.

Owing to the biennial nature of the Chinese cabbage, and after study of farmer practice, it was concluded that emphasis in this crop should be given to hybrid variety development. The 20% yield advantage also justifies this approach.

Open-pollinated population development remains the main thrust of cabbage breeding, however, with 28 new ones being developed, including some with higher yields than standard hybrid check varieties. Essentially 100% heading rates are now being observed in heat tolerant lines along with good resistance to soft rot, downy mildew and turnip mosaic virus.

The difficult decision to terminate the white potato breeding program was made because much has been accomplished toward our goal of producing a heat tolerant and disease resistant potato for the Asian tropics. Work will continue in testing these materials in multiple environments, including planting material increase and maintenance of disease-free pure line germplasm through tissue culture.

IBM Taiwan Corporation joined the Center in a Partnership program which provides us with a direct telephone link to the IBM 370 computer in Taipei. The company also provides training and consultation, CPU time, and much-needed hardware for punching and verifying cards. A dramatic reduction in time to analyze experimental data has resulted, as well as an increase in the volume of research data analysis.

As shown later in this report, the training course in Horticultural Crops was fully subscribed for the first time. Sixty-four trainees in various categories worked in the Center during the year, in addition to 56 summer student training projects. Several countries were added to the list of those served, including the Trust Territories of the Pacific, Western Samoa, Ghana and the Netherlands.

Outreach activities in Korea and the Philippines continued with special attention given to assisting Korea with its new drive to improve soybean yields. Korean soybean lines were grown in the winter in southern Taiwan to advance the generations of their promising crosses. Some of the 500 F_3 lines reported yields of 2.3 t/ha.

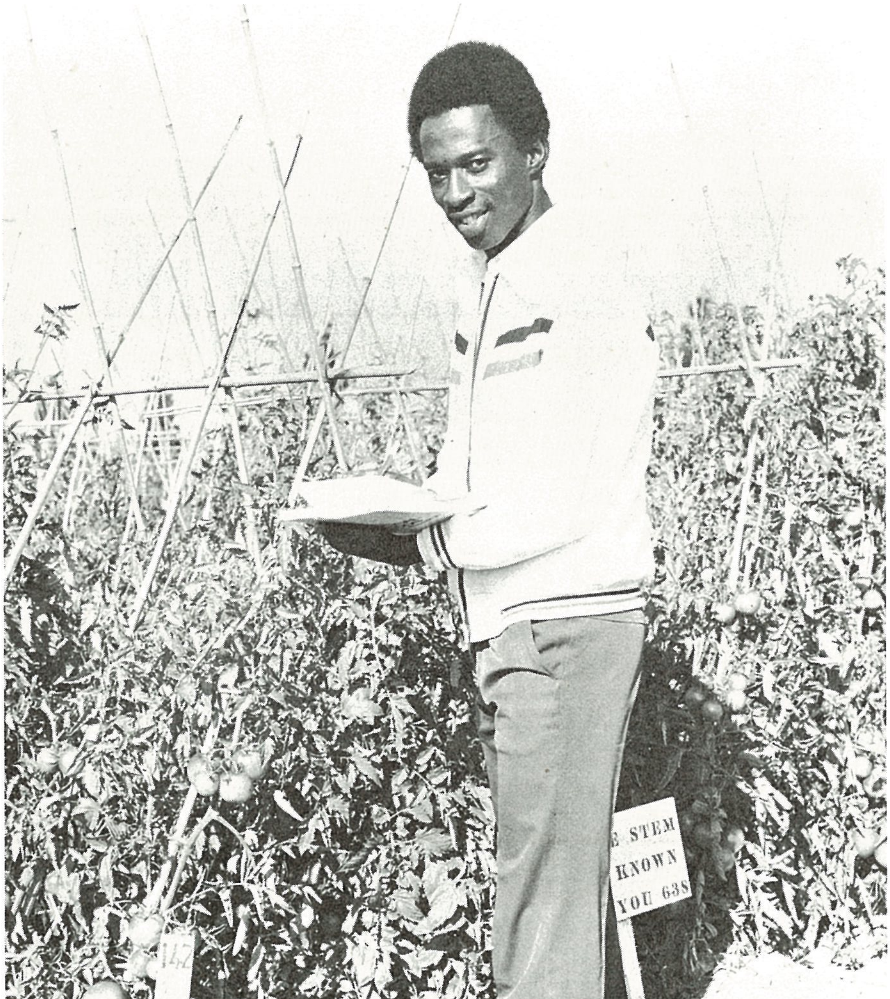
The sweet potato research progressed through "policross" nurseries in bringing together higher B-carotene and resistance to weevils. The Philippine outreach program reported yields of nearly 60 t/ha from lines already in national program trials. International testing has expanded in Thailand, Taiwan, Indonesia, and Bangladesh.

Soybean rust epidemiology gained a major new thrust at the Center with the addition of a full time pathologist supported from USDA contract funds. This important collaborative research could supply new information to all soybean producers, not just those in tropical Asia. Soybean advanced yield trials continue to show improved yields.

The Mungbean International Testing Program reached 35 countries and an AVRDC line was released in Costa Rica as "ASVEG 78". Resistance to beanfly has now been identified in both legume crops.

While the Center's program remains severely constrained by funding limits and rising costs, the technical productivity remains high. Some new and expanded sources of support are in sight and a continuing research and training program of high quality is anticipated.

J. C. Moomaw
Shanhua, Taiwan, ROC
June, 1979



A trainee from Ghana works on a tomato project.

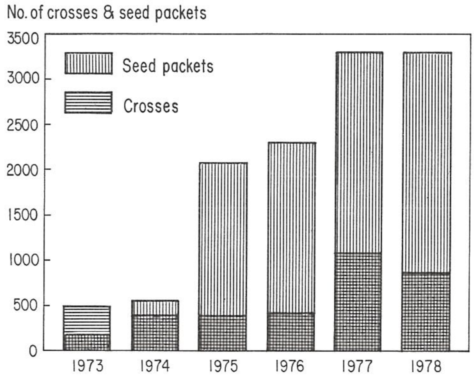


Fig. 1. Number of tomato crosses made and seed packets sent to cooperators.

TOMATO

Germplasm Collection and Distribution

We now have 4,755 cultivars in our germplasm collection. The growth of the AVRDC tomato hybridization and distribution program is shown in Fig. 1. We made 838 crosses in 1978. We supplied 2612 seed packets of elite breeding lines to 158 scientists in more than 50 countries. About 700 seed packets of other AVRDC materials were distributed throughout the tropical areas of Africa, Asia, South America and Pacific Islands.

Continued Good Performance in Several Locations

We received reports from several cooperators indicating superiority of AVRDC breeding lines over local cultivars in many tropical areas of the world.

In Taiwan, AVRDC fresh market lines excelled in heat tolerance and bacterial wilt resistance. However, preference for AVRDC materials was inconsistent. Some reported that because they are smaller and more acidic to the taste than the local cultivars, they could not be marketed. Others requested more seeds for planting in the summer of 1979 because they claimed marketing them was not a problem. There was general agreement on the desirability of some AVRDC F_1 combinations such as CL 1405 and CL 1430, primarily because of their bacterial wilt tolerance and bigger fruits. For the processing cultivars, the Taiwan Pineapple Co. planted 400 ha to TK 70-5 (AVRDC selection). The President Co. extended 100ha to TK 70-4. Other AVRDC introduced lines such as UC 82a and UC 82b are gaining acceptance among processors.

The French Mission in Tahiti reported excellent bacterial wilt resistance of AVRDC breeding lines, which yielded 13 to 35 t/ha compared to none for the susceptible check (Table 1).

Two SSD breeding lines, namely CL 554 (triple cross: VC 8-1-2-1/Venus//Kewalo) and CL 1094 (double cross: VC 9-1/Florida MH-1//ah

Table 1. Performance of AVRDC tomato lines in Tahiti, 1977[a].

Entry	Pedigree	Yield	Ave. Fruit weight	Wilt survival
		-t/ha-	-g-	-%-
CL 32d-0-1-19	VC 8-1-2-3/Venus	35	46	100
CL 127-4-1	Floradel/VC 8-1-2-1	33	45	100
CL 246-0-3B-9	(TR/VC 48-1)-17-1/ Manalucie	33	47	100
CL 11d-0-1-2	VC 9-1-2-9B/Venus	28	36	100
(124), check	Kagome 70	11	66	12
HN, check		0	0	0

[a]Data supplied by Dr. J. Reboul of French Mission; 13 entries included in the trial. No data supplied on replicates, planted, transplanted, or harvested.

TM-2a/VC 8-1-2-1), were evaluated at Cipanas Horticultural Experiment Station, Indonesia. Several lines from both crosses were selected with yields significantly higher than the check cultivars.

Tamil Nadu Agricultural University, Coimbatore, India, conducted a two-year summer trial of AVRDC accessions and breeding lines. They selected materials for further evaluation and use in their hybridization program.

A Philippine trial showed that, with good management during the regular growing season, marketable yields of 60 t/ha or more could be obtained from AVRDC breeding lines (Table 2). The Eden Fruits & Vegetable Farm selected outstanding genotypes from SSD lines 502 and 507. They outperformed the check cultivars in the trial. The commercial farm of RAM Food Products confirmed the high productivity and wilt resistance of selections CL 114-5-5-0-1 and CL 143-0-4B-1, which they are evaluating on a semi-commercial scale.

The Mennonite Central Committee in Bangladesh demonstrated the excellent yielding ability of CL 505 with pedigree VC 8-1-2-1/Venus//Kewalo over three monthly plantings (Table 3). Such materials could be very useful to Bangladesh farmers.

In seven locations in Thailand during the hot season, AVRDC accessions outyielded local checks by 343 to 386% (Table 4). Three accessions were recommended for commercial plantings: VC 48-1 for northern

Table 2. Performance of AVRDC tomato breeding lines during the dry season, Economic Garden, Los Baños, Philippines, 1978.[a]

AVRDC cross or (acc. no.)	Pedigree or (cultivar name)	Marketable yield	Fruit size
		-t/ha-	-g-
CL 8d-0-0-1	VC 11-1-2-1B/Venus	68	63
(6)	(VC 8-1-2-D)	66	44
(15)	(VC 8-1-2-7)	66	33
CL 32d-0-1-25	VC 9-1-2-3/Venus	65	44
CL 32d-0-1-4	VC 9-1-2-3/Venus	63	42
CL 32d-0-1-1	VC 9-1-2-3/Venus	59	45
(123)	(TK 3-4) check	46	27
	LSD .05	13	7

[a]Data supplied by Mrs. A.A. Virtucio, study leader AVRDC-POP, Philippines; data are means of 4 replications; planted Nov 28 (1977), harvested 15 times beginning Jan 30, ending Apr 4, 1978.

Table 3. Performance of the best yielding tomato SSD lines from cross VC 8-1-2-1/Venus//Kewalo, Noakhali, Bangladesh, 1978[a].

SSD No. or (cultivar name)	Flowering	Fruit size	Yield
	-days-	-g-	-t/ha-
10	39	45	44
40	43	52	41
45	43	46	39
29	38	79	37
41	42	56	37
(Master 2), check	37	60	14
SSD average[b]	41	54	37

[a]Data supplied by Mr. E. Nafziger, Mennonite Central Committee, Noakhali, Bangladesh; data are average of 3 plantings (Oct 17, Nov 9, 1977, and Jan 27, 1978). [b]Average of 12 SSD lines included in the trial.

Table 4. Yield performance of AVRDC tomato accessions in regional trial at 7 locations in rainy season, Thailand, 1977[a].

AVRDC accession no.	Cultivar name	Location							Average
		Rangsit	Sisaket	Tachai	Nan	Fang	Lampang	Maejo	
		t/ha							
L 1	VC 48-1	5	20	68	33	15	26	24	27
L 6	VC 8-1-2-d	15	34	66	17	9	30	9	26
L 35	(TR/VC 48-1)-17-2	8	22	65	22	12	26	17	25
L 15	VC 8-1-2-7	14	25	65	25	15	16	11	24
L 115	Roma	2	6	57	3	3	11	9	13
L 243	Plum (check)	b	b	b	3	2	15	b	7
	LSD .05	5	8	ns	9	5	6	5	-

[a] Data submitted by Mr. Balgium Chareonpanich and Mr. Banchong Sikkahmondol, Vegetable Branch, Department of Agriculture, Thailand; data per location are means of 4 replications. [b] Not included in the trial.

Thailand, VC 8-1-2-7 for the eastern and northern parts, and VC 8-1-2-d the central region. At Khon Kaen, some genotypes of CL 1131 with pedigree VC 48-1/Tamu Chico III//ha TM-2a/VC 11-1 were selected for further study.

A Nigerian report similarly confirmed excellent fruit setting and yield (24 to 34 t/ha) of selections CL 11d-0-1-2, CL 246-0-3B-9 and CL 143-0-4B-1.

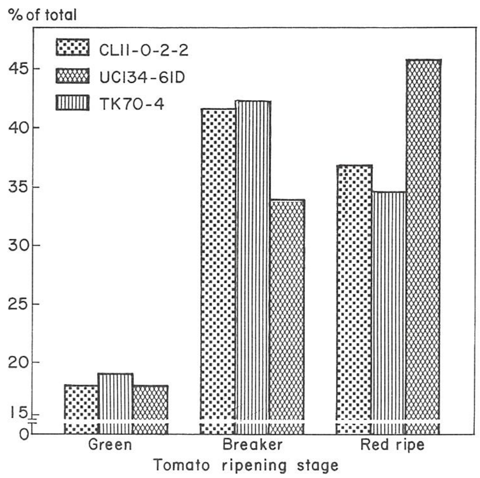
Progress in Developing Processing Cultivars

Only selections CL 143-0-4B-1 and CL 11-0-2-2-0-3 yielded at least 50 t/ha compared to other entries (0-3 t/ha) when planted in bacterial wilt infested areas. In a wilt free area, however, TK 70-4 (AVRDC selection) is still one of the best cultivars to grow in Taiwan.

We have demonstrated that it is possible to plant as early as Aug and harvest in late Nov by using new selections from crosses CL 1258, CL 1561 and CL 1591. These crosses mature 2 to 3 weeks earlier than TK 70-4, bear more firm and red fruits, have resistance to bacterial wilt and tolerance to leaf molds and gray leaf spot. We received several requests for seed of these materials from processing companies for their Aug 1979 plantings. Meanwhile, we are evaluating them for Apr or May harvestings in Taiwan.

Results of our experiment on using ethrel to concentrate maturity for once-over harvest of tomato in Taiwan were encouraging (Fig. 2). Combining breaker (turns red in 2 days) and red ripe fruits gave 76-78% harvestable fruits in varieties CL 11-0-2-2, TK 70-4 and UC 134-61D, which is comparable to the California figure. One practical application of the finding is to use ethrel to reduce the number of harvestings from the usual 7 - 11 to 2 harvests only, thus saving harvesting labor which constitutes 43% of the total labor cost in tomato production. The economics of this technique needs to be evaluated and the practice refined.

Fig. 2. Proportion of green, breaker and red ripe tomatoes in ethrel treated cultivars.



Hot Season Trials

We selected 130 new lines which combined heat tolerance, and resistance to bacterial wilt, leaf molds and gray leaf spot. Some had tolerance to TMV. We failed to break the linkage between small fruit size and wilt resistance in spite of growing 4,000 F_2 plants each of 4 crosses involving wilt resistance with small fruit as one parent and wilt susceptible with large fruit as another.

We conducted several trials at AVRDC which confirmed the potential of our lines for summer production in wilt-free areas (Table 5). In the trials harvested in Jun to Jul, 8 AVRDC lines yielded more than 6 times the check cultivar, White Skin. Our lines set more fruit and were more resistant to leaf diseases.

Rigorous Screening of Selected Accessions for Bacterial Wilt (*Pseudomonas solanacearum*) Resistance

Almost all tomato accessions have been tested in soil flats under high soil temperatures (32.5°C-39°C) conditions for resistance to bacterial wilt. Only 25 accessions survived. They were planted in the bacterial wilt nursery with reinforced inoculation of the pathogen to determine their

Table 5. Summary of performance of heat tolerant selections in 3 summer trials; 1978, AVRDC[a].

Entry	Pedigree	Average Marketable yield
		-------t/ha-------
CL 9d-0-3-6	VC 11-1-2-1B/Saturn	19
CL 9-0-0-1	VC 11-1-2-1B/Saturn	19
CL 143-0-10-3	VC 48-1/Tamu chico III	17
CL 11d-0-2-2-0-3	VC 9-1-2-9B/Venus	17
CL 123-2-4	ah TM-2a/VC 8-1-2-1	17
L 387 (check)	White Skin	3
LSD .05		3

[a]Trial I planted Apr 3, harvested 4 times beginning May 31, ending Jun 16. Trial II planted Apr 24, harvested 4 times beginning Jun 26, ending Jul 10. Trial III planted May 11, harvested 4 times beginning Jul 14, ending Jul 28. Data for 3 trials were combined, since Bartlett's test showed variances were homogeneous. Planted in wilt-free area.

Table 6. Percent survival, disease reaction and fruit size of tomato accessions rated resistant to the bacterial wilt pathogen, *Pseudomonas solanacearum*, in comparison to check, under high temperature screening environment. AVRDC, 1978[a].

Acc No.	Cultivar name[b]	Origin	% Survival	Disease[c] reaction	Relative Fruit size
285	Chang's #1	Taiwan	98	R	Small
4410	P.I. 390704	Peru	98	R	Small
4066	Line #8-12	Panama	97	R	Medium
4670	P.I. 406994	Panama	96	R	Small
4540	P.I. 406819	El Salvador	92	R	Small
245	KL 1 (check)	Malaysia	0	S	Medium

[a]Sown Aug 16 and transplanted Sep 18; evaluated 9 times starting Oct 20 and ending Dec 19 under high temperature regime (32.5 - 39°C). Soil had epiphytotic level of pathogen. [b]Only these accessions were rated resistant out of the more than 4000 accessions screened. [c]R = over 80% survival; S = less than 39% survival.

resistance throughout the mature plant stage. Five showed strong resistance under these conditions (Table 6).

Verification of Wilt Resistance in Cultivars and Breeding Lines

In a field trial, but without additional inoculation in the bacterial wilt nursery, 25 breeding lines and cultivars reported as bacterial wilt resistant in other areas were tested. Only L 3972, L 3987 and CL 8d-0-7-1 showed moderate resistance (Table 7). The popular cultivars Saturn (L 96) and Venus (L 95) were moderately susceptible. No plants of cultivar FP-1 (L 4151), one of three reportedly wilt resistant varieties bred in Malaysia, survived.

First Results from Root-Knot Nematode (*Meloidogyne incognita*) Nursery

We tested 60 tomato accessions and breeding lines in AVRDC's root-knot nematode nursery, which had been established more than a year before the trial started in Mar 1978. Susceptible variety TK 70, which served as a nematode feeder, had been planted in the nursery for three months prior to the screening trial. Nematode-infested tomato roots were cut into 2-cm pieces and put onto the ditched soil surface of furrows just before transplanting test seedlings. TK 70 seedlings also were transplanted in alternate rows as feeder plants.

Test plants were removed 60 and 84 days after transplanting for examination of the roots, visually and under the dissecting microscope. Root-

Table 7. Percent survival of some reportedly resistant tomato cultivars and breeding lines in bacterial wilt nursery without inoculation, AVRDC, 1978[a].

Acc. No.	Cultivar name	% survival	Disease reaction[b]
3972	Cranita 2-5-7	68	MR
3987	T 96	67	MR
-	CL 8d-0-7-1 (VC 11-1-2-1B/Venus)	63	MR
95	Venus	40	MS
96	Saturn	58	MS
274	Kewalo	29	S
4151	FP-1 (check)	0	S
3186	Yellow Plum (check)	3	S

[a]Sown Jul 24 and Transplanted Aug 17; evaluated 7 times beginning Oct 20 and ending Dec 19. [b]MR = 60-79% survival rate; MS = 40-59% survival rate; S = less than 39% survival rate.

knot infection ratings were made according to the following scales: highly resistant (0 gall/plant); resistant (1-10 galls/plant); moderately resistant (11-30 galls/plant); susceptible (31-100 galls/plant) and very susceptible (more than 100 galls/plant).

Fourteen accessions and breeding lines were resistant to root-knot nematode infection (Table 8). These were AVRDC accessions L 640, L 641, L 671, L 672, L 673, L 680, L 688, L885, L 887, L 890, L 892 and breeding lines CL 29-0-1-0, CL 106-5-1-0 and CL 320-1-1. None were rated highly resistant.

In the fall of 1978, 60 tomato accessions and breeding lines, including many of the resistant ones tested previously, were screened again. Twelve breeding lines showed resistance. Breeding lines CL 29-0-1-0, CL 320-1-1, CL 106-5-1-0 and CL 170-6-1-0 were confirmed to have good resistance, with only 1-2 galls/plant. All resistant accessions identified in previous tests also confirmed their resistance in the fall screening.

Soil Moisture Tolerance Studies

Low O_2 restricts the release of energy and results in metabolic products different from those of plants with adequate O_2. Ethanol and ethylene are two compounds produced by tomatoes which lack O_2. We studied the varietal differences in response to short periods of flooding and the nature of soil moisture tolerance.

Table 8. Root-knot nematode infection ratings of 60 tomato accessions and breeding lines planted in a nematode nursery, AVRDC, 1978[a].

Disease reaction	Number of accessions/ breeding lines
HR	0
R	14
MR	5
S	2
VS	39

[a]Planted Mar 31 and evaluated Jun 23 in field nursery infected with *Meloidogyne incognita;* HR = highly resistant; R = resistant; MR = moderately resistant; S = susceptible and VS = very susceptible.

One-month-old pot-grown seedlings of 20 promising entries were subjected to flooding for 3 days, or soil drenched 3 times, with a total of 100 ml ethanol or 135 mg ethrel solution per non-flooded pot. Plants were observed one week after initial treatment.

All plants survived all treatments. However, various degrees of morphological damage were observed. Flooding generally reduced stem growth and chlorophyll content of the first true leaf, and promoted epinastic curvature of the second leaf petiole and adventitious root number (Table 9). Ethrel generally elicited a response similar to flooding, except a more severe effect was observed. Ethanol caused a general increase in stem growth but not in adventitious roots. Moreover, ethanol had only slight effects on leaf chlorophyll content and epinastic curvature. Results generally indicate L 123 as the most moisture tolerant accession among entries tested.

One-month-old pot-grown seedlings of 4 accessions (L 95, L 123, L 226, and L 246) were subjected to flooding for 48 hours in another experiment. Table 10 shows that L 123 had the highest rate of root respiration after treatment, which supports the earlier finding that L 123 is the best moisture tolerant entry.

Ten entries were grown in the field and 6-week-old plants were subjected to flooding for 72 hours. Physiological and morphological responses were observed one week later. All plants survived. However, the vegetative growth of most entries, except L 123, was severely damaged. L 123 and L 2972 had higher root respiration than other entries (Table 11).

Table 9. Effects of flooding, ethanol or ethrel on tomato stem growth, epinastic curvature, chlorophyll content and adventitious root formation, AVRDC, 1978[a].

Selected[b] entries	Cultivar name	Relative stem growth[c]			Relative chlorophyll content[c]			Relative curvature[c]			Relative root No.[c]		
		Flooded	EtOH	Ethrel	Flooded	EtOH	Ethrel	Flooded	EtOH	Ethrel	Flooded	EtOH	Ethrel
L 95	Venus	115	132	73	17	112	63	130	109	172	23	53	1
L 123	TK 3	117	188	57	96	105	121	122	79	135	64	192	11
L 125	Divisoria 2	76	125	70	59	86	96	176	116	198	6	36	0
L 146	L.A. 1291	70	106	58	64	88	95	146	114	139	18	18	0
L 166	L.A. 1421	91	179	44	61	71	4	138	113	167	9	79	4
CL 11-0-1 -2-0-0	VC 9-1-2B/ Venus	81	106	48	83	97	99	119	76	158	18	79	10
Mean of 20 Entries		81	120	67	73	101	89	147	108	173	39	135	3

[a]Seeds were sown on Apr 4. [b]Entries not listed: L 97, L 118, L 124, L 133, L 203, L 226, L 245, L 283, L373, L 387, Cl 8d-0-7-1 and Cl 9-0-0-1-0. [c]Expressed as % of non-flooded control.

Table 10. Effect of flooding on tomato root respiration, AVRDC, 1978[a].

Entries	Cultivar name	Response to heat	Respiration ($mg\ CO_2/mg$ dry wt/hr) Control	Flooded	Ratio Flooded/Control
L 95	Venus	HS	2.14	0.64	0.30
L 123	TK 3	HS	2.11	1.51	0.72
L 226	NRG 7247	HT	1.83	0.77	0.42
L 246	KL-2	HT	3.24	0.78	0.24
LSD 0.05			0.81	0.53	

[a]HS = Heat Sensitive; HT = Heat Tolerant.

Our results imply that there may be more than one kind of anoxia injury to tomato. The O_2 deficit may lead to decrease in water uptake and to wilting (e.g. epinastic curvature), resulting from a damaged root system. The severe chlorosis in the lowest leaves of flooded plants may be due to a reduction in the import of cytokinins. On the other hand, the above ground plant parts must possess O_2-deficit tolerance for them to survive a pronounced O_2 deficit in their tissues. Therefore, "soil moisture tolerance" in tomato should include both plant survival and fruiting ability.

Field and greenhouse screening for soil moisture tolerance generally agreed. It should, therefore, be possible to use the simple greenhouse technique for mass screening at a relatively young seedling stage.

Heat Tolerance Studies

We conducted experiments to determine varietal responses to high temperature stress, and the relative as well as absolute contributions of physiological processes toward fruiting (i.e. fruits greater than 0.5cm) and yield under high temperature conditions.

High temperature at the macroscopic appearance of the inflorescence of pot-grown plants decreased flower and fruit numbers with increasing duration of high temperature. This result implies that sensitivity to high temperature is maximal after the macroscopic appearance of the inflorescence and damage to reproductive organs can take place before anthesis.

We evaluated 20 promising entries for heat tolerance in both field and greenhouse in another experiment. We observed substantial variation in fruiting ability and physiological components of fruiting among entries. Data were chosen for only 8 entries and listed in Table 12. Extremely

Table 11. Effect of 72 hrs. flooding on tomato root respiration, reproductive abscission, yield and yield components, AVRDC, 1978.[a]

Entries	Cultivar name or pedigree	Response to Heat[b]	Relative respiration rate[c]	Relative abscission rate[c]	Relative fruit no.[c]	Relative size[c]	Relative yield[c]
L 95	Venus	HS	0.57	0.57	0.45	0.91	0.41
L 123	TK 3	HS	1.10	4.15	0.63	0.89	0.56
L 125	Divisoria 2	HT	0.96	3.60	0.29	0.70	0.21
L 146	L.A. 1291	HS	0.62	2.55	0.27	0.98	0.27
L 166	L.A. 1421	HS	0.36	1.03	0.11	1.06	0.12
L 232	Nagcarlan	HT	0.97	4.42	0.36	0.82	0.30
L 388	Green Fruit	HS	0.59	3.59	0.32	1.07	0.35
L 2972	PI 289296	HT	1.02	12.48	0.71	0.74	0.52
L 3982	Tagalog	HT	0.73	7.02	0.38	0.65	0.25
CL 11-0-1 -2-0-0	VC 9-1-2-9B/ Venus	HT	0.79	0.94	0.35	0.63	0.22
Mean			0.75	4.04	0.43	0.85	0.32

[a]Sown Sep 8 and transplanted Oct 6. [b]HT: heat tolerant. HS: heat sensitive. [c]Expressed as ratio of flooded/control.

Table 12. Tomato fruiting and its physiological components under field[a], greenhouse[b] and laboratory[c] conditions, AVRDC, 1978.

Entries[d]	Cultivar name or pedigree	Response to heat	Pollen germination temperature[c] 21	28	34	38°C	Split anther[a]	Exserted style[a]	Fruiting[e]	Fruiting ratio[b] [f] (high/low)	Exserted style[b] Low	High
			%								%	
L 95	Venus	HS	39[g]	18	11	8	43	1	80	.40	0	10
CL 9-0-0 -1-0	VC 11-1-2-1B/ Venus	HT	27	40	3	0	9	17	77	.58	0	0
L 2972	PI 289296	HT	3	58	15	14	0	4	68	.93	0	0
L 283	Tamu chico III	HT	5	6	30	0	0	0	63	.86	0	0
L 123	TK 3	HS	1	50	33	8	7	0	60	.70	0	8
L 245	KL 1	HT	1	2	29	4	1	0	60	.79	0	37
L 125	Divisoria	HT	17	35	18	8	20	34	56	.51	0	63
L 3692	PI 365912	HT	8	12	39	2	0	76	27	.16	20	44

[a]Sown Aug 11 and transplanted to field Sep 19. Mean max and min temps of Sep 25 - Oct 25 were 30.3°C and 21.9°C. respectively. [b]Sown Sep 20 and transplanted into greenhouse Oct 11. [c]Pollen collected from field starting on Nov 3, 1978 for 26 days. [d]Entries not listed are: L 142, L 146, L 181, L 226, L 230, L 232, L 1076, L 3690, L 3693, L 3982, CL 8d-0-7-1 and CL 11-0-1-2-0-0. [e]% Fruiting = No. of enlarged fruit/No. of flowers. [f]No. of enlarged fruit per plant expressed as ratio of high temp (35-30/25-22°C) treated/low temp (30-25/22-17°C) control. [g]Underlined are peak values.

Table 13. Abscission rate of pedicels after removal of the reproductive organs at the time of heat treatment*, AVRDC, 1978.

Removed organs / Acc. No.	Cultivar name	Abscission Rate		
		Open flower	Small fruit (0.2 - 1.5 cm)	Large fruit (1.5 - 2.5 cm)
		%		
Heat tolerant*				
L 125	Divisoria	22[e]	15[e]	17[cd]
L 226	NGR 7247	97[ab]	73[abc]	75[a]
L 232	Nagcarlan	94[abc]	40[d]	19[bcd]
L 2972	PI 289296	98[abc]	63[bcd]	21[bc]
L 3690	PI 365914	81[cd]	60[bcd]	37[bc]
Heat sensitive+				
L 123	TK 3	98[ab]	62[bcd]	9[d]
L 146	L.A. 1291	88[bcd]	46[cd]	22[bcd]
L 166	L.A. 1421	100[a]	87[ab]	45[b]
L 386	Santa Cruz	100[a]	92[a]	40[bc]
L 387	White Skin	76[d]	82[ab]	45[b]

*Treated for six hours under high temperature (35-30^{o}C); means with different superscripts are significantly different ($P < 0.05$). +Based on data of Villareal et al. (1978).

high temperature (i.e. 38^{o}C) generally caused a marked decrease in pollen germination in vitro in almost all entries. However, there were varietal differences in terms of optimal temperature for pollen germination. Germination rates for pollen of L 283, L 245 and L 3692 were relatively higher at 34^{o}C than at other temperatures, although this did not always result in higher fruiting (e.g. L 3692).

Splitting of the antheridial cone under high temperature has been reported as one of the factors responsible for poor fruit set. L 95 and L 125 had more than 20% of flowers with split anther cones under field conditions. Nonetheless, they showed more than 50% fruit set.

A relatively high rate of style exsertion also was found among entries with poor fruit set under field conditions (e.g. L 3692), which supports the practical possibilities for selecting lines with normal style position. However, to achieve high yields the other physiological barriers to high fruit set must be eliminated.

The greenhouse experiment clearly demonstrated that L 283 and L 2972 are truly heat tolerant. This trait may be attributed to absence of style exsertion and relatively high pollen germination potential under high temperature conditions. On the other hand, although L 3692 had the highest pollen germination potential among entries at 34^{o}C, its style was rather easily exserted and this resulted in poor fruiting.

Another important character affecting fruiting under high temperature is the inherent tendency of reproductive organs to abscise. Table 13 shows the varietal differences in pedicel abscission under high temperature. L 125 had the lowest abscission rate at all reproductive stages.

Our results support the view that poor fruit-set at high temperatures is not the consequence of a single malfunctioning factor but a simultaneously impaired complex of components. Morever, our results support the possibility that the factors affected vary among varieties.

CHINESE CABBAGE

Collection, Screening and Distribution of Germplasm

Addition of 38 accessions in 1978 to the Chinese cabbage germplasm collection brings the total to 699. In addition, we received 10 S-allele stocks from the AVRDC Sub-Center in Korea.

Of 37 new accessions evaluated for heat tolerance, 9 exhibited tolerance.

We distributed 61 sets of trials (682 packets) of new AVRDC open-pollinated cultivars to different countries and provided 89 packets of accessions to cooperators.

Crossing Program and Segregating Populations

After growing 250 plants each of 32 F_2 populations during the 1977-78 winter to select putative heat tolerant plants (using "susceptibility to bolting" technique) with resistance to one or more major diseases, we advanced 1744 selections to the S_1 generation.

We advanced by one generation of selfing 248 selections from S_1 to S_4 generations.

Screening of all inbred lines (S_1 to S_5) for heat tolerance and disease resistance resulted in 126 selections from S_1 to S_4 generations taken for further tests.

We compounded 28 new open-pollinated populations by intercrossing advanced inbred lines having closely similar horticultural characters. We also intercrossed all advanced inbred lines carrying self-incompatibility and derived from diverse genetic backgrounds to isolate outstanding combinations for hybrid production. We also crossed them to open-pollinated cultivars, B 189 C_1 and 129 C_2, to develop good topcross combinations and to determine if this testing method can be used in identifying good combining inbreds.

Yield Trials

a) Advanced Tests. Three trials involved eight promising new open-pollinated entries. Only one trial provided meaningful results (Table 1). Entries 76 M(1)-4 and 76 M(2)-20 significantly outyielded the open-pollinated check (B 189 C_1), although the latter matured 4-5 days earlier and had a higher heading rate.

b) Preliminary Tests. We divided the open-pollinated populations synthesized in the winter of 1977-78 into 2 batches for preliminary yield tests (PYT) in the summer of 1978.

Batch 1 PYT, consisting of 24 entries, did not reveal significant differences for yield. However, we eliminated poor entries based on general appearance, maturity, heading rate, susceptibility to diseases and apparent yield. In the repeat planting, entry 77 M(3)-27 significantly outyielded the hybrid check (Table 2). All top entries matured at approximately the same time as the check and had close to or 100% heading rate. No significant differences for characters other than those listed in Table 2 were noted.

The PYT of the second batch OP materials revealed no entry which outyielded the hybrid check. However, two out of five gave significantly higher yields than B 189C_1, an OP check cultivar.

c) Combining Ability Trials. Hybrid combinations between lines carrying self-incompatibility were divided into two batches. The first batch consisted of 81 entries planted in RCB design with 2 replications. Table 3 shows the yield and other horticultural characters of promising combinations as compared with the check. Hybrid No. 59 significantly out yielded the F_1 check, Yuan Pao No. 2, and matured one week earlier.

The second batch did not reveal any combination more promising than the hybrid check.

We also tested 56 topcross combinations against 3 check varieties (Yuan Pao No. 2 F_1 and the OP parents, B 189 C_1 and 129 C_2). Table 4 shows the results from the top 4 entries.

The correlation between topcross performance of inbreds and their average yields in combination with other inbreds was highly significant ($r=0.68^{**}$) indicating that, as in maize, poor combining inbreds may be eliminated by using a broad base tester, e.g., open-pollinated varieties.

Table 1. Yield and other horticultural characteristics of top Chinese cabbage entries in the advanced yield trial during summer. AVRDC. 1978.[a]

Entry	Yield	Head weight	Maturity (DAT)[b]	Heading rate[c]	Total plant growth	Heading efficiency[d]	Head shape index[e]
	-t/ha-	-g-	da	-%-	-g-		
76 M(1)-4	23.6	878	38	86	1666	1.2	2.0
76 M(2)-20	21.3	748	37	92	1477	1.0	1.4
Yuan Pao No.2 (F_1 check)	20.1	709	38	90	1318	1.2	1.4
B 189 C_1 (OP check)	15.7	495	33	100	898	1.2	1.2
LSD (5%)	4.4	156	3	10	232	0.2	0.2
CV (%)	17	16	6	8	12	16	7

[a]Sown 30 May, transplanted 19 Jun. Design: RCB, 4 replicates. Plot size: 12 square meters. [b]DAT= days after transplanting. [c]Heading rate= $\frac{\text{No. plants w/heads}}{\text{Total no. of plants}} \times 100$

[d] Heading efficiency= $\frac{\text{weight of head}}{\text{weight of nonwrapper leaves}}$ [e]Head shape index= $\frac{\text{Length of head}}{\text{width of head}}$

Table 2. Yield and other horticultural characters of top Chinese cabbage entiries in a preliminary yield test. AVRDC. 1978[a].

Entry	Yield	Head Weight	Maturity (DAT)[b]	Heading rate[b]	heading efficiency[b]	head shape index[b]
	-t/ha-	-g-	da	-g-%		
77 M(3)-27	26.5	799	37	98	1.3	1.9
77 M(3)-26	24.6	795	39	98	1.4	2.2
77 M(3)-35	22.6	738	39	100	1.2	2.0
Yuan Pao No.2 (F_1 check)	20.1	677	37	91	1.4	1.6
LSD (5%)	5.8	152	3	ns	0.2	0.2
CV (%)	18	14	5	6	10	6

[a]Sown 27 Jul transplanted 24 Aug. Plot size 6 square meters. Design: RCB, 3 replicates. [b]See footnote Table 1 for definition of terms.

Improvement of New Open-pollinated Populations

We screened 14 promising open-pollinated lines for soft rot and downy mildew resistance in order to develop early maturing, heat tolerant strains with higher levels of disease resistance. We made single plant selections on 6 of 14 populations (Table 5).

The most promising is 77 M(3)-27, which combines high levels of resistance to soft rot and downy mildew with heat tolerance. This cultivar also gave the highest yield in an earlier preliminary yield test (See Table 2).

Further improvements will be undertaken on these populations by simple mass and/or family selection.

Heterosis Among Local Heat Tolerant Cultivars

We suspected that the low yields of heat tolerant F_1 hybrids developed by seed companies arise from lack of genetic diversity among sources of heat tolerance. To test this, we made diallel crosses (excluding reciprocals) among a random sample of HT accessions in the Chinese cabbage collection. Since our collection is routinely maintained using

Table 3. Yield and other horticultural characteristics of early maturing Chinese cabbage hybrid combinations. AVRDC. 1978.[a]

Hybrid	yield	head weight	Maturity (DAT)[b]	Heading rate[b]	Total plant growth	Heading efficiency[b]	Head shape index[b]
	-t/ha-	-g-		-%-	-g-		
59	29.3	972	32	100	1695	1.4	1.4
105	23.4	790	34	100	1334	1.5	1.5
61	23.2	729	32	100	1285	1.3	1.3
37	21.3	696	32	100	1170	1.5	1.4
34	20.1	616	34	100	1067	1.4	1.3
Y. P. No.2 (F_1 check)	18.7	720	39	94	1306	1.2	1.5
LSD (5%)	7.4	205	3	20	311	0.4	0.2
CV (%)	21	15	5	12	12	18	6

[a]Sown 2 May and transplanted 18 May. Plot size:6 square meters. Design: RCB, 2 replicates.
[b]See Table 1 footnote for definition of terms.

Table 4. Yield and other horticultural characteristics of top Chinese cabbage entries in the inbred/variety combining ability trial, AVRDC 1978.[a]

Topcross No.	Yield	Maturity (DAT)[b]	Heading rate[b]
	-t/ha-		-%-
30	21.0	38	97
28	18.8	38	91
65	18.8	34	94
66	18.5	36	94
Yuan Pao No.2(F_1 check)	16.2	40	91
B 129 C_2 (OP check)	9.4	42	69
LSD (5%)	5.3	4	18
CV (%)	18	5	11

[a]Sown 15 May and transplanted 1 Jun. Plot size: 6 square meters. Design: RCB, 2 replicates. [b]See Table 1 for definition of terms.

small population samples (20 plants per accession), bias towards finding significant heterosis exists. Despite this, results from two plantings of diallel materials and their parents revealed no significant genetic variation, using Griffing's Method 2 Diallel Analysis. Thus, our method of developing inbreds from intervarietal crosses using diverse parents appears sounder than simply extracting lines from HT local varieties.

Isolation of S-allele Homozygotes from Good Combining Lines

We planted and vernalized all outstanding inbred lines indentified from combining ability tests in the 1978 fall season for detection of S-allele homozygotes. Within each line, we kept 11 plants for pollination. At flowering stage, we selfed and sib-pollinated all plants within a line in full diallel fashion (including reciprocal) at the open-flower stage within the same day. For relative seed set comparisons, we also made a fully fertile cross (using bulked pollen of an open-pollinated cultivar) on each plant.

Although the ultimate consideration for self-incompatibility analysis depends on the final seed set, a number of lines showed clear cut results

Table 5. Disease reaction and selection rate on new open-pollinated Chinese cabbage varieties selected for further improvement. AVRDC. 1978.[a]

Entry	Total Plant No.	Disease reaction: Soft rot[b]	Disease reaction: Downy Mildew[c]	No. selections	Selection rate
		-%	-%		-%-
76 M(2)-18	441	21	2.0	25	5.7
76 M(2)-20	457	18	2.1	18	3.9
77 M(2)-24	428	2	1.8	37	8.6
77 M(2)-25	438	13	1.9	25	5.7
77 M(3)-27	468	3	0.5	49	10.5
77 M(2/3)-43	455	12	2.3	19	4.2
B 31 (check)	42	40	2.7	-	-

[a]Sown 15 Aug and transplanted 7 Sep. [b]Inoculated with 1 x 10^9 cells/ml bacterial suspension on Oct 4 and repeated 16 Oct only on apparently resistant entries. Percentage of plants susceptible indicated. Checks were inoculated 16 Oct. [c]Based on natural epiphytotics. Values shown are averages of individual plant scores using the scale:0=none; (1)=light; (2)=moderate; (3)=severe.

based simply on silique set (Table 6). Out of eight inbred lines analyzed, five or possibly six were homozygous for unknown S-alleles while two segregated. From the segregating lines, we identified plants homozygous for the dominant and recessive S-alleles and further maintained the lines by bud-selfing these exceptional individuals. We maintained lines already homozygous for S-alleles by bud-pollinating all plants within the line. Seed production of promising F_1 hybrids using these lines is now underway.

We made reciprocal crosses at the open flower stage between plants known to be S-allele homozygotes immediately after diallel analysis in order to test whether or not the S-alleles they carry are common. Results from partial allelism tests are interpreted in Table 7 using tentative numerical designations for S-alleles. Based on the results, C_{2-4} and C_{6-2} have a common recessive allele (S_1S_1). While C_{2-9} and C_{6-9} have a common dominant allele (S_2S_2). Line C_{9-8}, previously known to be homozygous for an unknown S-allele, also carries the dominant S_2S_2 allele. On

Table 6. Summary of diallel tests for self-incompatibility on selected Chinese cabbage inbred lines. AVRDC. 1978.

Line Code	No. of plants	S - alleles segregation characteristic	No. of S-allele homozygotes recognized[a]			S-allele interaction type
			SaSa	SbSb	unknown	
A-3	9	homozygous	-	-	1	unknown
C-2	11	segregating	1	2	-	III
C-6	10	segregating	1	1	-	III
C-9	11	homozygous	-	-	1	unknown
D-9	6	homozygous?	-	-	1?	unknown
D-10	11	homozygous	-	-	1	unknown
E-7	10	homozygous	-	-	1	unknown
G-6	10	homozygous	-	-	1	unknown

[a] SaSa=recessive; SbSb=dominant

the other hand, E_{7-8} had an unrelated S_3S_3 allele. However, the nature of its dominance cannot be determined in the current test.

International Trials

In yield trials by cooperators in 5 different countries, 3 new open-pollinated cultivars developed at AVRDC, 76 M(2)-12, 76 M(2)-17 and 76 M(2)-20, stood out in comparison with open-pollinated and/or F_1 hybrid checks (Table 8).

Soft Rot Resistance

In field screening of 32 accessions of Chinese cabbage that were rated as resistant or moderately resistant to the soft rot last year, with additional inoculation between Apr and Aug, only accessions B14, B18, B208, and B353 showed moderate to high resistance reactions, as the soil temperatures rose from 25°C to 31°C.

We screened 6 mass-pollinated F_2 Chinese cabbage crosses, including a total of 1,446 plants, for resistance to the bacterial soft rot during Aug-Oct, inoculating all the plants and evaluating them, 1, 2, and 3 weeks later. As shown in Table 9, cross CB 334 is resistant and CB 370 is susceptible.

Screening of 555 Chinese cabbage breeding lines of F_2S_1 generation for resistance to the bacterial soft rot during the summer involved 11,000 plants. All plants were inoculated and evaluated 8, 15 and 20

Table 7. Analysis of partial allelism tests with Chinese cabbage S-alleles using tentative numerical designations. AVRDC. 1978.[a]

S-allele character	S-allele character: Dominant (S_2S_2)			Recessive (S_1S_1)	Unknown (S_3S_3)
Dominant (S_2S_2)	C_{2-9}	C_{6-9}	C_{9-8}	C_{6-2}	E_{7-8}
C_{2-9}	-	I	-	-	-
C_{6-9}	I	-	-	F	F
C_{9-8}	I	I	I	-	F
Recessive (S_1S_1)					
C_{2-4}	F	F	F	I	-
C_{6-2}	F	F	F	-	F

[a]F: fertile, I: incompatible.

Table 8. Yield and rank of the top 3 new open-pollinated Chinese cabbage cultivars compared to checks in country trials, 1978.

Entries	Philippines I	Philippines II	Philippines III	Thailand	New Hebrides	Brazil	Saudi Arabia
	t/ha						
76 M(2)-12	20.6(6)[a]	29.1(2)	-[b]	39.8(3)	38.2(3)	13.4(1)	-[b]
76 M(2)-17	34.0(3)	32.4(1)	17.4(5)	42.2(2)	-[b]	12.4(3)	-[b]
76 M(2)-20	37.6(1)	25.9(4)	21.3(1)	42.3(1)	-[b]	12.1(4)	51.0(2)
B189 C1 (OP check)	20.4(7)	25.5(6)	13.6(9)	-[b]	33.1(5)	8.4(12)	31.7(8)
Yuan Pao No. 2	30.9(4)	20.4(11)	-[b]	32.6(8)	43.6(2)	10.8(7)	-[b]
LSD (5%)	13.1	7.7	ns[c]	5.0	ns	4.0	8.3

[a]Figures in parentheses indicate ranks. [b]Indicates line not included in the trial. [c]Nonsignificant.

Table 9. Soft rot reactions of mass pollinated F_2 Chinese cabbage crosses. AVRDC. 1978.[a]

Cross No.	No. of plants Infected/total	Infection rate	Soft rot reaction[b]
		-%-	
CB 334	60/242	25	R
CB 343	96/240	40	MR
CB 352	86/245	35	MR
CB 355	97/242	40	MR
CB 361	114/241	47	MR
CB 370	130/236	55	MS

[a]Planted 27 July, transplanted in the field 29 August. Inoculated on 29 September and evaluated 5,12 and 19 October. [b]Disease ratings used to evaluate the % soft rot infections:-HR:0-5%, R:6-25%, MR:26-50% MS:51-75% and S:over 75% plant infected.

days later. Breeding lines CB 334-33, CB 337-13, CB 337-115, CB 337-46 CB 338-1, CB 338-14, CB 338-24, CB 338-30, CB 338-37, CB 338-39, CB 352-1, CB 361-19, CB 361-21, CB 365-10, CB 365-20, and CB 365-48 as highly resistant (0 infection) to *Erwinia carotovcra.*

We screened 129 breeding lines from advanced F_2S_2-F_2S_5 generation for resistance to the bacterial soft rot in identical fashion, inoculating 2,580 plants and observing resistance reaction 1, 2 and 3 weeks later. Eight advanced breeding lines had been classified as highly resistant (0 to 5% plants infected) (Table 10). Among the resistant ones, breeding lines 9294-3, 10636-1, 10658-2, 10996-1 and 11003-2 showed no infection.

Turnip Mosaic Virus Resistance

We screened nine mass-pollinated F_2 Chinese cabbage breeding lines for resistance to Turnip Mosaic Virus (TuMV). The inoculation of 2,143 plants was by gently rubbing the leaves with cotton saturated with a mixture of one part crushed TuMV-infected plants to 10 parts of 0.05 M, pH 6.5 phosphate buffer containing 0.3% L-ascorbic acid and one part of fine carborundum. In field evaluations made twice during Sep and Oct, seven crosses (CB 354, CB 349, CB 336, CB 340, CB 363, CB 367, and CB 372) rated as moderately resistant (11 to 40% plants damaged).

Downy Mildew Resistance

In the fall of 1978, we screened six additional Chinese cabbage germplasm accessions in the field under artificially-created epiphytotic

Table 10. Screening 129 Chinese cabbage advanced breeding lines of F_2S_2-F_2S_5 for resistance to the bacterial soft rot. AVRDC. 1978.[a]

Disease reaction	No. advanced breeding lines	% of total
HR	8	6
R	29	23
MR	43	33
MS	35	27
S	14	11

[a]Sown: 3 Aug, Transplanted: 27 Aug, Inoculated: 27 Sep, Evaluated: 5,12 and 19 Oct. [b]Highly resistant(0-5% plant infected) entries: 9294-3, 10996-1, 10636-1, 10658-2, 11053-1, 9294-2, 10681-1, 11003-2.

conditions for resistance to downy mildew, caused by *Peronospora parasitica*. Accessions B662 and B663, both good heading types, rated as moderately resistant. The others were all susceptible.

Cabbage Webworm

Cabbage webworm (*Hellula undalis* F.) is an important pest of Chinese cabbage and other crucifers, especially in summer time, in Taiwan. Since AVRDC's Chinese cabbage program is aimed at developing heat tolerant varieties that farmers can grow in hot and humid weather of the tropics, this pest is likely to assume even greater importance. We, therefore, devoted considerable research to this pest, working on its biology, screening most of our Chinese cabbage germplasm for resistance, and testing a large number of insecticides.

Biology of Cabbage Webworm

Moths lay yellowish-white oval shaped eggs singly or in twos or threes on leaves, leaf petioles, or young growing buds. These eggs turn orange yellow before hatching in 2-4 days. Larvae feed mainly on young leaves and burrow through the growing buds beneath a protective web. Their feces cover the feeding site, making it difficult for insecticides to reach them. We observed from 1 to 40 larvae per plant during Jul-Aug, peak infestation period. Larvae have five instars and the individuals of more than one instar were found feeding on a single plant. Larvae pupated by first spinning loose webs and attaching themselves to leaves or by entering the soil. Pupation thus can be in soil or on the host plant. The pupa initially has a light brown color which turns to dark brown before the adult emerges in 4 to 7 days. Adults are mottled grey-brown moths with a black and silver lining on the wings. They are active at dusk. A single female lays from 44 to 194 eggs during the life span of 4 to 10 days.

Since Jul 1977 we monitored the incidence of this pest to study its seasonal occurrence and devise appropriate controls. We plant Chinese cabbage (variety, Fung Luh) in three 20 m x 1m rows once every month and monitor each week for 4 weeks the number of larvae on a 30 plant sample, beginning one month after transplanting. This insect is abundant only during Jun-Sep (Fig. 1), the hot and rainy summer months. It is evident therefore, that when devising control measures for heat tolerant lines one must consider the most serious pests during the tropical hot and rainy season.

Varietal Resistance Screening Against Cabbage Webworm

We screened 275 accessions from AVRDC's Chinese cabbage germplasm collection for resistance to this pest in a preiminary non-replicated field experiment during Jul. We evaluated the plants' resistance reac-

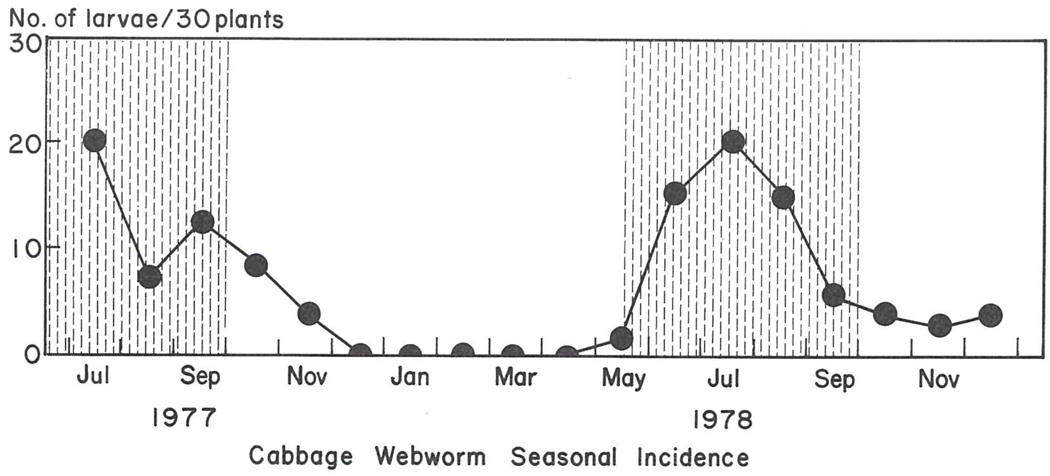


Fig. 1. Seasonal incidence of cabbage webworm on Chinese cabbage at AVRDC.

tion by counting the number of larvae per 10-plant sample and percent of damaged plants, 3 weeks after transplanting.

Of the 275 accessions tested during preliminary screening, 13 most promising accessions were further screened along with 3 susceptible checks a second time during Sep-Oct in a replicated experiment. Four accessions, AVRDC ACC. Nos. B 159, B 186, B 488, and B 501 were the least affected during three observations. Since cabbage webworm population was not as high as we encountered during the peak summer months, we will screen these materials in the summer of 1979 to confirm the resistance.

Chemical Control of Cabbage Webworm

We set up six insecticide screening tests, each with nine insecticide treatments and one control replicated four times, as described in our publication "Vegetable Pest Control: Insecticide Evaluation Tests," during Jul-Aug. An early maturing, heat tolerant, open pollinated variety was used in all tests. We screened 43 insecticides in various formulations-granules, wettable powders, and emulsifiable concentrates. We applied granular insecticides in the soil below the seedling at transplanting time and sprayed others each week beginning one week after transplanting. The results with only the most effective insecticides are summarized in Table 11.

On an active ingredient basis, parathion is the cheapest among all insecticides that gave good control of this pest. Because this insect burrows into the growing point and stem, soil application of systemic insecticides provides adequate control for a week or 10 days after transplanting, the most vulnerable period. However, Chinese cabbage being a delicate plant, expecially in the seedling stage, caution should be observed not to exceed an application rate of 1 to 2 kg ai/ha. We observed slight phytotoxicity with carbofuran at 2 and 3 kg ai/ha, but the symptoms disappeared in 7 to 10 days.

Ecological Study of Chinese Cabbage Insect Pests

To develop a judicious pest management program it is important to understand the periods of peak abundance of insects. We, therefore, started to monitor various insect pests of Chinese cabbage and commmon cabbage in 1976. Every month we plant Chinese cabbage and common cabbage and raise the crops until harvest, using all recommended cultural practices except insecticides. Each week we count the number of insects on a 30-plant sample, starting one month after transplanting. The results of the past three years are summarized in Figure 2. Our studies indicate that on both Chinese cabbage and common cabbage the incidence of diamondback moth starts in January, reaches a peak in February, and tapers off in April. Cabbage worm activity very closely follows that of diamondback moth, its population starts building up in February and tapers off in May. Aphids appear year round except numbers are small from June through September. Striped flea beetle appears between January and May, with the highest activity during April. We also maintain information on various weather parameters, such as temperature, humidity, rainfall, wind direction and velocity, with the view to correlating the pest abundance with these climatic factors for possible use in forecasting an insect pest outbreak.

Seasonal Effect on Growth and Head Development

We studied the plant growth and head yield of heat tolerant (HT), heat sensitive (HS) and moderately heat tolerant (MHT) accessions growing in the field throughout the year. Poor heading or low head yield were obtained for HS accession, B6, and MHT accession, B14, when they were grown during the summer (Fig. 3) Leaf number and total leaf area of HT accessions, B31, were generally lower than HS entries throughout the year; however, respectable head yields were obtained during the summer. The results imply that two fundamental physiological processes (leaf folding and accumulation of headed leaf area) governed the heading process in all seasons, and their relative or absolute contribution to heading greatly affects the final structure and firmness of the mature head.

The capability of B-31 to form heads during summer conditions may partly be due to better root growth. This observation was supported by our laboratory study (Table 12) where we grew plants in vermiculite. High temperature greatly reduced the root growth of heat sensitive entries (B-6 and B-40), whereas heat tolerant entries (B-31 and B-18) maintained better root growth and low shoot/root ratios.

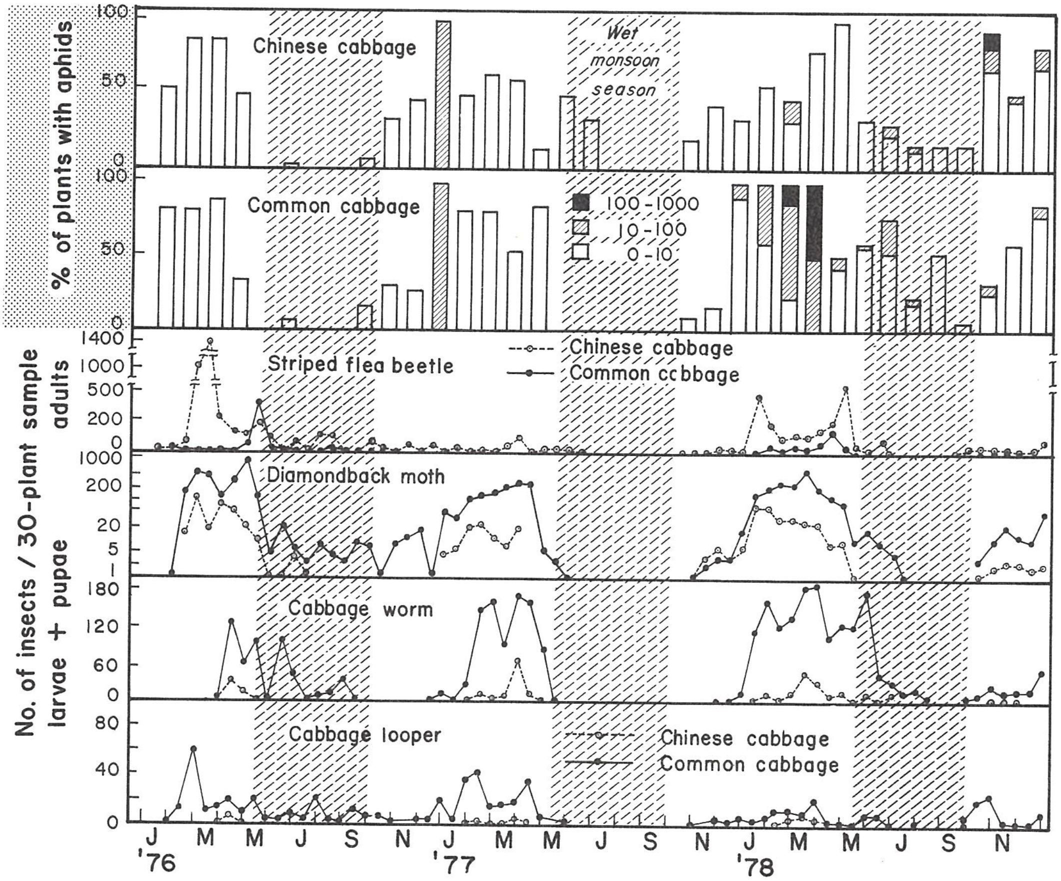


Fig. 2. Seasonal incidence of various insect pests on Chinese cabbage and common cabbage at AVRDC, 1976-78.

Physiology of Flowering and Seed Production

Certain Chinese cabbage varieties do not readily bolt or flower, whereas other varieties often bolt or flower prematurely in tropical regions. Flowering difficulty limits seed production, thus leading growers to obtain seeds from other sources, whereas premature bolting, which precludes head formation, represents a loss to the grower which can not be retrieved. We conducted experiments to study two problems of this physiological process.

In one study, we applied 8^{0}C treatment to some HT, HS and MHT accessions for 10 day periods at different growth stages and observed vegetative growth, bolting or flowering. The results are summarized in Figure 4. The heat tolerant accession bolted and flowered readily regardless of the growth stage at which the cold temperature treatment

Table 11. Summary of results obtained with the most effective insecticides for cabbage webworm control on Chinese cabbage. AVRDC. 1978.[a]

Screening test no.	Insecticide	Rate	No. larvae/10 plant		Yield
			I observ.	II observ.	
		-kg a.i./ha-			-t/ha-
I c	Mephosfolan 2G	2	2.3b	2.0a	4.8ab
	Terbufos 10G	2	7.3b	5.3a	6.3a
	Carbofuran 3G	2	3.5b	4.8a	5.2ab
	Control	-	40.3a	2.5a	0 c
II c	Carbofuran 3G	3	0.3b	3.3a	5.4a
	Carbofuran 3G	1	5.3ab	9.5a	4.5a
	Fensulfothion 5G	2	6.0ab	1.5a	4.0abc
	Control	-	27.8ab	6.8a	0 c
III d	Chlorpyrifos 40.8EC	0.25	1.5c	0 b	5.3a
	Control	-	23.3ab	f	0 d
IV d	EPN 45EC	0.25	2.0b	0.3a	4.2a
	Triazophos 40EC	0.25	6.0ab	4.0a	4.3a
	Control	-	16.3ab	f	0 b
V e	Methidathion 40EC	0.25	4.8bc	2.0a	4.9ab
	Methomyl 24EC	0.25	10.0abc	1.0a	4.8ab
	Parathion 50EC	0.25	1.5bc	0.5a	5.2a
	Triazophos 40EC	0.25	0.5c	0.3a	5.3a
	Control	-	25.8a	7.8a	0.9de

[a]Variety: B189C_1. Transplanting dates: Tests I & II 4 Jul, III & IV 12 Jul, and V 20 Jul. Observation dates: Tests I & II 18 Jul and 3 Aug, III & IV 24 Jul and 2 Aug, and V 2 and 8 Aug. Plot size: 13.5 square meters (4.5 m x 3 m). [b]Data are means of four replicates. Means followed by the same letter are not significantly different at 5% level. Harvest dates: 14 Aug (c) 18 Aug (d) 24 Aug (e), and all plants died (f)

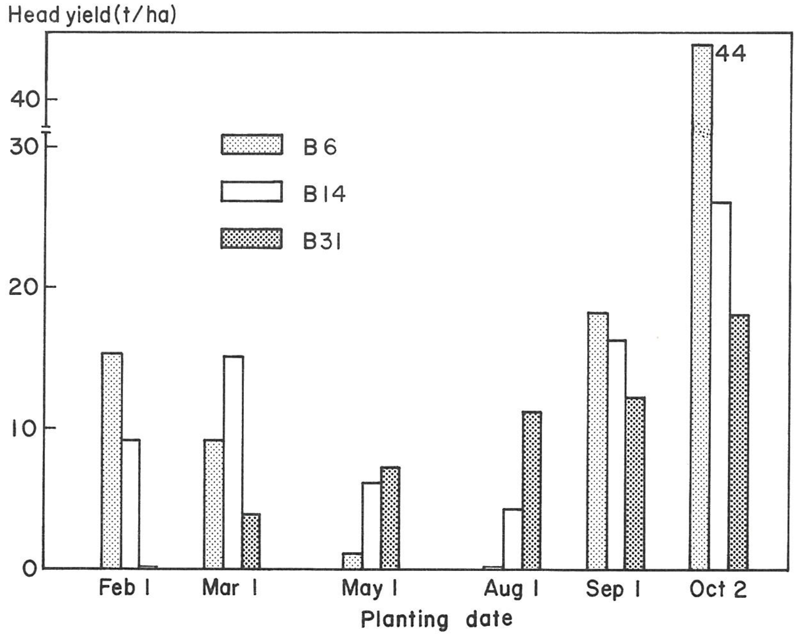


Fig. 3. Effects of seasonal conditions on head formation in heat tolerant (B31), moderately heat tolerant (B14) and heat sensitive (B6) Chinese cabbage accessions, AVRDC, 1978.

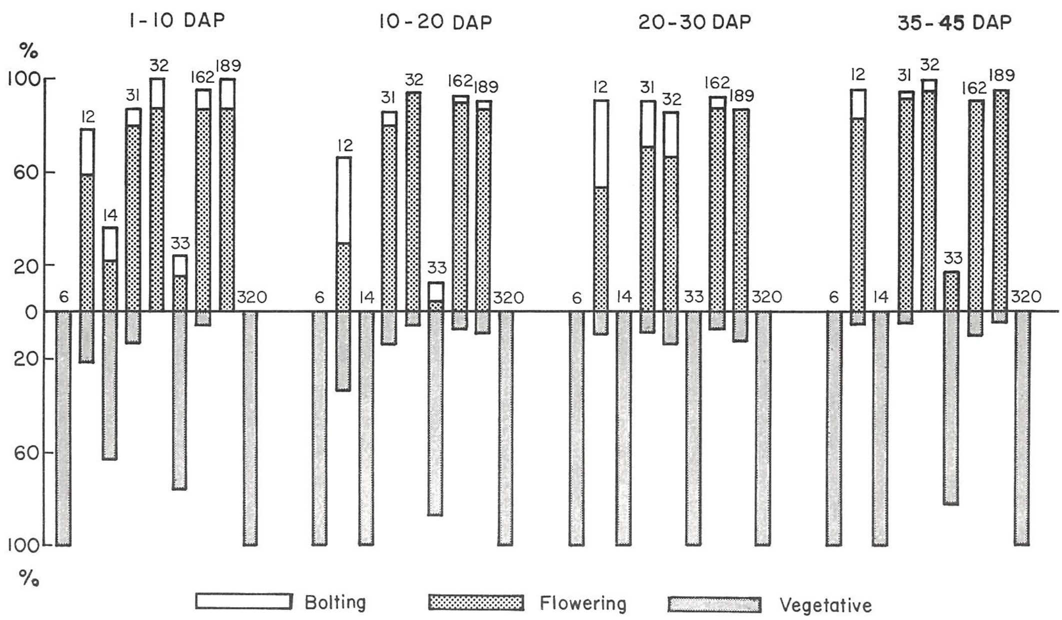


Fig. 4. Effects of vernalization at different ages on the bolting and flowering in several Chinese cabbage accessions. (Accession number indicated at top of columns.) AVRDC, 1978.

Table 12. Effect of temperature on growth of young Chinese cabbage plants. AVRDC. 1978.

Entries	Type	Root dry weight			dry weight Shoot/root ratio	
		High Temp.	Low Temp.	High/Low Temp.	High Temp.	Low Temp.
		---------- g ----------			----- g -----	
B-6	HS	0.28	0.59	0.47	5.5	2.8
B-31	HT	0.33	0.30	1.10	3.9	4.1
B-40	HS	0.17	0.39	0.44	5.2	3.1
B-189	HT	0.31	0.33	0.94	4.6	4.8
LSD 0.05			0.14	-	-	

[a]Temperature Treatments Low (20-25^{o}C) High (25-30^{o}C). Temperature treatments were begun 25 days after planting and continued for 15 days.

was applied. This is a clear indication that varieties vary genetically in their susceptibility to bolting or flowering and that the primary triggering mechanism appears to be environmental conditions.

To find whether photoperiod could influence the bolting and flowering, we subjected some HT and HS accessions to 13 and 16 hours of photoperiod without cold treatment. The results are summarized in Table 13. Heat tolerant accessions B31 and B189 flowered under continuous 16 hour photoperiod without cold treatment. However none of the flowered plants

Table 13. Effect of varying lengths of photoperiod on flowering without cold treatment in Chinese cabbage. AVRDC, 1978.

Entries	Percent plants flowering at photoperiod of	
	13 hours	16 hours
B-6	0	0
B-14	0	0
B-28	0	0
B-42	0	0
B-31	0	10
B-189	0	56

Table 14. Viability of pollen obtained from heat tolerant Chinese cabbage grown at different temperatures. AVRDC. 1978.

Entries	Pollen germination rate at Growing temperature rate		
	22-25 °C	25-30 °C	Mean
129	44	18	31
189	62	13	38
Mean	53**	16**	34.5

Table 15. Tipburn of Chinese cabbage cultured in sand under varying levels of Ca and B. AVRDC, 1978.

Treatment	Nutrient Concentration Ca	B	Plants with tipburn	Mean days to the first tipburn
	----ppm----		-%-	
Control	126	34	0	-
Low Ca	37	34	58 $\pm$ 27	41
Low B	126	0.2	31 $\pm$ 10	43
Low Ca & Low B	37	0.2	77 $\pm$ 22	40

set pods or seeds, possibly due to high temperatures beyond the ideal range of 20 °C to 24 °C. This high temperature effect could be due to pollen damage, as we observed in our laboratory study of the viability of pollens obtained from HT accessions B129 and B189 grown at two temperature ranges (Table 14).

Thus, bolting or flowering is the result of an interaction between temperature and variety. Preventing bolting or flowering by using an appropriate variety is a key to harvesting headed Chinese cabbages. The data also imply that relatively cold temperatures are needed for heat tolerant varieties to set pods and seeds.

Tipburn of Chinese Cabbage

The internal tipburn of heading Chinese cabbage plants is quite a wide-spread problem and may severely reduce marketability. The necrosis symptom turns from brown to black, beginning at the margins of leaves near the center of the head. The tipburn is suspected to be caused by

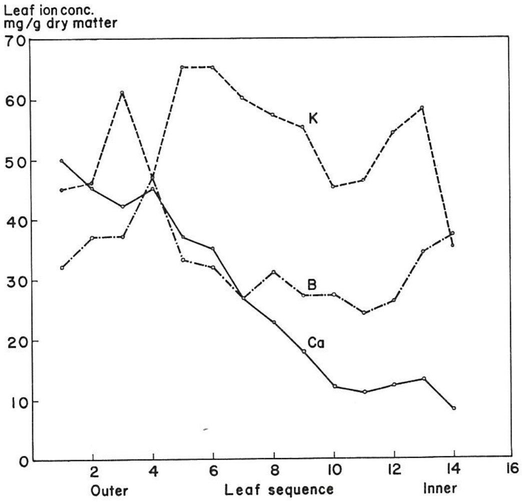


Fig. 5. Distribution of B, Ca and K content of Chinese cabbage leaves. AVRDC, 1978.

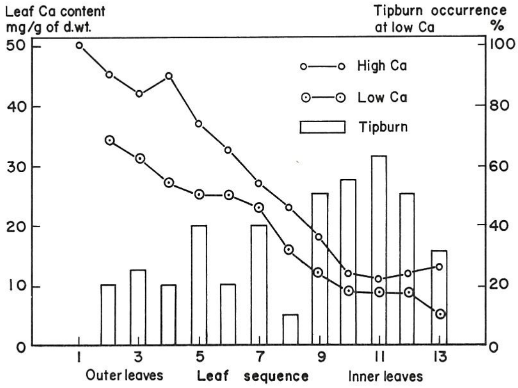


Fig. 6. Relationship of leaf Ca content and tipburn incidence in Chinese cabbage. AVRDC, 1978.

a mineral deficiency, and many environmental factors seem to accelerate it. We, therefore, conducted several experiments to study conditions conducive to tipburn.

We watered sand-cultured B189 plants daily with Hoagland solution containing variable amounts of calcium and boron. The results in Table 15 show that the plants developed tipburn readily when they were cultured under low Ca, low B, or both low Ca and low B. The disorder occurred first on the 8th or 9th leaf of young plants prior to heading. The necrotic area on the leaf margin was twice as great with low Ca as with low B. It seems likely, therefore, that exogenous Ca or B deficiencies may be responsible for tipburn with low levels of Ca causing the most serious damage.

The distribution of B, Ca and K in the plants grown in the control solution was determined by chemical analysis. Fig 5 shows the B and K content did not change greatly between outer and inner leaves, whereas there was a steady decline of Ca content from the outer leaves to inner leaves.

In a related study, we found a higher incidence of tipburn (Fig. 6) on the inner leaves of plants receiving low Ca. Since inner leaves have lower rates of transpiration than outer leaves, the results imply that Ca transport from the roots to the outer shoots of plants occurred mainly via the transpiration stream. Outer leaves, which receive adequate Ca, are unable to remobilize this element and transport it to the inner leaves.

Table 16. Tipburn of young Chinese cabbage plants under controlled root pressure. AVRDC. 1978.

Treatment	Entries	No. of tipburned plants[1]	No. of leaves	No. of tipburned leaves(mean)[2]
		--%--		
Plants covered all night, root pressure flow encouraged	B-141	0	22	0[a]
	B-189	33	28	1[a]
Plants not covered at night, root pressure flow discouraged	B-141	83	27	7[b]
	B-189	100	27	10[b]

[1]Based on observation of 6 plants per entry treatment. [2]Numbers followed by the same letter are not significantly different at the 5% probability level.

Since transpiration from inner head leaves is greatly restricted, an experiment was set up to encourage root pressure flow. Soil-cultured young plants, B141 and B189, were enclosed in plastic bags during the evening, in order to stop transpiration from all leaves. The results summarized in Table 16 indicate that root pressure flow is sufficient to provide enough Ca to the inner leaves to prevent tipburn, as long as the transpiration-induced flow is lowered. Therefore, high humidity, reduced stomatal aperature, less air movement, and maintenance of adequate soil moisture should favor the prevention of tipburn.

Four trainees admire their sweet potato crop.

SWEET POTATO

Our sweet potato germplasm collection remains at 389. We sent 280 breeding lines and 52 accessions to 19 scientists from 13 countries. We made 211 crosses (Table 1) which yielded 4409 true seeds. We were able to make more crosses since poor-flowering parentals were grafted to free-flowering root-stocks. This gave us abundant flowers to use for crossing (Table 1). However, synchronization of flowering of some parentals is still a problem. We also established six polycross nurseries. Five parental lines were included in each nursery. These nurseries produced 627 seeds of 30 combinations.

Botanical seeds were planted to give cuttings for vegetative propagation. The cuttings were planted for further increase (Table 2). We now have a total of about 4,000 genotypes which we will evaluate for promising characteristics.

Table 1. Sweet potato crosses made; AVRDC, 1978.

Kind of crosses	No. of crosses	% Total
Resistance to witches' broom	24	12
Resistance to weevil	79	37
Others (high yield potential, good eating & nutritional quality)	108	51
	211	100

Table 2. Number of seeds produced and converted to vegetatively propagated cuttings from various sources; AVRDC, 1978.

Source	Number of seeds: Sown	Number of seeds: Germinated	Germination
			%
Cross	4409	3261	74
Polycross	627	522	83
Open pollinated	1134	813	72
Total	6170	4596	

Cool Season Trials

We conducted a series of trials in September and October 1977 which were harvested in January 1978. We identified 203 outstanding breeding lines, capable of yielding at least 20 t/ha. The highest yielding selections are summarized in Table 3.

Summer Trials

Eight advanced and 12 preliminary trials, with tillage, were conducted in July. The high yield potential of selections AIS 209-2 and AIS 209-3 was verified (Table 4). In addition, new selections AIS 590-13 AIS 551-3 and AIS 438-3 also showed very respectable yields in spite of heavy rainfall and high temperatures during the trial. High yielding entries had a low vine/root ratio. In the preliminary trials some selections and one accession, Indonesia 6/2, gave very high yields (Table 5). These matrials will be used in our crossing program.

Survival of Sweet Potato Cuttings in Transport and Storage

AVRDC sends promising sweet potato breeding lines to scientists in several tropical countries for evaluation of yield and quality. Vine cuttings are usually sent because cuttings are easier to handle and are available throughout the year. Vine cuttings, however , deteriorate faster than roots. An experiment to determine the survival rate of cuttings in shipment indicated that survival rate decreases rapidly and varies among lines (Fig. 1).

Sometimes cuttings must be kept at AVRDC before shipment. It is, therefore, important to find the most suitable storage temperature for cuttings. The study showed that it is better to store the cuttings at higher temperatures (22-28°C) than at the lower temperatures (10-16°C), because at the lower temperatures the cuttings suffered from "chilling" injury.

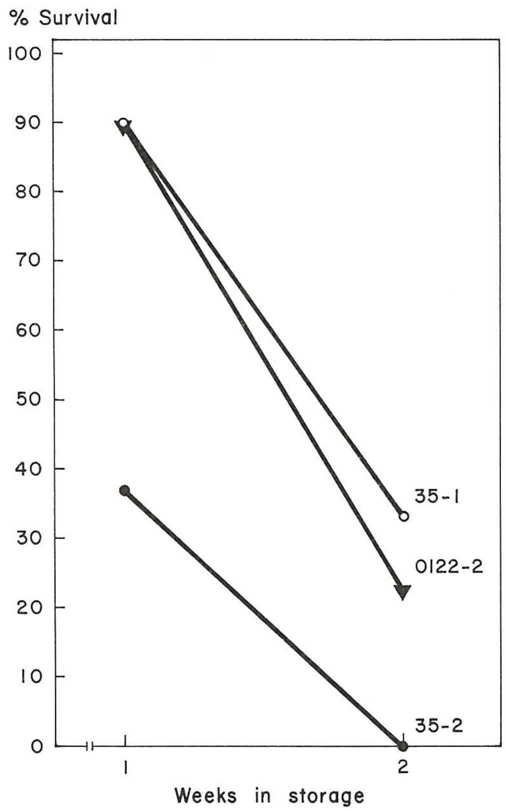


Fig. 1. Survival rate of three sweet potato lines.

Table 3. The best yielding new breeding lines in cool season observational trials; 1978, AVRDC.[a]

AVRDC cross no.	Pedigree	Yield: Marketable	Yield: Cull	Top Wt.	Top/root ratio	Remarks[b]
		-----t/ha-----				
Orange-fleshed						
AIS 483-3	Taiwan 2/AIS 0122-2	37	3	17	0.44	WBS/ + H
AIS 591-14	Polycross Tainung 57(2)	34	4	11	0.29	BWS + H
AIS 590-13	Polycross Tainung 57(1)	33	5	20	0.52	BWS + H
AIS 542-4	AIS 0122-2/PI 344123	33	3	18	0.51	H/BR
AIS 551-3	AIS 0122-2/Tainung 27/HDK 8	33	4	24	0.66	H/WBS
AIS 35-2	HDK 6/B6708 check	14	3	9	0.50	H
White or Yellow-fleshed						
I 488	PI 344129/American Yellow Skin	43	3	24	0.52	BR/BR
AIS 478-8	PI 344129/Tainung New 31	40	4	17	0.39	BR/WBS
AIS 0117-25	PI 344129 (OP)	38	3	14	0.35	BR
AIS 497-1	PI 344129/Taiwan 2	36	5	14	0.34	BR/WBS
AIS 591-41	Polycross Tainung 57(2)	36	3	13	0.33	BWS
AIS 242-2	B 6708/Tainung 56 check	10	2	12	1.00	H

[a]1250 breeding lines were planted in 25 groups of 50 entries each on Sep 20-22 (77) and harvested Jan (120 days); yield from 20 hills.
[b]H=high yield; W=sweet potato weevil; B=witches' broom; R=resistant; S=susceptible.

Table 4. Yield and vine/root ratio of the best yielding sweet potato (with tillage) lines in summer advanced trials, 1978, AVRDC.[a]

Acc. selection (or acc.) no.	Pedigree or (cultivar) name	Marketable yield	Vine/root ratio	Flesh color
		-t/ha-		
AIS 590-13	Polycross Tainung 57(1)	25	1.1	orange
AIS 209-2	B 6708/OK 9-3	23	0.9	orange
AIS 551-3	B 6708 (OP)//Tainung 27/HDK 8	20	1.2	orange
AIS 209-3	B 6708/OK 9-3	18	1.1	orange
AIS 438-3	Taiwan 2/B 6708	16	1.5	white
(I 57)	(Tainung 57), check	5	3.1	yellow
AIS 35-1	HDK 6/B 6708, check	12	1.5	orange

[a]80 breeding lines included in 8 separate advanced trials; planted July 4 and 5 and harvested Nov. 6-14; vegetative stage coincided with heavy rainfall in Jul, Aug, Sep and Oct; mean of 4 replications.

Table 5. Yield and flesh color of the best yielding sweet potato breeding lines (with tillage) in summer preliminary trials, 1978, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree or (cultivar) name	Yield		Flesh Color
		Marketable	Cull	
		-------t/ha------		
AIS 551-1	B6708//Tainung 27/HDK 8	25	8	orange
(I 389)	Indonesia 6/2	23	4	orange
AIS 580-1	Tainung 27/HDK 8//PI 318548	19	4	yellow
AIS 608-652	Polycross B 6708(1)	17	10	orange
AIS 392-14	B 6708/B 7199//Tainung 44	17	5	orange
AIS 35-1	HDK 6/B 6708, check	13	4	orange
(I 57)	(Tainung 57), check	5	6	yellow

[a]240 breeding lines included in 12 separate trials; planted July 6-10 and harvested Nov 6-14; vegetative stage coincided with heavy rainfall in July, Aug, Sept, and Oct; mean of 3 replications.

Relay Cropping with Corn

As in the tomato, we conducted an experiment to determine if there is a genetic basis in selecting sweet potato genotypes for relay cropping. We grew a monoculture (mono-crop) of green corn and 40 days before harvesting the corn, we relay planted 30-cm cuttings of sweet potato on the corn ridge. The results demonstrated that the relay-planted sweet potato had lower yield than mono-crop (Table 6). The yield loss varied from 29 to 85%, due primarily to a reduction in the number of roots, rather than mean root weight.

International Activities

Distribution of sweet potato breeding materials is more difficult than for sexually propagated crops because of quarantine regulations both in Taiwan and recipient countries. In spite of this, we have received several country reports from Thailand, Indonesia, Taiwan, and Bangladesh.

Trials in Indonesia evaluated 50 sweet potato selections and accessions at 3 elevations, in West and East Java. AVRDC materials were exceptionally good performers at lower elevations (Table 7). However, selections AIS 128 and AIS 0122-2 compared favorably with the check cultivar even at an elevation of 1100 m. These lines will be further evaluated under highland conditions.

The advanced trials in Noakhali, Bangladesh, conducted by the Mennonite Central Committee demonstrated that AVRDC materials were comparable in yield to check, but they had higher vitamin A content (Table 8). AVRDC lines in the observational trial demonstrated high yield potential by yielding 42-51 t/ha in 179 days (Table 8).

At the Taitung DAIS in Taiwan, selection AIS 0122-2, AIS 272-9, and AIS 243-2 yielded 29 to 35 t/ha. Selection AIS 0122-2 was considered to have the quality suitable for use in desserts.

The Horticulture Department of Kasetsart University in Thailand reported high root and top yields of selections AIS 35-2, AIS 106-2, and AIS 010-6. Selection AIS 35-2, for example, gave 83 t/ha tops and 20 t/ha roots.

In trials at the Maejo Agricultural Experiment Station, Thailand, selections AIS 010-1 and AIS 35-2 yielded an average of 29 t/ha and 27 t/ha respectively, more than twice the yield of Okud, the local check.

Screening for Sweet Potato Weevil Resistance

During 1978 we continued the screening of sweet potato accessions and breeding materials for resistance to sweet potato weevil (*Cylas*

Table 6. Marketable roots, number per ha and average weight per root of 10 sweet potato materials when relay planted with sweet corn or when monocropped; AVRDC, 1978.[a]

Entries	Marketable roots			Number of roots			Average wt. per root		
	mono	relay	loss	mono	relay	loss	mono	relay	loss
	---t/ha----		-%-	--1000/ha---		-%-	------g------		-%-
Selections									
AIS 272-2	15	10	33	110	49	55	230	204	11
AIS 35-2	16	8	50	96	53	45	182	167	8
AIS 278-1	19	8	58	83	52	37	233	110	53
AIS 0122-2	38	12	69	136	37	73	287	174	39
Accessions									
I 6	17	12	29	90	55	39	182	222	22[b]
I 1	20	11	45	145	58	60	208	119	43
I 117	20	8	60	91	32	64	216	256	18[b]
I 57	17	4	76	106	38	64	182	106	42
I 152	15	3	80	63	22	65	230	154	33
I 54	13	2	85	86	14	84	192	150	22

[a] Sweet potato planted Oct, 1977 and harvested Jan 26, 1978 (121 days); relay sweet potato overlapped with sweet corn for 40 days.
[b] % increase in average wt. per root

Table 7. Performance of AVRDC breeding lines at different elevations compared to local check, 1977, Bogor, Indonesia.[a]

AVRDC sel or (acc. no)	Pedigree or (cultivar name)	Location: Jambege (350 m)	Location: Kuningan (559 m)	Location: Pacet (1100 m)	Average
		t/ha			
AIS 128	PI 315345/Acadian	20	26	11	19
(I 57)	(Tainung 57)	25	18	7	17
AIS 0122-2	B 6708 (OP)	18	16	12	15
AIS 35-2	HDK 6/B 6708	20	15	4	13
	(Local), check	9	17	12	13
AIS 35-1	HDK 6/B 6708	22	11	3	12

[a]Evaluated conducted from Jun to Oct (1977) in 120 days; data in each location are means of 4 replications.

Table 8. Yield performance of AVRDC breeding lines in Noakhali, Bangladesh, 1978.[a]

AVRDC select. no.	Pedigree	Yield	Flesh color
		-t/ha-	
Advanced			
AIS 230	B 6733/HDK 8	22	orange
AIS 35-2	HDK 6/B 6708	22	orange
AIS 35-1	HDK 6/B 6708	19	orange
check	local cultivar	18	white
	LSD .05	6	
Observational			
AIS 243-2	B 6708/Tainung 56	41	white
AIS 0122-2	B 6708 (op)	42	orange
AIS 272-9	Red Tuber Tail/ Allgood	36	yellow

[a]Data supplied by the MCC; advanced trial planted Nov 2 (77) and harvested April 3 (150 days); observational trial planted Nov 3 and harvested May 5 (179 days).

formicarius). We conducted five field tests, three at AVRDC and two at Penghu Island located in Taiwan straits. An experimental field technique developed during 1974 (AVRDC Annual Report 1974) involving planting of test materials between heavily infested source rows of a highly susceptible variety was adapted for the tests at AVRDC. At Penghu Island, however, we released the weevils in the experimental area two months after planting. The selection of sweet potato entries was based on pedigree or relative resistance rating during previous tests.

In the first experiment we tested 141 breeding materials and 6 accessions. We evaluated their performance in relation to the number of insects found per unit root weight and insect damage based on the weight of damaged root material when sliced in 2.5 m thick slices, a technique we developed in 1976 (AVRDC Sweet Potato Report 1976). The data were subjected to three statistical analysis tests based on standard deviation as outlined in Table 9.

Forty four entries fell in MR or R catagories by all three criteria. The performance of selected entries is summarized in Table 10.

We tested 44 crosses or accessions along with several additional entries from crosses made by our sweet potato breeders and three reference varieties (I 57, I 117 and AIS 35-2) simultaneously in identical experiments at Penghu Island and AVRDC. Considerable differences in resistance rating at the two locations were observed. None of the entries had identical relative resistance ratings, based on the earlier described three statistical test criteria, at both locations. Many entries planted at Penghu Island gave no yield or not enough to evaluate, possibly due to a combination of disease, and/or insects. Witches broom, transmitted by a leaf hopper, is the most serious sweet potato disease on Penghu. Sweet potato weevil and a stem borer (*Omphisa* sp.) are common on the island.

In another test, 164 new accessions along with three reference varieties (I 57, I 117, and AIS 35-2) were planted at AVRDC in March and Penghu in May. Over 50% of the accessions planted on Penghu Island either yielded nothing or not enough to enable us to evaluate their performance. Only two accessions (I 237 and I 284) among the remaining had identical moderate resistance ratings at both locations.

So far, only two AVRDC accessions, I 123 and I 152, have proved consistantly moderately resistant to weevil at various locations during the past four years. We are now using these materials in our breeding program.

Effect of Sweet Potato Weevil Infestation on Sweet Potato Yield

In the field, sweet potato weevil attacks both the roots and the stems. To determine the extent of yield reduction, we studied the relationship between the weevil infestation and the yield. We planted sweet potatoes (variety AIS 35-2) on beds spaced 1 meter apart over a one hectare area during November 1977 and released weevils over the entire field two months later. In June 1978 we harvested a 1 meter row at the junction of a 10 meter grid (119 samples) throughout the field. We counted the number of insects in 50 cm stems and in roots. The insect damage to roots was determined by weighing the damaged root slices (2.5 mm thick). We repeated this experiment by planting the same variety in the same field two weeks after sampling the first crop,

Table 9. Sweet potato weevil relative resistance ranking methods.

1. Based on weevil numbers

I (HR): Highly Resistant = $< (\bar{X})_{wn} - (1sd)_{wn}$

II (MR): Mod. Resistant = $(\bar{X})_{wn} - (1sd)_{wn}$ to $(\bar{X})_{wn}$

III (S): Susceptible = $(\bar{X})_{wn}$ to $(\bar{X})_{wn} + (2sd)_{wn}$

IV (HS): Highly Susceptible = $> (\bar{X})_{wn} + (2sd)_{wn}$

2. Based on % damaged roots

I (HR): Highly Resistant = $< (\bar{X})_{\%d} - (1sd)_{\%d}$

II (MR): Mod. Resistant = $(\bar{X})_{\%d} - (1sd)_{\%d}$ to $(\bar{X})_{\%d}$

III (S): Susceptible = $(\bar{X})_{\%d}$ to $(\bar{X})_{\%d} + (2sd)_{\%d}$

IV (HS): Highly Susceptible = $> (\bar{X})_{\%d} + (2sd)_{\%d}$

3. Based on weevil numbers + % damaged roots

I (HR): Highly Resistant

$< ((\bar{X})_{wn} - (1sd)_{wn}) + ((\bar{X})_{\%d} - (1sd)_{\%d})$

II (MR): Moderately Resistant

$((\bar{X})_{wn} - (1sd)_{wn}) + ((\bar{X})_{\%d} - (1sd)_{\%d})$ to $((\bar{X})_{wn} + (\bar{X})_{\%d})$

III (S): Susceptible

$((\bar{X})_{wn} + (\bar{X})_{\%d})$ to $((\bar{X})_{wn} + (2sd)_{wn}) + ((\bar{X})_{\%d} + (2sd)_{\%d})$

IV (HS): Highly Susceptible

$> ((\bar{X})_{wn} + (2sd)_{wn}) + ((\bar{X})_{\%d} + (2sd)_{\%d})$

wn=No. weevils/kg roots, %d=Percent damaged roots, $\bar{X}$=Mean, sd=standard deviation.

Table 10. Relative resistance rating performance of selected sweet potato crosses; AVRDC, 1978.

AVRDC cross no.	Pedigree	No. weevils[a] per kg roots (W)	Damaged roots % by wt. (D)	Relative resistance rating based on W	D	W+D	Yield t/ha
CI 496-1	I 123/I 90	0.8	3.0	MR	HR	HR	9.7
CI 499-2	I 123/I 134	0	0	MR	HR	HR	5.2
CI 500-6	I 123/I 122	0	0.2	MR	HR	HR	10.8
CI 418-1	I 6/I 134	0	0	MR	HR	HR	12.6
CI 515-4	I 134/I 152	20.2	56.5	S	HS	S	7.9[b]
Mean for 147 entries		8.0	21.9				

Planted: 19-21 Oct. 1977, harvested 10-13 April 1978.
[a]Includes larvae & Pupae & adults.
Susceptible check. Plot size: 5 x 1 m. HR: Highly Resistant.
MR: Moderately Resistant. S: Susceptible. HS: Highly Susceptible.

but only over half a hectare area. We did not release the weevils this time. We sampled the field in November in identical fashion and determined insect damage.

We statistically analyzed the data to study the correlation between the extent of weevil infestation and yield. Figures 2 to 5 summarize our findings during both seasons.

In the first test, when weevil infestation was moderate, yield was not correlated to the number of weevils in the stem. However, during the second test, although the infestation was greater, there was a surprisingly significant (5% level) positive correlation between the yield and the number of insects in the stem. In neither test did we observe any correlation between yield and the number of insects in the roots or percent of roots damaged. As expected, we found a significant (1% level) positive correlation between the number of weevils in roots and the percent of roots damaged. It appears, therefore, that weevil infestation in sweet potato stems or roots will not reduce the yield significantly. However, the off flavor induced by terpenes synthesized in the roots due to sweet potato weevil attack makes even very slightly infested roots totally unfit for human consumption.

Physiology of Flowering

Induction of flowering is an important but difficult first step in the sweet potato breeding program. Experiments were performed in the

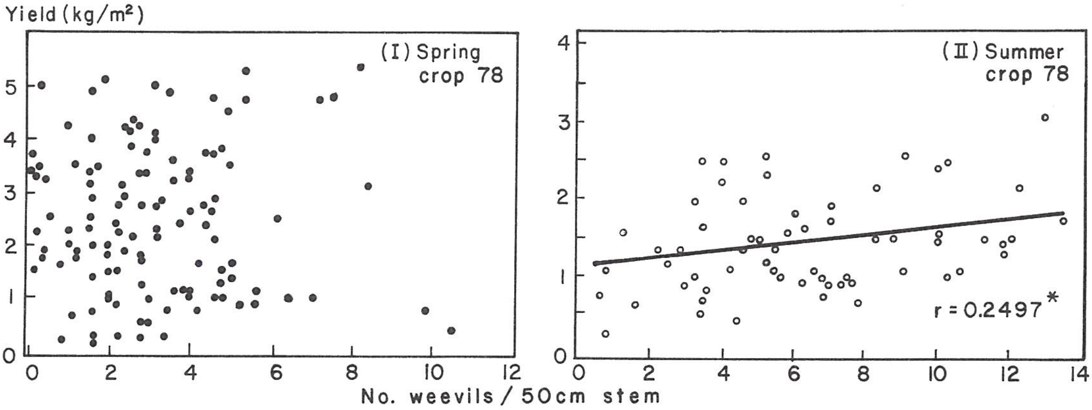


Fig. 2. Relation between number of weevils in stem and root yield.

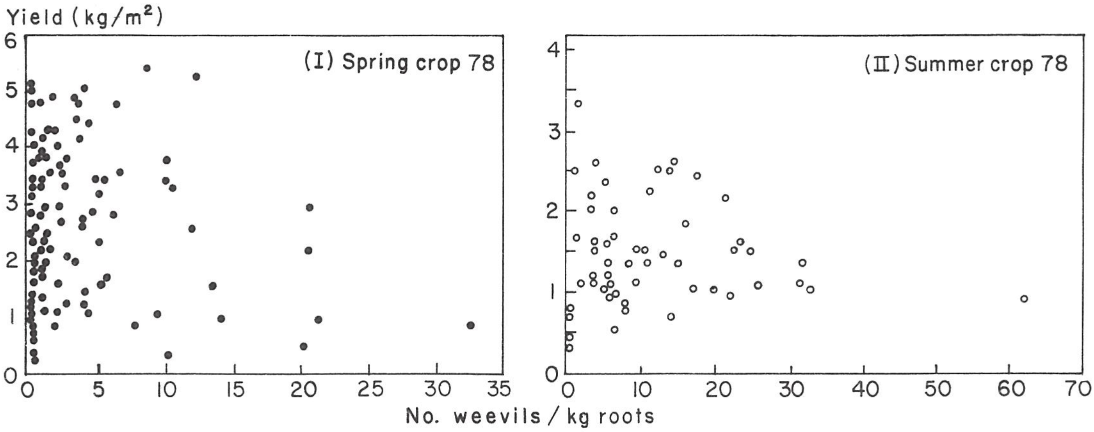


Fig. 3. Relation between number of weevils in roots and root yield.

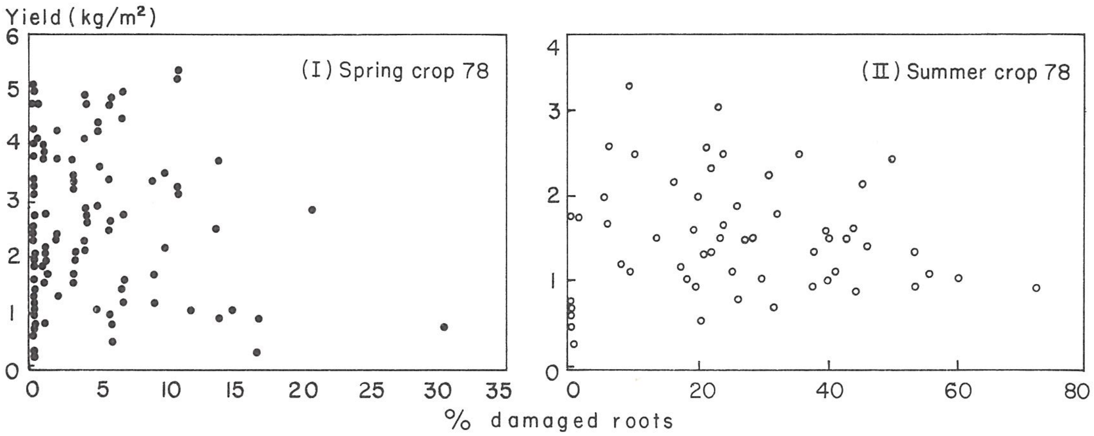


Fig. 4. Relation between percent damaged roots and root yield.

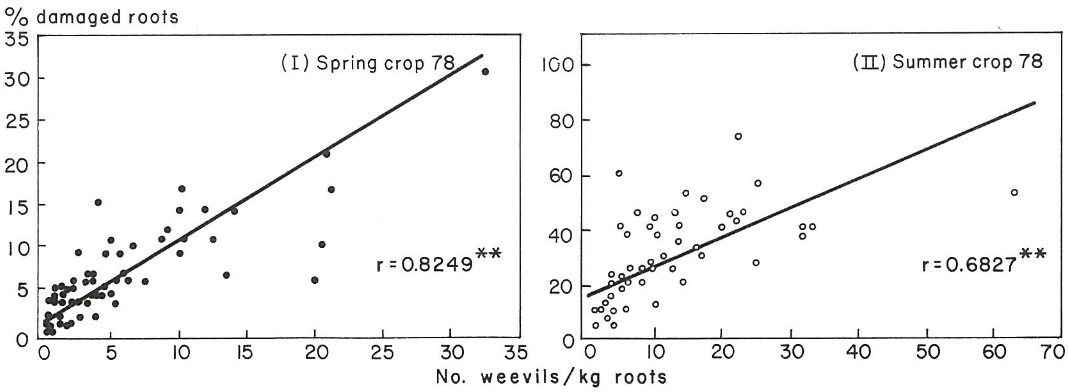


Fig. 5. Relation between number of weevils in roots and percent root damage.

past two years to study the nature and possible artificial promotion of flowering.

<u>Effect of photoperiod</u>. We planted cuttings of four accessions (I-20, I-44, I-57, and I-82) in clay pots and gave them continuous light (i.e., natural photoperiod supplemented with artificial light) until they reached 10 cm. Then the plants were submitted to either 5 hrs, 9 hrs or natural (12.5 to 13.3 hrs) photoperiods. No flower buds were observed under natural or 5 hr photoperiods. However, accessions I-57 (100% plants), I-82 (70% plants), and I-44 (60% plants) formed flower buds 6 weeks after the start of the 9 hr photoperiod treatment. Unfortunately, none of these flower buds reached anthesis.

<u>Effect of grafting</u>. We grafted scions of three accessions (I-44, I-57, and I-82) on stocks of their own or *Pharbitis nil*, which flowers readily in spring and fall. Grafts were grown under natural photoperiod (12.5 to 13.3 hrs). Flower buds formed on grafts on *P. nil* but not on their own stocks. An average of two open flowers per graft formed on I-57 and I-82.

<u>Effect of chemicals</u>. TIBA (50 and 100 mg/l), ABA (5 and 25 mg/l) and 2,4-D (10 and 50 mg/l), which have been reported to promote flowering, were applied twice weekly on cuttings of I-20 and I-44 under natural photoperiod (12.5-13.3 hrs.). Neither open flowers nor buds resulted.

We applied various chemicals (in total of 50 μ/meristem) to the apical meristems of cuttings of I-57, AIS 35-2, and AIS 234-2 under natural photoperiod (11.6 to 13.2 hrs). Average maximum and minimum temperatures during the experiment were 27.7 and 17.7^{O}C, respectively. $GA_{4/7}$ and GA_5 were significantly effective in promoting flower bud formation on AIS 243-2, but not on I-57 or AIS 35-2 (Fig. 6). About 30% of those flower buds on AIS 243-2 reached anthesis. The stem growth of all 3 accession also was increased by chemical treatments.

In a factorial experiment, one factor was the chemical applied--GA_5, ABA, GA_5 + ABA in a total of 50 μ/meristem or no chemical. A second factor was the plant--cuttings of AIS 243-2, I-212, and graft of I-212 on AIS 243-2. A third factor was photoperiod--grown under natural photoperiod (12.9 to 13.4 to 13.0 hrs) or 8 hrs. Maximum and minimum temperatures during the experiment were 31.6 and 23.8°C, respectively. No flower buds or open flowers resulted.

All the experiments were carried out in seasons when there was no natural flowering. When grown during the fall or winter season, most of these accessions tended to flower rather readily. This response indicates that the optimum daylength for flower formation is 9-11 hrs. However, the high temperatures appeared to nullify the inductive effect of the short day photoperiod. Flower bud or open flower promotion induced by grafting on *Pharbitis nil*, or by other chemical treatments, depends upon the daylength and temperature under which the plants are grown.

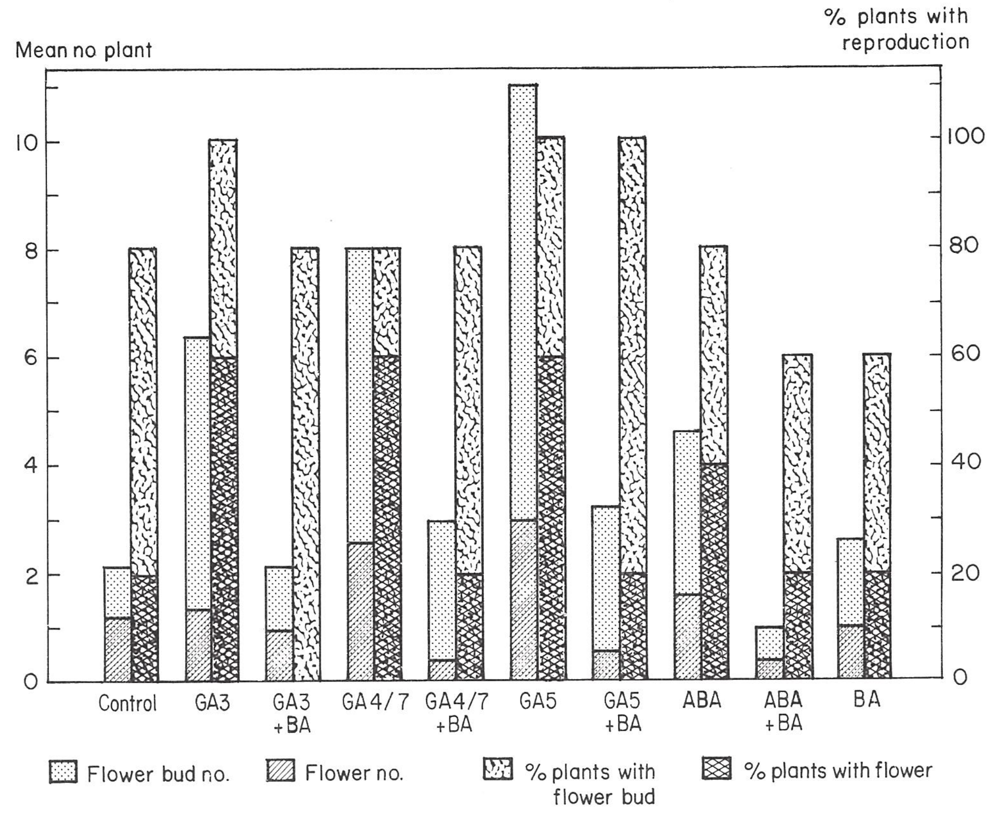
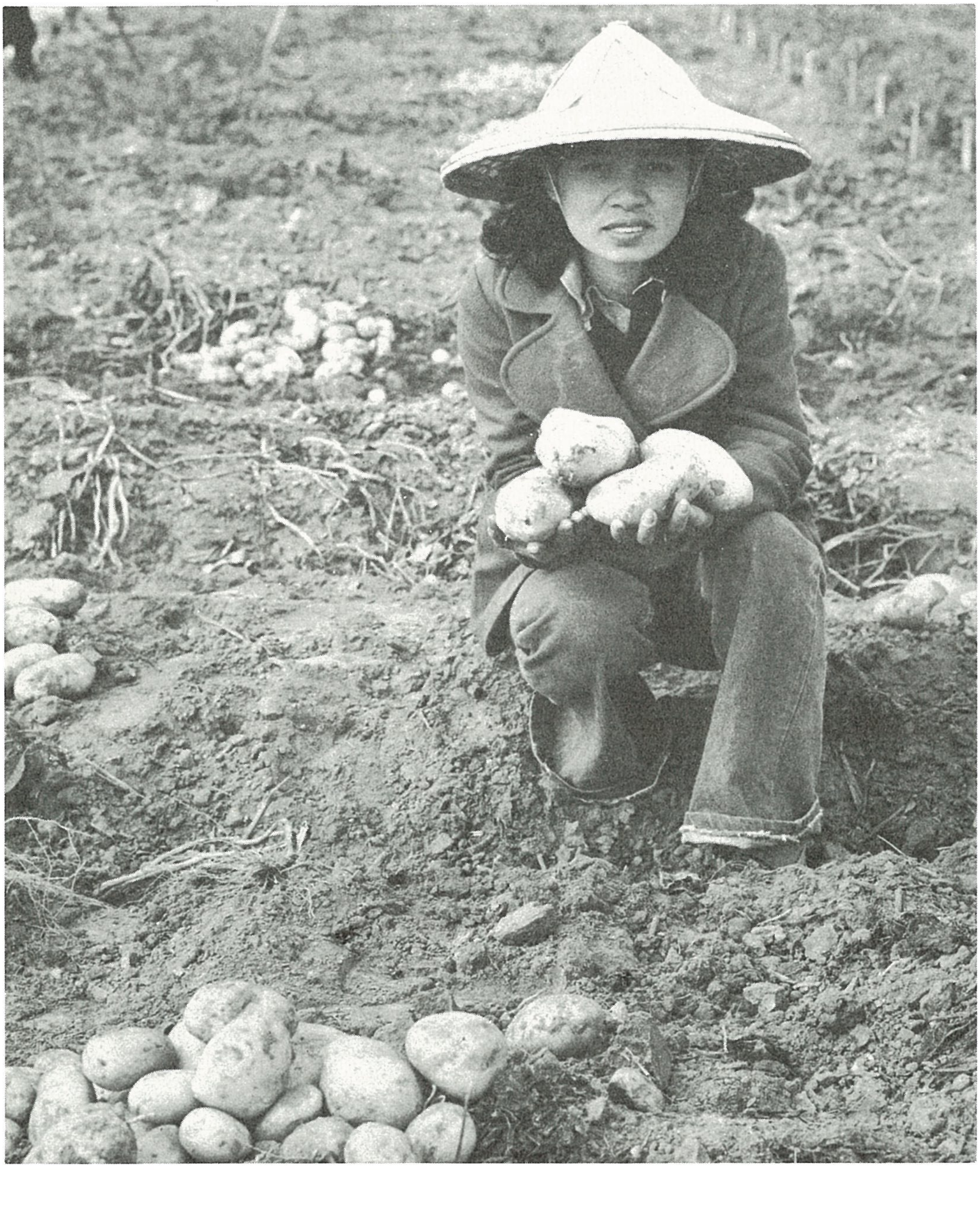


Fig. 6. Effects of exogenous growth regulators on flower bud formation and flowering of AIS 243-2.



WHITE POTATO

Collection, Screening and Distribution of Germplasm

No germplasm was added to the collection of 1282 cultivated tetraploids in 1978. We obtained 21 true seed populations with diverse genetic background from the University of Guelph. The International Potato Center (CIP) provided 8 populations carrying root knot nematode and bacterial wilt resistance and 9 with PVY (Potato Virus Y) immunity.

We distributed 37 clonal samples of breeding lines during the year. We provided true seeds of AVRDC crosses to CIP, the Institute of Plant Breeding (Philippines) and others.

Crossing Program and Segregating Populations

We developed cycle-3 populations in the 1977-78 winter season from diallel crosses of 5 selected cycle-2 clones. We also made other crosses between outstanding cycle-1, -2 clones. Five heat tolerant clones were crossed with bacterial wilt resistant accessions, S 422 (WIS-BR-63-20) and S 499 (WIS-BR-69-107).

Seedlings of cycle 3 populations and other crosses were grown in a nethouse from Apr 11 - Jun 20. Since the tuberization phase coincided with high early summer temperatures, we selected only putative heat tolerant seedlings with high total yield and/or high mean tuber weight. On this basis, we eliminated 80% of total genotypes and concentrated only on an easily manageable 20%.

A simple phenotypic correlation analysis among seedling traits revealed that total yield depended largely upon total number of tubers ($r = 0.78^{**}$). Clones with high average tuber weight produced very few tubers ($r = 0.57^{**}$). Plant height was positively correlated both with haulm growth ($r = 0.42^{**}$) and internode length ($r = 0.65^{**}$).

All selected genotypes were immediately induced to sprout and planted on Jul 28 for heat tolerance screening. We included an approximately equal number of unselected genotypes as controls. All surviving genotypes were harvested on Nov 2, 97 days after planting. We selected promising heat tolerant genotypes based on marketable yield, uniform shape, and relative absence of tuber disorders such as cracks and second growth.

Table 1. Phenotypic correlations among characters of cycle 3 white potato clones, summer trial; 1978, AVRDC[a].

Characters	Total yield	Marketable yield	Total tubers	Marketable tubers	Plant height
	-------g---------				--cm--
Haulm Growth (g)	0.75**	0.63**	0.51**	0.56**	0.38**
Total Yield (g)		0.86**	0.64**	0.83**	0.35**
Marketable Yield (g)			0.22**	0.92**	0.38**
Total Tubers				0.32**	NS
Marketable Tubers					0.33**

[a]Sample sizes ranged from 75-105; planted Jul 28 and harvested Nov. 2.

The simple phenotypic correlations among traits of the summer planting of cycle 3 populations showed that there were highly significant positive correlations between yield (total and marketable) and all other traits (Table 1). Results imply that heat tolerant clones are not necessarily those with limited vegetative growth or high tuberization efficiency. Rather a certain amount of top growth is required, below which tuber production is impaired. However, the correlation of yield with top growth is not expected to be linear, since excessive haulm production has a well-known antagonistic effect on tuberization.

No significant correlation was noted between yield of cycle 3 clones during the hot season and their traits as seedlings. Thus, none of the seedling characters can serve as indicators for heat tolerance. Initial selection for high total yield and/or high mean tuber weight among seedlings grown during spring to early summer was largely ineffective for identifying heat tolerant clones. This is further supported by the insignificant t-values for traits of selected and unselected (control) clones grown during the summer.

Interestingly, length of tuber dormancy was significantly associated with performance during the hot season (Table 2). Generally, genotypes that did not readily sprout after treatment with GA_3 and thiourea had better haulm growth, more total marketable tubers and higher total and marketable yield than those with short dormancy. It is suspected that these results may be explained by the concentration of endogenous gibberellins, as both dormancy and tuberization are known to be contrastingly influenced by these growth regulators.

Further evidence is provided by examination of the tuber dormancy of selected heat tolerant cycle 3 clones (Table 3). Excepting clone

Table 2. Comparative means for different characters of cycle 3 white potato clones with long or short dormancy, summer trial; 1978, AVRDC[a].

Clone dormancy	Haulm growth	Total yield	Marketable yield	Total tubers	Marketable tubers
	-----------	g/hill	---------	--number/hill	------
Long	374.3	403.9	267.1	9.9	3.4
Short	237.2	228.7	116.9	7.1	1.6
t-value	3.1**	5.7**	5.1**	3.2**	4.9**
d.f.	74	103	103	103	103

[a]Data from same trial as presented in Table 1.

77-54-164, all selections originated from tubers with long dormancy. Although correlations are insignificant, most of these selections were selected originally as promising seedling genotypes based on their high total yield and/or high mean tuber weight.

Yield Trials

We conducted three trials involving selected cycle 1 and cycle 2 clones in the summer. All three trials were planted on Jun 9 and harvested 105 days later.

Poor emergence and reduced stand at harvest characterized all wet season trials. Nonetheless, indications are that selection 1282-19 is by far the most promising heat tolerant clone among those tested (Tables 4 and 5). Selections 1282-1 and 1282-12 yielded marketable tubers, but not as many as 1282-19. Although the actual marketable yield of 1282-19 is still low (6-8 t/ha), in comparison with yields attainable in winter, improvement of the stand at harvest could markedly increase its yield. The heat sensitive check (S 18) produced no tubers.

Potato Transplanting Experiment

We tested transplanting as a technique to improve the stand at harvest, using 1282-19 (heat tolerant) and S 510 (heat sensitive) clones. All direct-planted plots were planted on Jul 11. At the same time, tubers for transplanting were started in flats containing the standard greenhouse soil mixture (i.e. equal parts of soil, sand, rice hulls and compost). We repeated the transplanting into flats because of poor emergence, using vermiculite as the medium. The "seedlings" were set out in the field 18 days later. The experiment was lifted Nov 2, 115 days after direct planting and 80 days after transplanting (98 days including time in the flats).

Table 3. Yield and other horticultural characters of white potato clones selected from cycle 3 population, summer trial; 1978, AVRDC[a].

Selection No.	Total yield	Marketable yield	Total tubers	Marketable tuber	Haulm growth	Plant height	Tuberization efficiency[b]	Tuber dormancy period
	----- g -----		---No---	---No---	---g---	---cm---		
Selected from test clones								
77-45-59	700	610	12	8	550	54	1.3	long
77-51-4	610	520	10	4	780	79	0.8	long
77-52-39	650	500	16	8	520	55	1.2	long
77-53-14	700	620	10	7	-	60	-	long
Selected from control clones								
77-53-28	610	400	13	6	540	37	1.1	long
77-54-164	530	530	5	5	500	75	1.1	short

[a]Data from same trial as presented in Table 1. [b]Ratio of total yield to haulm growth.

Table 4. Yield and other horticultural characters of selected white potato entries in a summer yield trial (I); 1978, AVRDC[a].

Entry	Emergence rate	Stand at harvest	Total yield[b]	Marketable yield[b]	Haulm growth
	---------%----------		------t/ha-------		-g-
1282-19	95	62	13.8	6.3	551
1282-12	50	48	5.7	2.4	649
S 18 (check)	75	22	0	0	210

[a]Mean of 2 replications; RCB design; 4.5 m^2 plots with 20 hills/plot; planted Jun 9 and lifted Sep 22. [b]Uncorrected for stand.

Table 6 shows a summary of ANOVA, including important contrasts. All characters showed significant treatment differences (Table 7). Orthogonal contrasts between heat tolerant and heat sensitive varieties were significant for all traits except emergence rate. This indicates that the two varieties, regardless of planting system, are truly different with respect to hot season performance, although they have similar emergence potential. S 510 yielded no marketable tubers, while 1282-19 produced an average yield of 8.6 t/ha.

Table 8 shows the comparative means of all characters in the transplanting and direct planting treatments. Transplanted clones had a 100% emergence rate as compared to 66% for the conventional (direct planting) system. Stand at harvest was also much higher with transplanting. The marketable yield was about twice as much as that of direct

Table 5. Yield and other horticultural characters of selected white potato entries in a summer yield (II); 1978, AVRDC[a].

Entry	Emergence rate	Stand at harvest	Total yield[b]	Marketable yield[b]	Haulm growth
	--------%--------		-------t/ha------		-g-
1282-19	100	70	14.6	7.6	642
1282-1	100	85	10.8	4.4	519
S 18 (check)	70	40	0	0	245

[a]Mean of 2 replications, RCB design; 2.25 m^2 plots with 10 hills/plot; planted Jun 9 and lifted Sep 22. [b]Uncorrected for stand.

Table 6. Sum of squares for characters measured in white potato transplanting experiment; 1978, AVRDC[a].

Source of variation[b]	d.f.	Emergence rate[c]	Stand at harvest[c]	Total yield	Marketable yield	Total tubers	Marketable tubers	Haulm growth
		---------%----------		-------t/ha------		-----per hill------		-g-[d]
Treatment	5	1.299**	1.15**	768.7**	310.8	117.08	22.34**	32538.8
HT vs HS	1	0.003	0.13*	620.5**	224.5**	114.08	18.25**	20090.1
T vs N	1	0.990**	0.71**	74.9**	42.9**	0.11	1.76	5953.5*
Residual	3	0.306	0.31*	73.2**	43.4**	2.89	2.33	6495.2

[a]RCB design, 2 replications; 4.5 m^2 plots with 20 hills/plot.

	Treatments	
	Directly planted	Transplanted
Planted ("sown")	Jul 10	Jul 28
Transplanted	-	Aug 14
Lifted	Nov 2	Nov 2

[b]HT=heat tolerant; HS=heat sensitive; T=transplanted; N=direct (standard) planted. [c]Percentages transformed to arcsin prior to analysis [d]Original units of data not those appearing in table.

Table 7. Comparative variety means for characters measured in white potato transplanting experiment; 1978, AVRDC[a].

Variety	Emergence rate	Stand at harvest	Total yield	Marketable yield	Total tubers	Marketable tubers	Haulm growth
	---------%---------		--------t/ha------		-------per hill-----		-g-
HT (1282-10)	79	76	15.6	8.6	13	2.5	206
HS (S 510)	75	59	1.4	0	6	0	124
Significance	NS	*	**	**	**	**	**

[a]Taken across transplanting/direct planting factor. Data from same experiment as reported in Table 6.

Table 8. Comparative means of transplanting and direct planting systems for characters measured in white potato transplanting experiment; 1978, AVRDC[a].

Planting system	Emergence rate	Stand at harvest	Total yield	Marketable yield	Total tubers	Marketable tubers	Haulm growth
	-------%---------		------t/ha-------		----per hill------		-g-
Transplanting	100	91	12.1	7.0	10	1.8	197
Direct planting	66	56	6.8	3.0	9	1.0	150
Significance	**	**	**	**	NS	NS	*

[a]Taken across variety factor. Data from same experiment as reported in Table 6.

planting, although the number of tubers produced per hill was similar. This implies that the difference in yield between planting systems resulted mainly from difference in final stand, although better vegetative growth of transplanted plots also may have contributed.

Our earlier supposition that the yield potential of heat tolerant 1282-19 could be improved by increasing the final stand is decisively supported by the data in Table 9. Transplanted 1282-19 yielded 14 t/ha of marketable tubers, compared to 6 t/ha when planted directly.

Genetic Studies of Bacterial Wilt Resistance[a]

We studied the inheritance of resistance to bacterial wilt *Pseudomonas solanacearum*, using AVRDC crosses between heat tolerant and BW resistant clones. The tetraploid parental clones were 1282-9, 1282-19, and WIS-BR-63-20. Based on their disease index, 1282-9 was rated susceptible to bacterial wilt while 1282-19 and WIS BR-63-20 were resistant (Table 10).

Results from tests on hybrid and selfed progenies of parental clones show that the genetic hypothesis which assumes that 3 genes condition the reaction to the pathogen fits well to the observed resistant: susceptible rating among the different families studied (Table 11).

Of the 3 proposed loci, one gene when dominant (designated E) imparts susceptibility and exhibits dosage-dependent epistatic effects over the other two dominant genes for resistance (F and G). E in quadruplex form is epistatic to F and G regardless of the dosage of the latter genes. In triplex and duplex states, E is epistatic only when one of F or G is nulliplex. The epistatic effect of E in simplex form is completely null. Dominant genes F and G act independently of each other and confer resistance when the epistatic effect of the gene E is absent. The hypothesis also assumes random chromsome assortment (Table 12).

Among the parental clones used, 1282-19 combines both heat tolerance and useful resistance to bacterial wilt. Thus, two of the key limitations to potato adaptation in the lowland tropics appear to have been potentially resolved in this clone.

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[a]This experiment was conducted in part by Mr. Sahat, a Research Intern from Indonesia.

Table 9. Comparative variety means in two planting schemes for characters measured in white potato transplanting experiment; 1978, AVRDC[a].

Treatment	Emergence rate[b]		Stand at harvest		Total yield	Marketable yield	Total tubers	Marketable tubers	Haulm growth
	O	T	O	T					
	----------%----------				-------t/ha-------		------per hill-----		-g-
HT transplanted	100	1.57	100	1.57	22.5	14.0	12	4	252
HT direct planted	69	.98	64	.95	12.4	6.0	13	2	183
HS transplanted	100	1.57	82	1.14	1.8	0	7	0	142
HS direct planted	62	.94	48	.75	1.2	0	6	0	116
LSD (5%)		.36		.25	3.7	3.3	5	1.5	74
CV (%)	13		10		17	21	20	48	17

[a]Data from same experiment as reported on in Table 6. [b]O = original data, T = transformed to arcsin for statistical analysis.

Table 10. Reaction of parental white potato clones to *Pseudomonas solanacearum* under greenhouse condition; 1978, AVRDC.

Clone	No. plants tested	Disease index[a]	Reaction
1282-9	6	3.9 ± 0.9	susceptible
1282-19	10	1.4 ± 0.3	resistant
WIS-BR-63-20	8	1.2 ± 0.4	resistant

[a]Based on the stem inoculation procedure and the disease index scale (ranging from 1.0 = no. infection, to 5.0 = complete wilting) as described by Sequeira and Rowe (1969). Amer. Potato J. 46: 451-462.

International Cooperation

Philippines

Of the different AVRDC clones distributed, the Philippine National Potato Program selected 7 clones based on relative yield and tuber quality, from lowland tropics trials at two locations (Los Baños and Pampanga) for future evaluation, namely: No. 1282-1, 1282-17, 1282-19; 1282-5, 1284-8, 1284-12 and 1284-9. Among the selected AVRDC clones, all except 1284-8 and 1284-9 were known to be heat tolerant from past trials at Twin Rivers Research Center, Davao.

At the medium elevation of Bukidnon (approximate elevation 450m), the Philippine Packing Corporation selected 25 out of the original 69 clones introduced from AVRDC for further tests. In a trial planted Jun 21, at Sankanan along with German varieties, 4 AVRDC selections were included in the top 10 clones with marketable yields ranging from 16.7-37.9 t/ha. The best AVRDC clone (1284-3) ranked second and yielded 33.4 t/ha.

Taiwan

Taiwan Sugar Research Institute continued testing potato clones for spring production. Virus infection limited yields in a trial planted on Feb 20 and lifted May 29. Four AVRDC lines, selected for further evaluation trials, had yields ranging from 8.5 to 11.5 t/ha, selection 1282-17 outyielding the other clones and Norin No. 1, check, yielding 5.7 t/ha.

Table 11. Expected and observed segregation ratios among selfed and hybrid white potato families of resistant and susceptible tetraploid clones; 1978, AVRDC.

Family	Proposed genotypes of parental clones[a]	Expected segregation[b] (R : S)	Total plants	R : S Proportion		Chi square	P
				Expected	Observed		
1282-9 selfed	Eeeeffffgggg	1 : 3	202	51 : 151	49 : 153	.059	.80-.90
WIS-BR-63-20 selfed	EEEeFfffGggg	27 : 37	179	76 : 103	78 : 101	.143	.70-.80
1282-19 selfed	EEEeFfffGggg	27 : 37	185	78 : 107	80 : 105	.089	.70-.80
1282-9 x WIS-BR-63-20		3 : 5	209	78 : 131	78 : 131	.003	.95-.98
1282-19 x WIS-BR-63-20		27 : 37	165	70 : 95	70 : 95	.006	.90-.95

[a]Gene nomenclatures are tentative and assigned simply for convenience. Clone 1282-9 is susceptible while WIS-BR-63-20 and 1282-19 are resistant (see Table 10). [b]Expected segregation ratios were arrived at through analysis of the segregational consequences of proposed parental genotypes, taking all assumptions underlying the hypothesis accordingly.

Table 12. Proposed explanation of the genetic control of white potato's resistance to the bacterial wilt pathogen, *Pseudomonas Solanacearum*; AVRDC, 1978.

Dosage of epistatic gene[a]	Combination of hypostatic genes[b]		Proposed reaction[c]	Comments
E	F	G		
Quadruplex				
EEEE	any combination		Susceptible	Quadruplex E gene surpresses all combinations of F & G genes
Triplex				
EEEe	F---	gggg	Susceptible	
EEEe	ffff	G---	Susceptible	
EEEe	F---	G---	Resistant	Both F and G genes must be dominant to surpress E gene in Triplex or duplex
Duplex				
EEee	F---	gggg	Susceptible	
EEee	ffff	G---	Susceptible	
EEee	F---	G---	Resistant	
Simplex				
Eeee	F---	gggg	Resistant	Both F and G genes must be recessive in order for E gene in simplex to suppress resistance
Eeee	ffff	G---	Resistant	
Eeee	F---	G---	Resistant	
Eeee	ffff	gggg	Susceptible	
Nulliplex				
eeee	any combination		Resistant	Any combination of F and G genes can overcome E in nulliplex and give resistance

[a]Tends to suppress a plant's resistance to the pathogen.
[b]Tends to confer resistance to the pathogen.
[c]Based on the assumptions of the hypothesis, which includes random chromosome assortment.

MUNGBEAN

Germplasm Collection and Evaluation

Receipt of 726 new accessions, mainly from University of Teheran and Punjab Agricultural University, but originating in 12 countries, brought our germplasm accessions to 4927. We supplied seed packets of 3496 accessions and 1946 breeding lines to 101 researchers in 35 countries. Most cooperators (77 researchers in 16 countries) are from Asia. Although this crop is relatively new in Latin America, interest has increased rapidly. Fourteen scientists in 11 countries in the area requested mungbean seeds in 1978.

Table 1 indicates that future collection of germplasm has to be emphasized in countries such as Burma, Indonesia, Pakistan, Sri Lanka, Bangladesh, and Mainland China.

The 68 accessions selected for high yield and disease and insect pest resistance were evaluated in the field in the fall of 1977 for genetic variability of 29 agronomic characters (Table 2). The varietal differences were highly significant for all characters studied. The association polygon (Figure 1) showed simple phenotypic correlation among 8 important characters. All significant relationships were positive except that between protein content and response to daylength. The correlation indicates that taller accessions of later maturity and longer petiole length are likely to produce higher yields in the fall season at AVRDC. The cultivar with higher protein content tends to be less sensitive to long-day conditions. We shall try to determine if the same relationships are valid in other seasons.

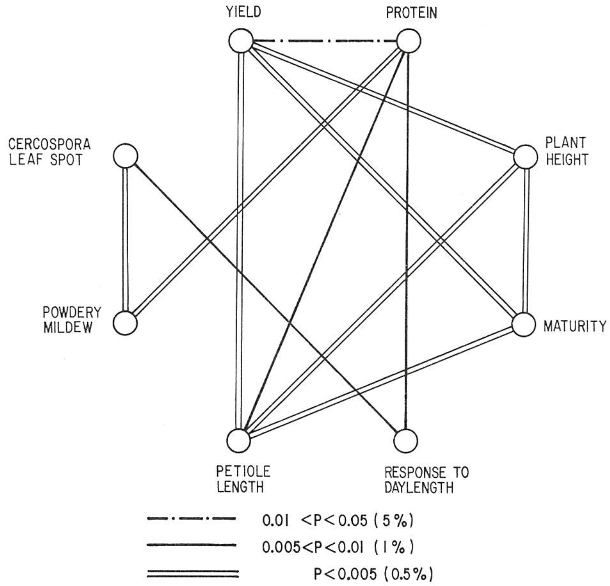


Fig. 1. Association polygon for 8 characters in a collection of 68 mungbeans. AVRDC, fall, 1977.

Table 1. Comparison of mungbean plantings in major producing countries with their contribution to the mungbean germplasm collection maintained at 1978, AVRDC.

Country	Area planted		Accession collected	
	-1000 ha-	-%-	-number-	-%-
India	1,940.0	72.5	2,510	50.9
Thailand	222.8	8.3	235	4.7
Burma	184.0	6.9	10	0.2
Indonesia	147.4	5.5	63	1.2
Pakistan	68.4	2.6	54	1.1
Philippines	39.3	1.5	301	6.1
Bangladesh	15.2	0.6	1	0.0
Iran	30.0	1.1	249	5.1
Sri Lanka	8.3	0.3	4	0.1
Korea	8.0	0.3	140	2.8
Taiwan	4.7	0.2	34	0.6
Others	Unknown		1,205	24.5
Total	2,676.1 + unknown		4,927	100.0

Table 2. Genetic variability of 29 characters estimated from 68 promising mungbean varieties; 1978, AVRDC.

Character	Mean+SE	Range	Extreme lines
Yield (kg/ha)	886+19	339 - 1,222	V3109 - V2673
Pod/plant	26+0.8	11 - 47	V3109 - V4535
Seeds/pod	11+0.1	9 - 14	V2184 - V1414
1000 seed wt (gr)	46+1.2	23 - 89	V2517 - V3686
pod length (mm)	88+1	65 - 139	V4717 - V1414
Pod thickness (mm)	5+0.1	4 - 7	V4717 - V1944
No. of cluster	8+0.2	4 - 16	V1745 - V2676
No of cluster on main stem	5+0.1	3 - 9	V1745 - V2676
No. of pods on main stem	20+0.5	11 - 37	V3109 - V4535
Ave. No. of pods/cluster	3+0.04	2 - 5	V2010 - V1853
Position of 1st pod (node)	7+0.06	5 - 9	V3109 - V2075
Length of peducle (cm)	16+0.2	9 - 21	V3109 - V2159
Plant height (cm)	52+0.9	23 - 74	V3109 - V2075
No. of node on main stem	12+0.1	9 - 15	V3109 - V2075
Average length of internode (cm)	4+0.1	2.5 - 5.8	V3109 - V1945
Protein (%)	21.8+	19 - 25	V4718 - V1016
Days to flowering (DAP)	41+0.3	34 - 52	V3109 - V2075
Days to 1st pod maturity (DAP)	63+0.4	55 - 76	V3109 - V2075
Mean Maturity (DAP)	89+0.2	86 - 96	V1709 - V2075
Photoperiod response (da) between 16 hr & 12 hr	19+0.9	3 - 43	V1101 - V1667
Hairiness (1-5)	2.2+0.04	0.8 - 3.1	V1945 - V1133
Stem diameter (mm)	6.4+0.1	3.6 - 9.3	V3109 - V2075
Total No. of branches	3.4+0.05	1.8 - 4.6	V2787 - V1330
Longest branch (cm)	19+0.8	4.4 - 45.7	V3109 - V2075
No. of branch with pods	1.5+0.06	0.2 - 2.9	V2013 - V2075
Width of middle leaflet (cm)	10+0.13	6.4 - 13.3	V3109 - V2808
Length of middle leaflet (cm)	11+0.11	8.1 - 13.5	V2667 - V2808
Leaf shape (length/width)	1.09+0.01	0.98 - 1.27	V1067 - V3109
Petiole length (cm)	16+0.2	9.6 - 21.7	V2310 - V2013

Planted on Sep 8, 1977 in 4 rows 6 m long and 50 cm apart with 3 replications. SE; Standard error.

Breeding for High Yield and Disease Resistance

We made 327 crosses this year (Table 3) and started to use our own advanced breeding lines as parental sources in hybridization. We received 10 lines resistant to mungbean yellow mosaic virus (MYMV), which is a very serious disease in the Indian Subcontinent but does not occur in Taiwan, from scientists in Pakistan and India, and made more than 83 crosses with other high yielding and large seeded accessions from the Philippines, Korea and Taiwan. Mungbean researchers in those areas regularly infected epidemically by MYMV may be interested in the segregating F_2 seeds from these crosses.

Mungbean yields were considerably higher in 1978 during spring, with a mean of 1.7 t/ha in the Spring and 0.7 t/ha in the fall (Table 4). In both 1976 and 1977, mungbean in summer produced the highest yield. In 1978, mungbean in summer were planted about one month earlier (Jul 3) than in 1977 (Aug 11). The result indicates that summer mungbean should be planted near the end of the rainy season while the temperature is still high, rather than either in the middle of the wet monsoon season or in the cool fall season. Mungbean planted in Aug at AVRDC can be harvested in the dry season in Oct. Spring planting is not recommended, because harvest is often hampered by continuous rain from the onset of the wet monsoon season.

A breeding line (VC1089-B-29-3B-2-B) which was the highest yielding in 1977 outyielded 19 other entries when average yields of 3 seasons were compared (Table 4). This line has performed well in Costa Rica, and

Table 3. Mungbean crosses made in 1978, AVRDC.

Purpose of Cross	High yield	Disease Resistant to[a]				Total
		CLS	PM	MMV	MYMV	
High yield	16	13	3	9	27	28
Large seed	15	4	1	2	3	25
Selected breeding lines	50	3	1	5	18	77
CLS		1	3	12	13	49
PM				3	8	19
MMV					13	39
MYMV					1	83

Note: 98 of 3 or 4-way crosses were made to combine several traits.

[a]CLS = *Cercospora* Leaf spot; PM = Powdery mildew; MMV = Mungbean mottle virus; MYMV = Mungbean yellow mosaic virus.

Table 4. Yield, daily production rate, mean maturity, plant height and protein content of 10 selected elite mungbean cultivars in 3 seasonal yield trials; 1978, AVRDC.

AVRDC acc.	Cultivar name or pedigree	Yield (t/ha)				Daily production (kg/ha/da)			Mean maturity (DAP)[d]			Plant height (cm)		
		Sp.[a]	Su.[b]	Fa.[c]	Mean	Sp.	Su.	Fa.	Sp.	Su.	Fa.	Sp.	Su.	Fa.
VC 1089 Sel. A	ML-3 / Ph. Coll L	1.8	1.7	0.8	1.4	23	24	10	79	70	79	55	82	45
V 2773	ML-3	1.8	1.3	0.8	1.3	22	18	10	82	73	77	62	82	45
V 3476	Pag-asa (CES 1D-21)	1.7	1.3	0.9	1.3	22	19	11	78	70	74	48	73	36
V 2272	ML-5	1.8	1.4	0.7	1.3	22	19	9	82	72	76	62	88	39
VC 1209 Sel. A	ML-3 / CES 55	1.8	1.3	0.7	1.3	22	18	9	81	72	78	56	78	39
V 2984	Kyungkijaerae 5	1.9	1.1	0.8	1.2	24	17	10	79	64	74	58	79	42
V 1381	MG-50-10A(G)	1.7	1.3	0.6	1.2	22	21	8	77	63	75	47	70	37
V 2184	PHLV 18	1.8	1.2	0.7	1.2	23	19	9	77	63	75	47	67	40
VC 1163 Sel. A	EG-MG-4 / ML-6	1.9	1.1	0.6	1.2	23	16	8	82	70	78	50	74	29
V 3404	Utong 1 (MTA)	1.7	1.2	0.7	1.2	21	17	8	79	68	79	71	92	48
Grand mean		1.7	1.1	0.7	1.2	23	16	9	79	68	76	55	77	39
H.S.D. (0.05)		0.3	0.3	0.2					2	2	2	6	12	7
C.V. (%)		11.1	17.1	18.9					1	2	2	6	9	11

[a]Sown Mar 8; [b]Sown Jul 3; [c]Sown Sep 15. For all seasons, a total of 20 varieties were planted in the plot size of 6 rows of 6 m in length and 50 cm apart with 4 replications. [d]DAP=days after planting.

was named "ASVEG 78" by local researchers. In Canada, the same line was considered to be suitable for machine harvest, due to relatively uniform maturity and a good podding pattern. However, we observed a severe attack of a virus disease on this line in Suweon, Korea, and in Pingtung, Taiwan.

By the end of 1977, AVRDC pathologists nearly completed screening the mungbean germplasm collection for resistance to *Cercospora* leaf spot, CLS, (*Cercospora canescens*), powdery mildew, PM (*Erysiphe polygoni*), and mungbean mottle virus, MMV. They identified 6 lines resistant to CLS, 15 lines highly resistant to PM and 7 lines resistant to MMV. These accessions and 10 MYMV resistant ones were evaluated for their agronomic characteristics and photoperiod response. The seeds and agronomic data of these resistant lines are available upon request.

In 1978, our pathologists mainly screened advanced breeding lines, 412 entries against CLS in the summer and 316 entries against PM in the fall, under both natural and induced epiphytotic conditions. Nineteen breeding lines were rated highly resistant to PM, but none showed resistance to CLS. Since CLS resistant gene(s) found in mungbean appeared not to be very strong, we are attempting to transfer highly resistant CLS gene(s) from blackgram (*Vigna mungo*) through interspecific hybridization.

Combining Large Seed Size and Photoperiod Insensitivity with Powdery Mildew Resistance

The close association of the PM resistance with small seed size and photoperiod sensitivity was finally broken. AVRDC breeding lines (VC1560 Sel. C and VC1482 Sel. A) have 1000 seed wt. of 80 g and 72 g, respectively. Both are insensitive to photoperiod and rated highly resistant to powdery mildew.

Root Diseases

We screened 745 accessions for damping-off and root disease complex in the root disease nursery in both spring and fall. None were resistant to both diseases in both seasons, however, 11 in the spring and 2 in the fall were rated resistant to the root disease complex. Three were rated resistant in the fall but none in the spring to damping off caused by pathogens *Pythium* sp and *Rhizoctonia* sp.

Root-knot Nematode Resistance

We screened 100 accessions in the spring and 105 in the fall for resistance to root-knot nematodes. In the nematode nursery, rows of test material were alternated with rows of the susceptible tomato cultivar TK 70, which served as feeder plants. Of seven accessions rated moderately resistant in the spring, six of them (one accession was not retested) were rated resistant in the fall. Four accessions (V1412, V1709, V2010, V2773) were rated highly resistant to this pest in the fall.

Fungicide Increases Yield

We conducted yield trials of 27 breeding lines and 3 check cultivars in the fall with and without fungicide protection, in order to estimate their yield potential under farmers' conditions and the yield loss caused by fungal diseases. Most of mungbean farmers in Asian use little fungicide but fungal diseases (CLS and PM) can be quite serious. Insecticides were applied for both fields, according AVRDC standard cultural management practices.

On the average, application of fungicide increased yield by 303 kg/ha, 1000 seed wt. by 8 g, plant height by 7 cm and delayed maturity by 1.3 days (Table 5). All entries were rated visually for resistance to powdery mildew. There is no significant relationship between visual disease rating and actual yield reduction, which means that certain lines which were rated susceptible performed well even without a fungicide. Meanwhile, some lines rated highly resistant showed up to 32% yield reduction when fungicide was not applied. The fungicide may work as a growth stimulator for certain genotypes.

Transferring Resistant Genes from Blackgram

Since we had failed to find strong and stable resistance genes to *Cercospora* leaf spot and bruchid after complete and thorough screening of our world mungbean germplasm collection, we started to transfer highly resistant genes from a closely related species, blackgram (*Vigna mungo*). We found there is very evident reciprocal effect in crossability. Only when mungbean was used as the female and blackgram as the male, were we able to get viable F_1 seeds. There also was a clear difference in crossability among mungbean varieties. An Indian line (ML-3) was either poorly crossed with blackgram or the F_1 seed showed a higher rate of hybrid breakdown. When we used F_1 plants from intraspecific crosses (i.e.

Table 5. Effect of fungicide on mungbean yield and other agronomic traits in the advanced yield trial, AVRDC, Fall, 1978.

	Without fungicide	With fungicide	Difference
Yield (kg/ha)	807	1110	+303
1000 seed wt (g)	47.7	53.4	+ 5.7
Plant height (cm)	40	47	+ 7
Days to 1st pod (DAP)	68.4	69.7	+ 1.3

Each value is mean of 60 observations (30 lines x 2 replications). Planted on Sep 21 in 4 rows of 6 m in length and 50 cm apart with 2 replications. Fungicides used are Daconil on 29 & 52 DAP and Milcub-super on 57, 65 & 73 DAP.

Table 6. Crossability, germinability and survival rate in inter-specific crosses between mungbeans (*Vigna radiata*) and blackgrams (*Vigna mungo*); 1978, AVRDC.

Blackgram / Mungbean	VM 2011 Weevil Rest	VM 2156 CLS Rest	VM 3180 Scarab Rest	Average
V2007 (Korea)	75%[1] 48%[2] 38%[3]	96 50 50	86 58 46	86 50 44
V 2773 (India)	50 80 0	89 8 0	100 5 5	80 28 1
V 2010 (China)	60 10 5	100 58 53	53 79 75	71 52 48
V 2184 (Phil.)	100 74 57	86 80 56	67 86 82	84 80 64
F_1 (V 2010 x V 2184)	86 85 45	100 85 80	83 92 74	90 88 68
Average	74 58 31	94 55 47	78 68 58	82 60 46

[1]Crossability; % of successful pollinations over total pollinations attempted. [2]Germinability; % of germinated plants over total number of seeds sown. [3]Survival rate; % of plants reaching flowering stage over total number of seeds sown.

mungbean/mungbean), the genetic barrier in the inter-specific crossing seemed to become weaker. In other words, crossability, germination ability, and survival rate were higher when F_1 plants derived from a cross between two mungbean varieties were used as the female plant in the interspecific cross with blackgram (Table 6).

Table 7. Crossability and germinability of interspecific crosses between mungbean, ricebean and *sublobata;* Fall, 1978, AVRDC.

Female \ Male	Mungbean V 2184	Ricebean TC 1975	*Sublobata* TC 1966
Mungbean V 2184		65%[a] 100%[b]	88% 100%
Ricebean TC 1975	5% 100%		0% 0%
Sublobata TC 1966	90% 80%	35% 68%	

[a]Crossability. [b]Germinability of F_1 seeds.

When we attempted to transfer beanfly resistant genes from ricebean (*Vigna umbellata*) to mungbean, we were able to get viable F_1 plants, but all of them were completely sterile (no diploid F_2 seeds were produced). We tried *Vigna radiata* var *Sublobata* (possible ancestor of mungbean and blackgram) as a genetic bridge for the interspecific cross between mungbean and ricebean. We were able to get viable F_1 plants from all combinations except a cross in which ricebean was used as the female parent (Table 7).

Environmental Physiology

In 1978, AVRDC physiologists emphasized studies on mungbean response to various environment factors. They planted three mungbean cultivars (V1104, V2013, V2184) once or twice every month for the last two years. All three cultivars grew very poorly and did not produce any yield when planted from early Nov to early Feb, which indicates that temperature is a critical factor. However, even if temperature is above optimum, day length is critical for reproductive growth of the photoperiod sensitive cultivar (V1104). The cultivar (V1104) did not produce any yield when it was planted after Mar 20 or before Jul 6 in both years.

We found there was a strong positive correlation (r=.81**) between yields of both V2013 and V2184 and temperature during a 20 day period after plant emergence (Fig. 2), which means the warmer the weather, the higher the mungbean yield. The same relationship was also found between the yield of the 2 cultivars and temperature during 30 days after the first flowering (Fig. 3).

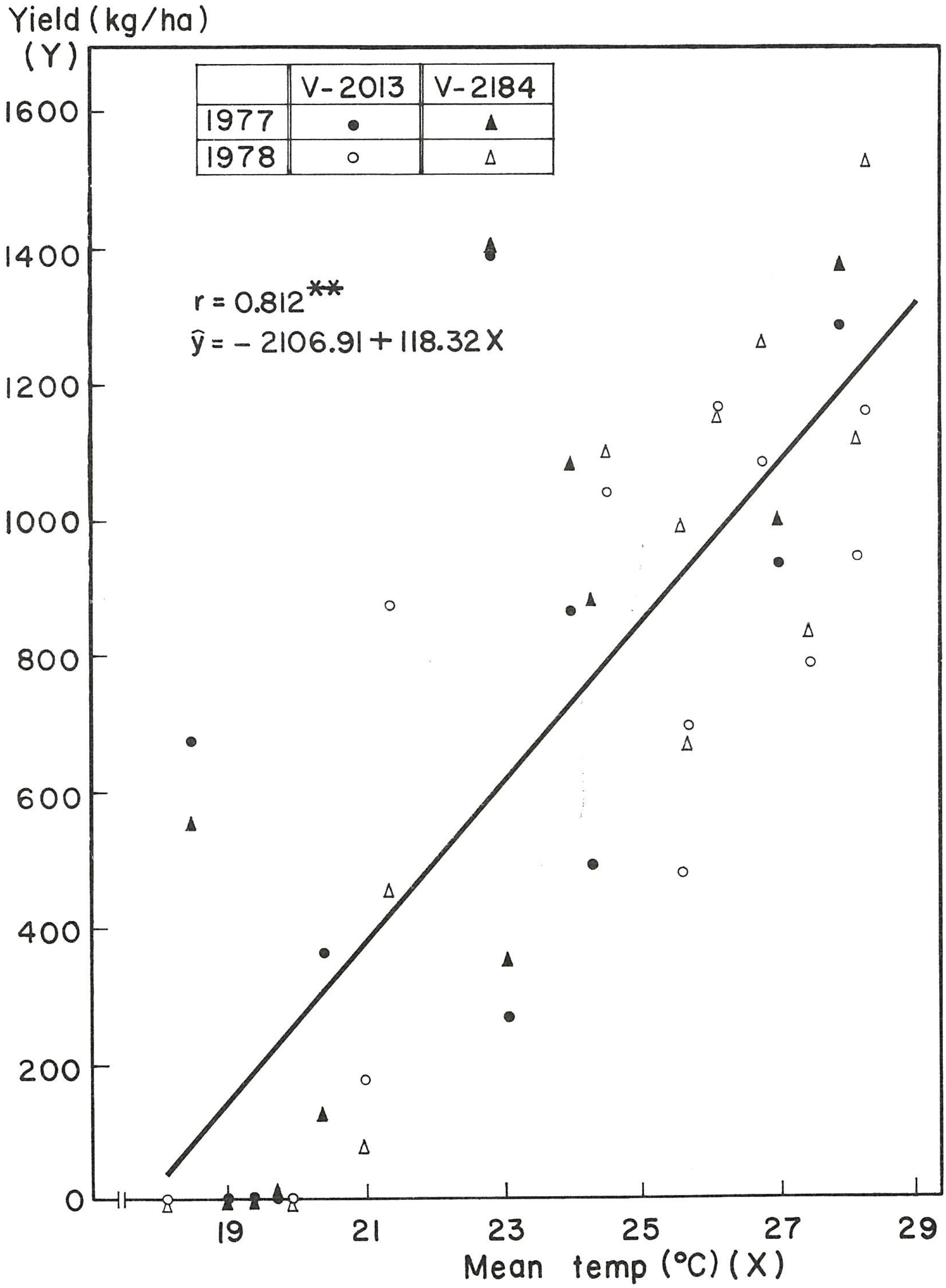


Fig. 2. Mungbean yield in relation to daily mean temperature during the period of 30 days after emergence.

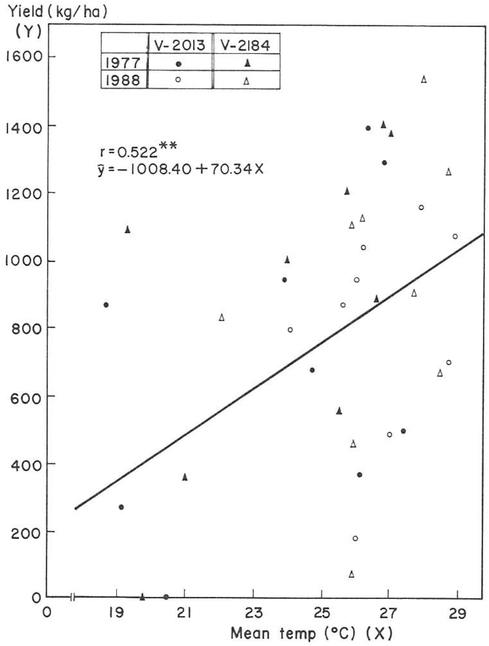


Fig. 3. Mungbean yield in relation to daily mean temperature during the period of 30 days after the first flowering.

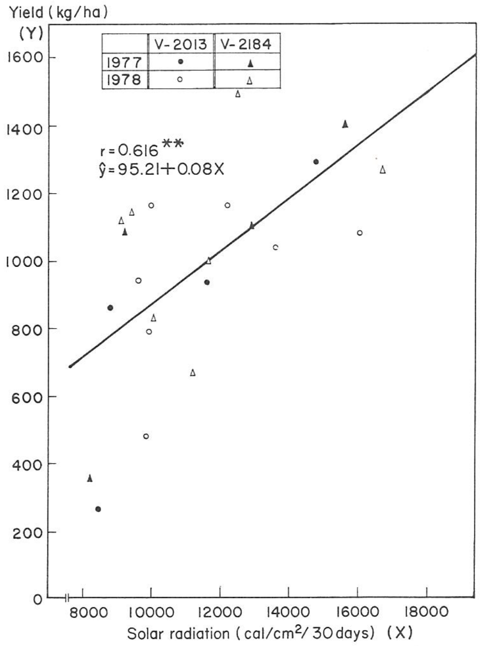


Fig. 4. Mungbean yield in relation to solar radiation during the period of 30 days after the first flowering.

Yields of V2013 and V2184 planted in Mar to early May and Sep to Oct were found to be highly associated with total solar radiation received after the initial flowering (Fig. 4).

During the rainy period (Jun to Sep) the amount of rainfall and drainage conditions also greatly affect mungbean growth and yield.

From these two years of experiments, we can recommend Mar and Sep to be the best time for mungbean planting in Southern Taiwan. Selection of the best cultivar for a given planting also is important.

Effect of Cold Temperature on Early Growth

Although we knew mungbean would flourish in warmer weather, we are interested in the behavior of mungbean under low temperature stress, since farmers in Asia usually plant this crop either before or after rice, when temperature could be a limiting factor for mungbean yield.

AVRDC breeders planted 800 accessions and 200 advanced breeding lines in Nov to screen for a cold tolerant source.

Our physiologists compared the yield of 14 varieties grown under 2 different temperature regimes, one planting on Feb 28 and the other on Apr 14. Emergence of the Apr planting was 1.5 days earlier than that of the Feb planting. No varietal difference was found in this character for either planting. Leaf number and area, and dry weight of seedlings for the first four weeks appeared to be depressed in the Feb planting. Among 14 varieties, only V1016 appeared to perform better under low temperature during early growth, however, yield of V1484, V2013 and V2184 from the Feb planting were comparable with those from the later planting.

In the greenhouse, 14 varieties grown in pots were subjected to 8-10^{o}C for 3 days starting from 20 days after emergence. V 1250, V2013, V1950 and V1398 tolerated the cold treatment and produced yields comparable to the control (32/24^{o}C).

Varietal Screening for Drought Tolerance

AVRDC physiologists studied the effect of water stress on yield in the greenhouse. Twenty cultivar and breeding lines grown in pots were subjected to 75-100 centibars of soil moisture tension for 8 days from the start of flowering, after which the soil was Kept well watered. The moisture stress generally reduced total dry matter production and yield. However, some entries recovered well after stress and produced yields equivalent to the non-stressed control. V2013 was highly tolerant to the stress and V1281 and V3372 appeared to suffer less from the drought. Although reduction rate due to the stress was a little higher, V3388 and V3404 had the highest actual yield after the stress.

It was reported that proline accumulation could be a criterion for laboratory screening for drought resistance in several cereal crops. Therefore, we measured the proline contents of leaf disks of 20 mungbean cultivars after 24 hrs of polyethylene glycol (PEG)- imposed in-vitro stress. Although the proline increased greatly after PEG-imposed stress, no correlation between proline accumulation and drought tolerance was found.

Varietal Screening for Flood Tolerance

Since soil flooding is considered one of the factors limiting mungbean yield during the wet monsoon season, 20 promising entries were planted in a field that was regularly irrigated and flooded starting from 20 days after emergence and extending to maturity. Soil flooding generally extended days to flowering and maturity and reduced yield (Fig. 5). VC1006-40-1 had the highest yields both in flooded and non-flooded fields, whereas V1968, V2984, V3092 and V3372 yields were nearly alike in both treatments.

Three Accessions Relatively Resistant to Beanflies

Early in 1978 we finished testing most of our mungbean germplasm for resistance to beanflies (*Ophiomyia phaseoli, O. centrocematis* and *Melanagromyza sojae*) by a non-replicated mass screening technique we developed in 1976 (AVRDC Mungbean Report 1976). Failing to find any 'immune' accession during this primary screening, we selected 658 accessions that were least affected and, based on a statistical mean and standard deviation technique, fell into high relative resistance (HRR) and moderate relative resistance (MRR) categories (Fig. 6). We planted these materials in a nonreplicated experiment at AVRDC during the spring of 1978 and evaluated these materials at 3 weeks after emergence by dissecting the plants and counting the number of beanfly maggots and pupae inside. Again, using the same statistical technique, we categorized their relative resistance. From this we again selected 151 least affected materials that fell in HRR and MRR categories and planted them for the third time in a replicated (3) experiment at AVRDC in Jun. Three weeks after emergence we evaluated their performance in the usual fashion and classified them into various relative resistance categories. Twenty two accessions were determined as having MRR.

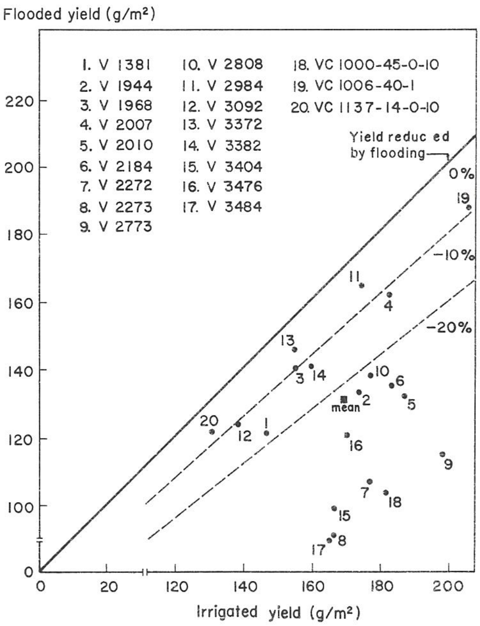


Fig. 5. Mungbean yield in relation to 50% flowering for 20 promising accessions grown under flooding conditions.

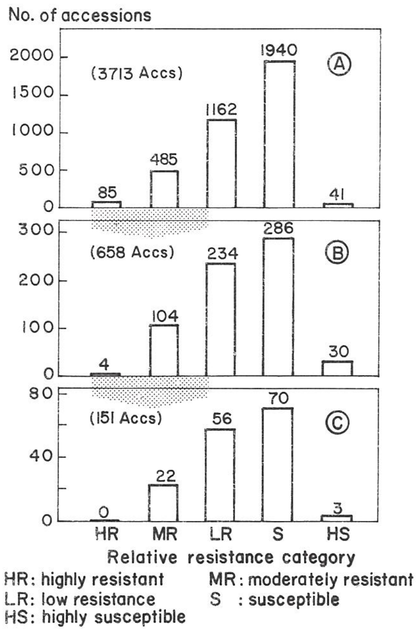


Fig. 6. Relative resistance reaction of AVRDC mungbean germplasm to beanflies during preliminary (A), second (B) and third (C) screening. AVRDC, 1978.

To assess the consistency of the resistance at various locations, we selected 28 least affected accessions from MRR and low relative resistance (LRR) categories and planted them along with 4 susceptible accessions at 6 locations - Taitung, Hualien, Taichung, AVRDC, Tainan, and Pingtung-in Taiwan in a replicated (3) experiment during the fall 1978 season. We evaluated their relative resistance reaction at 3 and 6 weeks after emergence, statistically analyzed the data for each location, and then combined the analyses for all locations to determine the geographical influence on the relative resistance reaction. The results of combined analyses for all locations for the three most promising accessions along with a susceptible check are summarized in Table 8.

AVRDC accessions V2396, V3495, and V4281 were the least affected at most locations or were among the least affected at others. We consider these three relatively resistant and plan to use them as source of beanfly resistance in our breeding program.

Screening for Thrip Resistance

Thrip (*Magalurothrips usitatus*, Bagnall) cause plants to bear no flowers in severe cases, and pod set to be severely reduced if the attack comes at the flowering stage.

Since this insect is very agile, especially when disturbed, making it impossible to count, we took advantage of leaf crinkling to evaluate our mungbean germplasm for resistance. The severity of damage was ranked from 0, indicating all leaves healthy, to 10, indicating all leaves

Table 8. Resistant reaction of selected AVRDC mungbean accessions to beanflies at six locations in Taiwan. Combined analysis for all locations, AVRDC, 1978.

AVRDC acc. no.	No. beanfly maggots + pupae/plant	
	Weeks after planting	
	3	6
V2396	0.09 de	0.06 ef
V3495	0.09 de	0.05 f
V4281	0.06 e	0.04 f
V2184*	0.40 a	0.35 a

Means of 3 replicates at each of six locations. Means followed by the same letter are not significantly different at 5% level. *Susceptible check .

crinkled. Since heavy infestation of this insect may reduce pod set, we evaluated the entire germplasm once again at 65 DAE to observe pod setting rate. We found a highly significant negative correlation between thrip damage at 30DAE and proportion of pods ready for harvest at 65 DAE. Most that scored 0 to 1 on our crinkling rating scale had more than 90% of pods ready for harvest, whereas the germplasm as a whole, which averaged 4.1 damage rating, had only 11% of pods ready for harvest at this time.

Aphid Resistance

Cowpea aphids (*Aphis craccivora*) are sporadic in nature and their infestation usually occurs during the cooler months of the year. Of the 2892 accessions evaluated during Nov and Dec we found 357 free of aphid infestation. We will test these materials at various locations in Taiwan during 1979.

Podborer Resistance

During the past two years we have observed seven lepidopterous insects attacking mungbean pods: *Maruca testulalis, Heliothis armigera, Porthesia taiwana, Notolophus australis posticus, Cosmolyce boeticus, Ostrinia furnacalis* and *Etiella zinckenella*. Populations of some of these insects start building up in Oct and remain high until Jun. During fall 1978, therefore, we screened most of our mungbean germplasm between the source row blocks of well extablished pigeon pea in our multiple insect pest resistance screening area. At harvest we counted the proportion of damaged pods in each accession and grouped the accessions, based on percent of damaged pods, into five categories by a statistical mean and standard deviation technique. Among 2609 accessions tested none fell into high relative resistance and 231 into moderate relative resistance categories. Since the podborer population was not as high as we sometimes encounter in spring, we will test these 231 accessions again during 1979.

Bruchid Resistance

Bruchid (*Callosobruchus chinensis*) is a serious pest of many legumes, especially in storage. Although the severity of its damage is realized in storage, the primary infestation begins in the field. Adult females lay eggs on pods and the newly hatched grub bores through the pod and enters the developing grain. Because the primary infestation starts in the field, we first screened our mungbean germplasm for resistance to this insect in the field. We planted 525 accessions in our multiple insect pest resistance screening area during the fall of 1977, released a large number of adult bruchids at flowering time, and once every week thereafter from source stations established at the junction of 5m x 5m grid throughout the planted area. We harvested the mature pods, held them in storage for 10 weeks and counted the number of adults that emerged. Seventeen accessions were free of bruchids. We planted these accessions along with a reference variety, V2184, in clay pots (6 pots with two plants each for each accession), placed randomly in the greenhouse, and released a large number of insects at flowering and each week thereafter. We harvested the mature pods, counted the number of eggs laid on 10 pod samples, stored them in plastic containers for up to 15 weeks, and counted the number of adults that emerged. The results are summarized in Table 9. Bruchids did not lay eggs on the pods of accessions VM2011 and VM3529, because the hair on the pubescent pods entangled their legs, and, as a result, no adults emerged after the 15 week incubation. However, bruchids laid eggs on the pods of other accessions and a large number of insects emerged from these pods.

We selected accessions VM2011 and VM3529 along with two susceptible ones, V3565 and V2184, and confined 50 bruchid adults 1 to 6 days old on 25g of seeds after adjusting the grain moisture to 12-13%. We allowed the insects to lay eggs for one week and, after counting the number of eggs laid, discarded all insects. We incubated these grains for up to 12 weeks and counted the adults that emerged at 6, 9 and 12 weeks after oviposition. The results are summarized in Table 10. It is evident that the insects lay eggs on the seeds of VM2011 and VM3529 as they do on the susceptible ones. However, the insect emergence is practically nil, especially from VM2011, whereas the seeds of susceptible ones were totally destroyed and scores of bruchid adults emerged. Accession VM2011 seems to have two mechanisms of resistance, in pods a mechanical factor, and in seeds, possibly antibiosis, We consider accession VM2011 all but immune to this insect, both in the field and in storage. This accession belongs to *Vigna mungo*. In literature *V. mungo* is listed as one of the hosts for this pest. Our plant breeders are now crossing this material with high yielding and agronomically desirable mungbean lines.

Ecology of Mungbean Insect Pests

In order to develop a judicious insect pest management program it is important to understand their peak periods of abundance. We have, therefore, been monitoring the seasonal abundance of various pests of mungbean since 1975. Once every two weeks we plant mungbean, V2184 (PHLV 18), in a 20m x 1m row and raise the crop until harvest, using all recommended cultural practices except insecticides. When 4 weeks old we take a 100 plant sample, dissect each and count the number of beanfly maggots and pupae as well as percent plants damaged by beanflies. We also installed a 15 watt Ellisco black-light trap in 1975 near the field where we monitor the insects. Every week we count the number of green stink bugs (*Nezara viridula*), scarabid green beetles (*Anomala cupripes*), limabean podborers (*Etiella zinckenella*) and corn earworms (*Heliothis armigera*) caught in the light trap. The changes in the population of these insects during the past four years are depicted in Fig. 7. Beanfly population starts building up in Feb and remains high until the onset of monsoon rains in Jun. During Jun-Sep the population is at the lowest level in the year. Again in Sep-Oct the insect number starts building up and remains high during the fall. The ideal time for

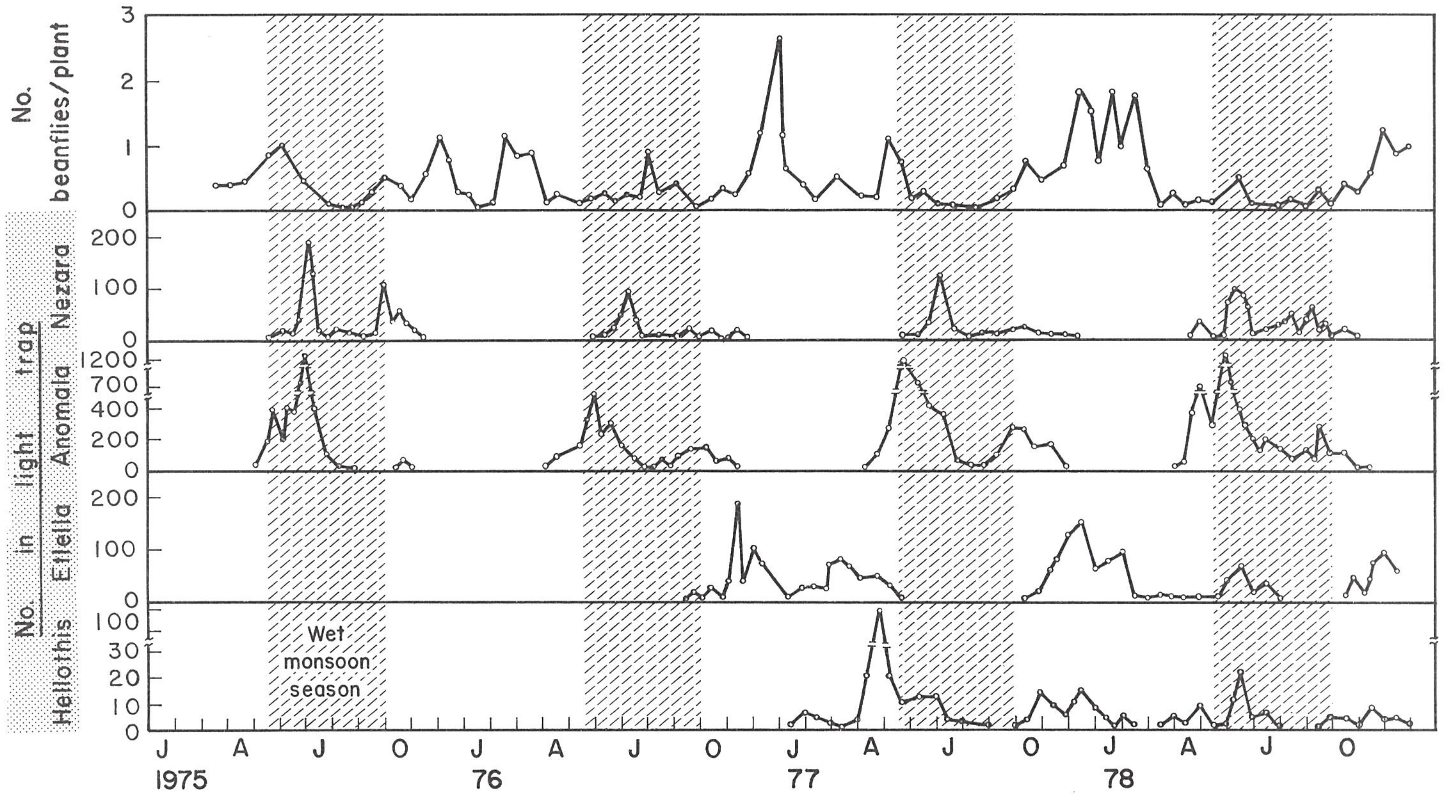


Fig. 7. Seasonal incidence of insect pests on mungbeans at AVRDC, 1975-78.

Table 9. Oviposition and emergence of *Callosobruchus chinensis* adults from pods harvested from greenhouse experiment. AVRDC, 1978.

AVRDC acc. no.	Eggs/pod	Insects /100g pods
V1909[a]	1.2±1.3	29±28
V1944	2.7±2.0	400±570
VM2011	0	0
V2938	1.1±1.1	1223±9.29
V3465	0.9±0.5	176±400
VM3529	0	0
V3531	0.7±0.4	156±315
V3570	0.3±0.7	28±50
V3615	1.3±1.0	32±64
V3219	1.4±1.6	308±347
V2184	0.8±0.5	258±335

Data are averages of 10 pods for oviposition and 6 replicates for insect emergence. Incubation period 15 weeks. Room temperature and humidity condition.
[a]"V" for *Vigna radiata* (mungbean) and "VM" for *V. mungo* (blackgram).

Table 10. *Callosobruchus chinensis* oviposition and adult emergence from mungbean and blackgram seeds; 1978, AVRDC

AVRDC acc. no.	25g seeds			
	No. eggs laid	No. adults emerged		
		6 wks	9 wks	12 wks
Blackgram				
VM2011	160±130	1±1	2±0	2±0
VM3529	245±249	1±2	16±22	23±18
Mungbean				
V3565	399±400	226±190	291±200	384±133
V2184	196±101	316±116	444±133	523±138

3 replicates. Incubator temp. 32±1°C & RH 65±2%.

this pest incidence appears to be the dry period of spring and the fall, especially in the fall. The green stink bug starts appearing late in May. Its population reaches a peak in Jun and declines thereafter in the rainy summer months. Scarabid green beetle is an important mungbean pest during Apr, May and Jun. During the past four years it has unfailingly started appearing around the middle of Apr. The population rises very rapidly during the following four weeks. It is almost nonexistant from October to Mar. Limabean podborer infestation starts in Oct and its population is very low. Corn earworm is prevalent almost throughout the year, but its population is very low during Jul-Aug. We also maintain information on various weather parameters, such as temperature, relative humidity, rainfall, wind direction and velocity, and solar radiation, with the view to correlating the insect pest abundance with these climatic factors. Such information might be used to forecast an insect pest outbreak.

Chemical Control of Beanflies

Since beanfly infestation is very important during the first 3 weeks after germination, during 1978 we tested seed treatment formulations of carbofuran and triazophos, which have given satisfactory control of beanflies in the past in granular and foliar spray formulations. We coated mungbean seeds with 0.5%, 1%, and 1.5% a.i. of either carbofuran or triazophos before planting. For comparison, we also applied carbofuran 3% granules and triazophos 5% granules along with the seeds and included four weekly sprays of 0.5 kg a.i./ha of triazophos 40EC as a standard treatment. Carbofuran 30ST (seed treatment) at 1% or 1.5% seed coating gave excellent control for up to 3 weeks after planting, but was not very effective beyond that. Carbofuran 3% granules, however, gave good control until 5 weeks after planting.

International Cooperation

AVRDC has been coordinating the Seventh International Mungbean Nursery (IMN). A total of 20 entries (15 cultivars + 5 AVRDC breeding lines) were evaluated by 34 researchers at 44 sites in 22 countries. At the end of 1978, we had received data from 17 trials. The sites ranged from $7^{o}50'$ south (Muneng, Indonesia) to 42^{o} north (Chatham, Canada). Table 11 shows the average yield of all entries with its range at each site, and climatic and geographical conditions. Although varietal differences in yield at each site were quite great, when averaged over all sites there appears to be not much difference. After we received all data, results will be fully analyzed and published separately.

In Taiwan, we have organized a Regional Mungbean Yield Trial, in which 6 District Agricultural Improvement Stations (DAIS) and one college have participated. Most institutes plant twice (spring and fall), giving total of 14 trials. By the end of 1978, we had received data on 8 trials. A breeding line (VC 1163-2-2-6-2B) and a cultivar from the Philippines (CES 1D-21) performed relatively well, although average yields were rather low in 1978.

Table 11. Intermediate report on average mungbean yield, geographical and climatic information of 17 locations participating in the Seventh International Mungbean Nursery; 1978, AVRDC.

Country	Location	Latitude	Elevation	Min. temp.	Max. temp.	Rain-fall	Planting Date	Ave. yield	Range	Ave. yield rank
			-m-	---°C	------	-mm-		-----t/ha	----	
Indonesia	Muneng	8°S	10	22	32	104	Jul 29	1.1	0.8-1.4	3
Indonesia	Bogor	7°S	240	21	31	824	Jun 12	0.5	0.2-0.8	14
Indonesia	Sukamandi							1.1	0.8-1.6	3
Malaysia	Sarawak	4°N	20	23	34	511	Apr 11	0.9	0.6-1.3	6
Philippines	Davao	7°N	3	22	32	298	Feb 16	1.4	1.0-1.5	2
Philippines	UPLB	14°N	50	22	33	9	Feb 8	0.8	0.6-0.9	7
Philippines	UPLB	14°N	50	24	32	1314	Jun 23	0.3	0.1-0.5	17
Philippines	POP						Jun 22	0.7	0.6-1.2	8
Thailand	Khon Kaen	16°N	180	24	36	228	Feb 13	0.4	0.1-0.6	15
Taiwan	AVRDC	23°N	9	21	29	437	Mar 8	1.7	1.3-2.0	1
Taiwan	AVRDC	23°N	9	24	32	649	Jul 3	1.1	0.7-1.7	3
Taiwan	AVRDC	23°N	9	19	28	125	Sep 19	0.7	0.4-0.9	8
Bangladesh	Mymensingh	25°N	18	26	32	868	Jul 5	0.7	0.4-1.0	8
Nepal	Khumaltar	28°N		16	25	384	Mar 27	0.6	0.3-1.0	11
Pakistan	Faisalabad	31°N	20	19	33	36	Mar 7	0.6	0.3-0.9	11
Pakistan	Lahore	32°N	230	17	34	127	Feb 24	0.6	0.4-0.8	11
Canada	Chatham	42°N	180	15	26	289	May 27	0.4	0 -1.1	15

The 7th IMN were conducted at 44 locations in 21 countries in 1978-1979. After all data has been received, the results will be published in a separate report.
Yield data are means of 20 entries at each location in 4 rows of 6 m in length and 40 to 60 cm apart with 3 replications.

We sent 260 of our best breeding lines to scientists in the Philippines (UPLB and POP) and Thailand in order to select locally adaptable lines. From these, 22 lines and 84 single plants were selected at Economic Garden and 24 lines at the University of Philippines at Los Baños, both in Philippines. In Thailand, several outstanding lines were advanced to preliminary yield trials.

The AVRDC Philippine Outreach Program (POP) conducted yield trials of 40 AVRDC advanced lines and reported that 6 outyielded the best local cultivar (CES 1D-21). They also conducted two preliminary yield trials (dry and wet season, respectively) and an elite yield trial of blackgram (*Vigna mungo*). The seeds of blackgram were sent by AVRDC in 1977. Table 11 shows yield and other agronomic characters of the 5 best lines. Two lines (VM3115 and VM3171) were considered very promising because of high yield potential, short plant height and early maturity.

In Malaysia, MARDI conducted yield trials of 13 entries (6 breeding lines, 4 cultivars and 3 local checks). An AVRDC breeding line (VC 1163-2-2-6-2B) yielded 2.5 t/ha. The same line also was the highest yielding in the Taiwan Regional Yield Trial.

AVRDC has helped the Office of Rural Development (ORD) in Korea to organize a Regional Mungbean Yield Trial at 5 locations. The results are reported in the section on the outreach program.

A cooperator reported from Bangladesh (Noakhali) that V 2272(ML-5) produced the highest yield (1.19 t/ha). V 3404(6601), V 3485(PAK-22) and V 3486(71-17) were rated resistant to Mungbean Yellow Mosaic Virus.

S. Shanmugasundaram, soybean crop coordinator (right), and assistant scientist T.S. Toung discuss soybean yield trial with a student from The Netherlands.

SOYBEAN

Germplasm Collection Now 9116

Receipt of 215 new accessions from Korea, Philippines, Thailand and U.S.A. increased the *Glycine* germplasm collection to 9116 in 1978.

We made 590 crosses using 55 different parents to combine high yield, soybean rust resistance and photoperiod-insensitivity.

High Yield 2.9 t/ha., in Advanced Yield Trial

We evaluated 50 selected F_8 and F_9 breeding lines for yield and adaptability in 4 sets during spring, summer, and autumn seasons. The highest yield, 2.9 t/ha, from our breeding line during spring season was significantly higher than the check cultivars Kaohsiung #3 and Shih Shih (Table 1). The yields of some of our lines were on a par with Shih Shih and the seed quality was better. Some of our lines also were as early as Shih Shih. A maximum of 28 kg/ha per day was recorded by our line GC 30116-53 compared to 22 kg/ha per day by Kaohsiung #3.

Breeding line GC 30229-8 with narrow leaf gave the highest yield, 2.8 t/ha, during the summer season. Several other lines gave significantly higher yields than the check cultivar Shih Shih (Table 2). Some of our lines showed no bacterial pustule symptom and others were earlier maturing than Kaohsiung #3. Maximum yield of 26 kg/ha per day was registed by the line GC 30229-8 in contrast to Shih Shih's 19 kg/ha per day. This line showed no bacterial pustule symptom.

Yields in the autumn season were generally lower than in spring and summer season. Once again the narrow leaf line GC 30229-8 gave the highest yield, 2.2 t/ha, which averaged 25 kg/ha per day.

Breeding Lines with Wide Adaptability Identified

Lines GC 30229-8 and GC 30116-53 may be regarded as adapted to all the three seasons. One line was adapted to spring and autumn season. Two lines were suitable for spring and summer. Two other lines were found to be adapted to summer and autumn seasons (Fig. 1).

A total of 6,104 bulk populations, pedigrees and germplasm were screened for yield, disease resistance, adaptability and other desirable agronomic characters.

Differences between our selected breeding lines and the check cultivars Kaohsiung #3 and Tainung #4 during spring and summer seasons in the IYT-I and IYT-II were significant (Tables 3 and 4). Highest yield was 3.4 t/ha with 33 kg/ha per day efficiency. Most of our lines were earlier than the checks and better in seed quality. The distribution of ITY-I and IYT-II entries (Fig. 2 and 3) indicate the excellent potential to select superior lines for yield.

Narrow Leaf Line Records Highest (36 kg) Yield/Ha Per Day

Among the PYT-I and II, during spring and summer seasons breeding line GC 40359-1-55 with narrow leaf gave 3.4 t/ha in 96 days. The per day per hectare productivity (36 kg) is twice that of the check cultivar (19 kg). Selections were based on seed quality, early maturity and high per day productivity (Tables 5 and 6). A substantial number of breeding lines were considerably higher in yield than the check and the grand mean in PYT-I and II during spring and summer seasons (Fig. 4 and 5). Line GC 40359-1-55 was found to be adapted to both spring and summer seasons.

Table 1. Soybean breeding lines with superior yield or other desirable characters selected during spring season advanced yield trial; 1978, AVRDC[a].

Acc. or cross no.	Parents	Yield[c]	Flower ing	Matu- rity	100 seed weight	Seed[b] quality	Produc- tivity
		-t/ha-	---days-----		-g-		kg/ha/da
GC 30116-53	KS 469/CH #1	2.9**	45	98	20*	3*	28
GC 30243-5	64-4/64-2	2.9**	46**	101	19**	2	27
GC 30217-1-8	KS 535/KS 482	2.8**	41	99	20*	2	27
GC 30293-6-10	CH #1/Anoka	2.8**	44	105**	16**	2	25
GC 30183-57	KS466/Shih Shih	2.8**	44	98	21	2	27
GC 30229-8	Shih Shih/SRF 400	2.7*	40	106**	17**	3**	24
GC 30066-1-1	HS #3/Shin 2	2.7**	40	101	21	3**	25
GC 30295-6-6	Clark 63/Shih Shih	2.6*	39	94	21	3**	26
G 38 (ck)[d]	Shih Shih	2.3	40	92*	22*	4**	26
G 2043 (ck)[d]	Kaohsiung #3	2.1	43	98	21	2	22

[a]Sown Feb. 2, 1978. [b]Seed quality 1=excellent; 2=good; 3=fair; 4=poor. [c]Significance indicated is relative to Kaohsiung #3. [d]Mean of 3 trials.

Table 2. Soybean breeding lines with high yield and other desirable characters selected during summer season advanced yield trial; 1978, AVRDC[a].

Acc. or cross no.	Parents	Yield[d]	Flower-ing	Matu-rity	Bacterial pustule rating[b]	Produc-tivity
		-t/ha-	-----da------			-kg/ha/da-
GC 30229-8	Shih Shih/SRF 400	2.8**	35**	107	0.0	26
GC 30120-2-10	KS 482/Lee	2.7*	37	115*	1.5	24
GC 30293-6-10	CH #1/Anoka	2.6*	33**	105	0.5	25
GC 30238-3-34	PI 154194/CH #3	2.6*	30**	113*	1.0	23
GC 30213-1-5	HS #3/Clark 63	2.6*	38*	111	0.0	23
GC 30252-1-8	Clark 63/Palmetto	2.5*	39*	110	0.0	23
GC 30257-1-7	Forest/Shih Shih	2.5*	37	105	0.0	24
GC 30104-1-1	Taichung #4/Yagi 1	2.3	38*	107	0.5	22
G 2034 (ck)[c]	Kaohsiung #3	2.3	37	108	0.8	22
G 38 (ck)[c]	Shih Shih	1.7	31**	89**	2.0	19

[a]Sown Jul 11, 1978. [b]0=no symptom; 1=very mild; 2=moderate symptom; 3=severe symptom. [c]Mean of 3 trials. [d]Significance indicated is relative to Kaohsiung # 3.

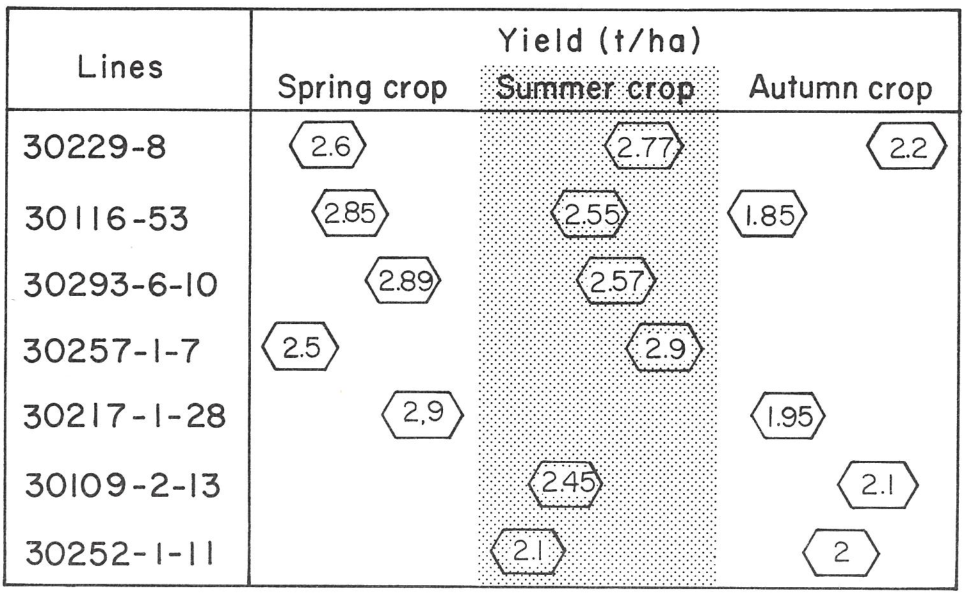


Fig. 1. Soybean breeding lines from advanced yield trial, selected for their wide adaptability and high yield.

Table 3. Soybean breeding lines with high yield potential in the intermediate yield trial I and II (IYT I and IYT-II) during spring season; 1978, AVRDC[a].

Acc. or cross no.	Parents	Yield[b]	Flower-ing	Maturity	Seed quality[d]	Produc-tivity
		-t/ha-	-day-	-days-		-kg/ha/da-
GC 30273-10-9	KS 535/Jupiter	3.4**	42*	106	1.5*	32
GC 30273-14-8-1	KS 535/Jupiter	3.4**	42*	106	2.0	33
GC 30080-2-8	HS #3/Tamana	3.1*	40**	96**	2.0	32
GC 30090-2-7	R-10/Lee	3.1*	44*	102	1.5*	31
GC 40061-4-0-1-1	Shih Shih/CH #1	3.0*	47	98*	2.5	31
GC 30257-2-0-7	Forrest/Shih Shih	2.9	44*	98*	2.5	30
GC 30295-6-6	Clark 63/Shih Shih	2.9	42*	95*	2.5	30
G 2043 (ck)	Kaohsiung #3	2.3[c]	48	109	2.8	22

Number of lines evaluated: ITY-I = 255; IYT-II = 201.
[a]Sown Feb 24-28, [b]Significance indicated is relative to Kaohsiung #3. [c]Mean of two trials. [d]See Table 1.

Table 4. Soybean breeding lines with high yield potential in the intermediate yield trial I and II (IYT-I and IYT-II) During summer season; 1978, AVRDC[a].

Acc. or cross no.	Parents	Yield[b]	Flower-ing	Maturity	Seed[d] quality	Produc-tivity
		-t/ha-	------da--------			-kg/ha/da-
GC 30299-29-6-3	Clark 63/CH #3	3.4**	35*	105	2.5	32
GC 30187-9-8	CH #2/KS 528	3.3**	43*	99	2.0	33
GC 30187-10-6	CH #2/KS 528	3.2**	43*	99	2.0	32
GC 40408-2-0-3	Palmetto/Shih Shih	2.5*	42*	103	1.5*	24
GC 30238-19-14	PI 154194/CH #3	2.5*	36*	105	2.0	24
GC 30187-10-9	CH #2/KS 528	2.4*	42*	103	2.0	24
G 57 (ck)	Tainung #4	1.5[c]	39	104	2.9	14

Number of lines evaluated: IYT-I=255; ITY-II=201.
[a]Sown Jul 12-17. [b]Significance indicated is relative to Tainung #4. [c]Mean of two trials. [d]See Table 1.

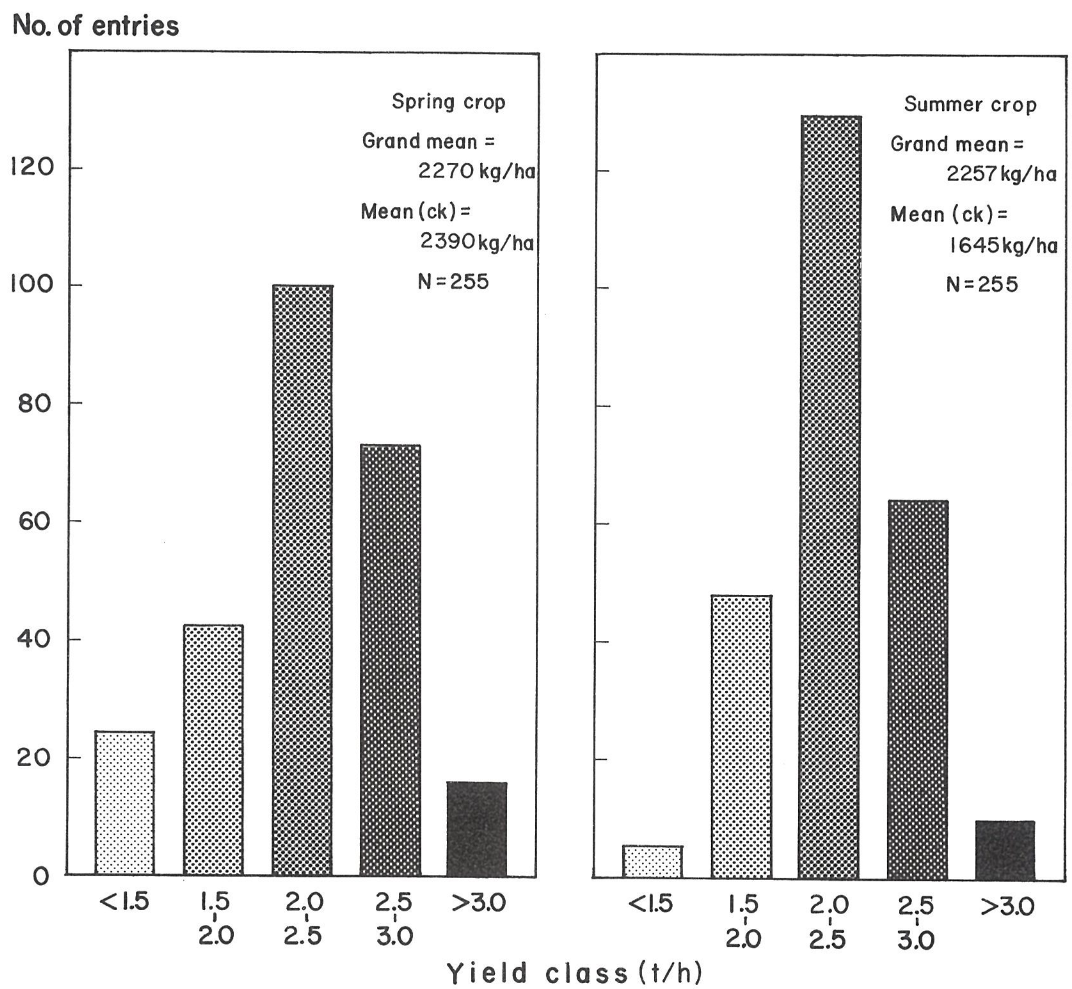


Fig. 2. Distribution of soybean breeding lines in different yield classes in the intermediate yield trial (IYT-I).

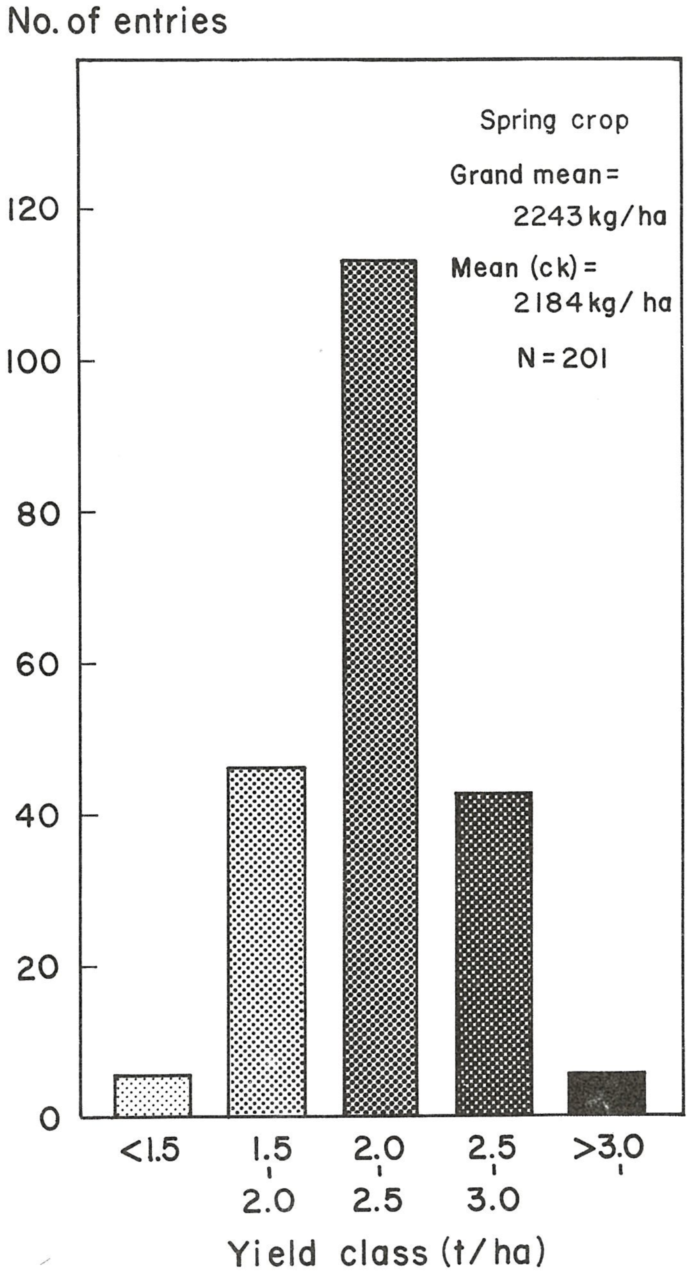


Fig. 3. Distribution of soybean breeding lines in different yield classes in IYT-II.

Table 5. Promising soybean lines from the preliminary yield trial (PYT-I and PYT-II) during spring season; 1978, AVRDC[a].

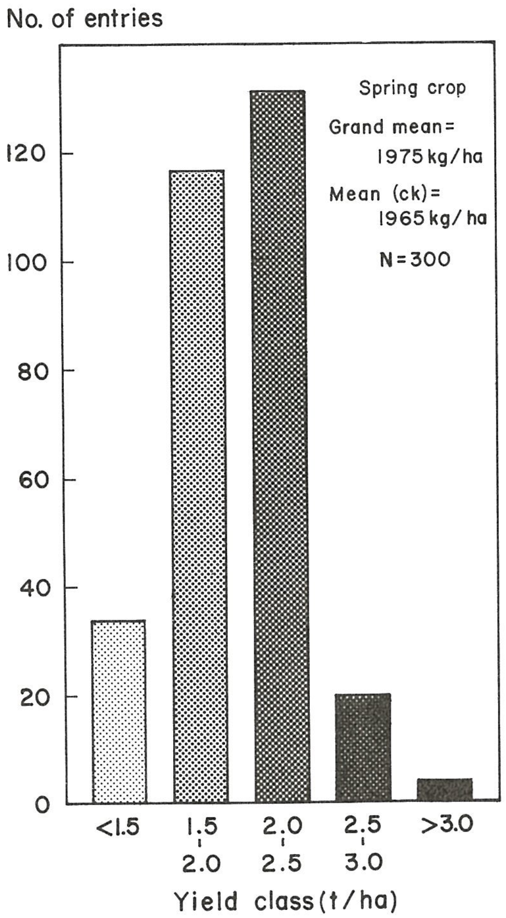
Acc. or cross no.	Parents	Yield[b]	Flowering	Maturity	Seed quality[c]	Productivity
		-t/ha-	--------da--------			-kg/ha/da-
GC 40359-1-55	SRF 400/PI 297550	3.4**	36*	96*	3.0	36
GC 40713-0-10	Norman/CH #1	3.4**	40**	100	2.5	34
GC 40713-0-53-2	Norman/CH #1	3.3**	41**	98	2.0*	33
GC 30104-2-77-1	Tainung #4/Yagi 1	3.1**	48	99	2.0*	32
GC 30044-2-10	Aochi/Tainung #4	3.1**	48	104	2.0*	30
GC 40142-0-140	CH #3/PI 297550	3.0**	46	96*	1.5*	31
GC 30104-2-74	Tainung #4/Yagi 1	2.9*	48	109	1.5*	27
GC 30243-10-8	64-4/64-2	2.8*	48	98*	2.0*	29
G 2043 (ck)	Kaohsiung #3	1.9[d]	47	105	3.2	19

Number of lines evaluated: PYT-I=300; PYT-II=125.
[a]Sown March 1-7, 1978. [b]Significance indicated is relative to Kaohsiung #3. [c]See Table 1. [d]Mean of two trials.

Table 6. Promising soybean breeding lines from the Preliminary Yield Trial II during summer season; 1978, AVRDC[a].

Acc. or cross no.	Parents	Yield[b]	Flowering	Maturity	Seed quality[c]	Productivity
		-t/ha-	------da------			-kg/ha/da-
GC 40713-0-18	Norman/CH #1	2.7**	37	93	2.0	29
GC 40359-1-55	SRF 400/PI 297550	2.6*	28**	88**	1.0*	30
GC 40409-6-14	Palmetto/PI 153212	2.6*	34*	90*	1.5	28
GC 40440-0-37	SRF 400/PI 200492	2.6*	36	100	1.5	26
GC 40548-0-17	Palmetto/KS 460	2.5*	37	94	2.0	26
G 57(CK)	Tainung #4	1.9	37	97	2.2	19
LSD .05		0.4	2	5	1.1	5

[a]Sown Jul 25, 1978. [b]Significance indicated is relative to Tainung #4. [c]See Table 1.



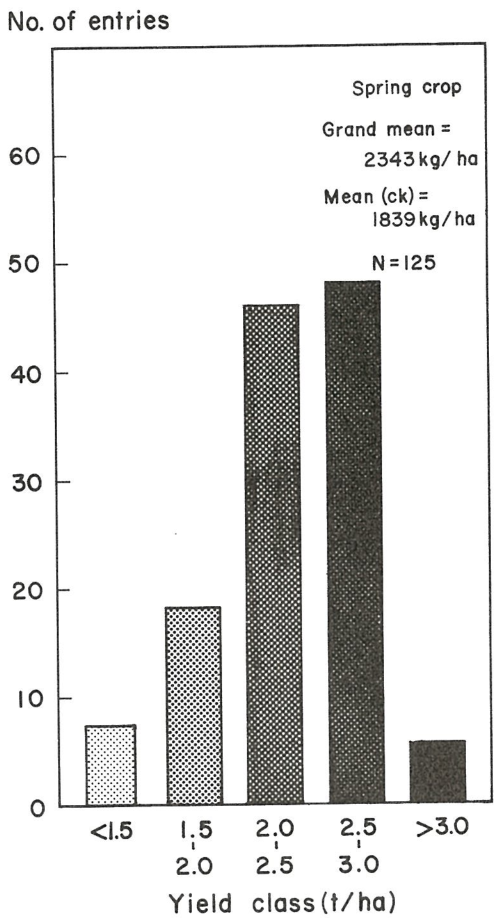


Fig. 4. Distribution of soybean Preliminary Yield Trial I entries in different yield classes.

Fig. 5. Distribution of soybean Preliminary Yield Trial II entries in different yield classes.

Influence of Temperature on Photoperiod-Sensitive and-Insensitive Cultivars

The role of night temperature on photo-sensitive selection G 2120 and photo-insensitive Acc. G 215 grown under constant 10-hour and 16-hour days was different. For G 2120 the basic vegetative phase (bvp), insensitive to photoperiod (9 days from emergence), is also insensitive to the temperature regimes used. Temperature sensitive phase appears to be 20 days, beginning 9 days after emergence. Temperature could not override the photo-periodic response in G 2120.

In Acc. G 215 the bvp is sensitive to temperature. Results also suggest photoperiod x temperature interaction on bvp. Photosensitivity score of G 215 may be altered by high night temperature.

Best Source of Resistance to Soybean Rust

Pathology screened 824 accessions (Acc.), including 180 U.S. and other named cultivars for resistance to soybean rust (*Phakopsora pachyrhizi*) under natural and induced epiphytotic conditions. The cultivar TK #5 was a susceptible check and rust reactions were evaluated using the IWGSR rating system. Among those tested, Acc. G 8586 (PI 230970) and G 8587 (PI 230971) still appear the best sources of resistance to soybean rust. Among the named cultivars tested only the Indonesian cultivar Orba rated moderately susceptible (MS). All other named cultivars rated susceptible (Table 7).

During the spring and autumn seasons, we screened 663 breeding lines in the F_3 generation for resistance to soybean rust. The cultivars TK#5 and Shih Shih were susceptible checks and rust reactions were evaluated using the IWGSR rating system. The best line in the spring test rated MS and 84 lines rated moderately resistant (MR) in the autumn test (Table 8). Induced and natural epiphytotic conditions were used for the spring and autumn seasons respectively. The best pedigrees were selected from GC 60005 (Shih Shih/PI 230970), and GC 60037 (UPSL-85/PI 230971). Seven pedigrees were best for resistance and combine good agronomic characters.

Table 7. Evaluation of rust resistance of 813 soybean germplasm accessions under induced epiphytotic conditions; 1978, AVRDC.

Disease reaction	IWGSR rating	Spring	Autumn		Total
		Accessions	Named cultivars	Other accessions	
R	223	0	0	1	1
MR	323	5	0	3	8
MS	333	10	1	4	15
S	343	446	179	164	789
					813

[a] Plants inoculated with spore suspension 3 times in spring and 4 times in autumn season.

Table 8. Evaluation of rust resistance of 663 soybean breeding lines under induced and natural epiphytotic conditions; 1978, AVRDC.

Disease reaction	IWGSR rating	Spring season[a]	Fall season[b]	Total
R	223	0	0	0
MR	323	0	84	84
MS	333	1	49	50
S	343	447	82	529

[a]Induced epiphytotic conditions obtained by inoculating spreader rows of the cultivars TK-5 and Shih-Shih twice with a spore suspension. [b]Natural epiphytotic conditions.

A New Project on Soybean Rust Epidemiology Started

A new project studying the epidemiology of soybean rust has been initiated by AVRDC with partial funding from the US Dept. of Agriculture. The objectives of the project in general are; 1) a determination of the environmental factors and their effect on disease incidence and development, 2) a determination of sources of initial inoculum, 3) an evaluation and correlation between yield loss, and disease development, rates of disease intensification and spread, 4) development and use of a quantitative rust assessment scheme. Preliminary results indicate that: the date of initial disease incidence and the amount of initial inoculum differentially affects disease development and yield loss among three local cultivars, Shih-shih, TK #5 and TN #4; the resistance observed in the accessions G-8586 and G-8587 appears to be general resistance, reducing the rate of disease development; the primary inoculum source for three experiments was local but not the Soybean Rust Nursery maintained at AVRDC. Final results and conclusions are forthcoming.

Resistance to Root Diseases

Pathology screened 23 accessions and breeding lines for post-emergence damping off and root disease complex in both spring and autumn seasons. In the spring two lines, 30067-0-8 (KS 519/Aochi), and 30255-1-12 (PI 96983-Ped/HS #1) were resistant to damping-off and one line and two accessions were rated resistant, moderately resistant and moderately susceptible (30043-4-7 (Aochi/Tainung #3), Palmetto, KS 535, respectively). In autumn one accession (KS 535) and four breeding lines (30067-0-8, 30043-4-7, 30255-1-12, 30290-11-11 (KS 419/KS 528)) rated resistant

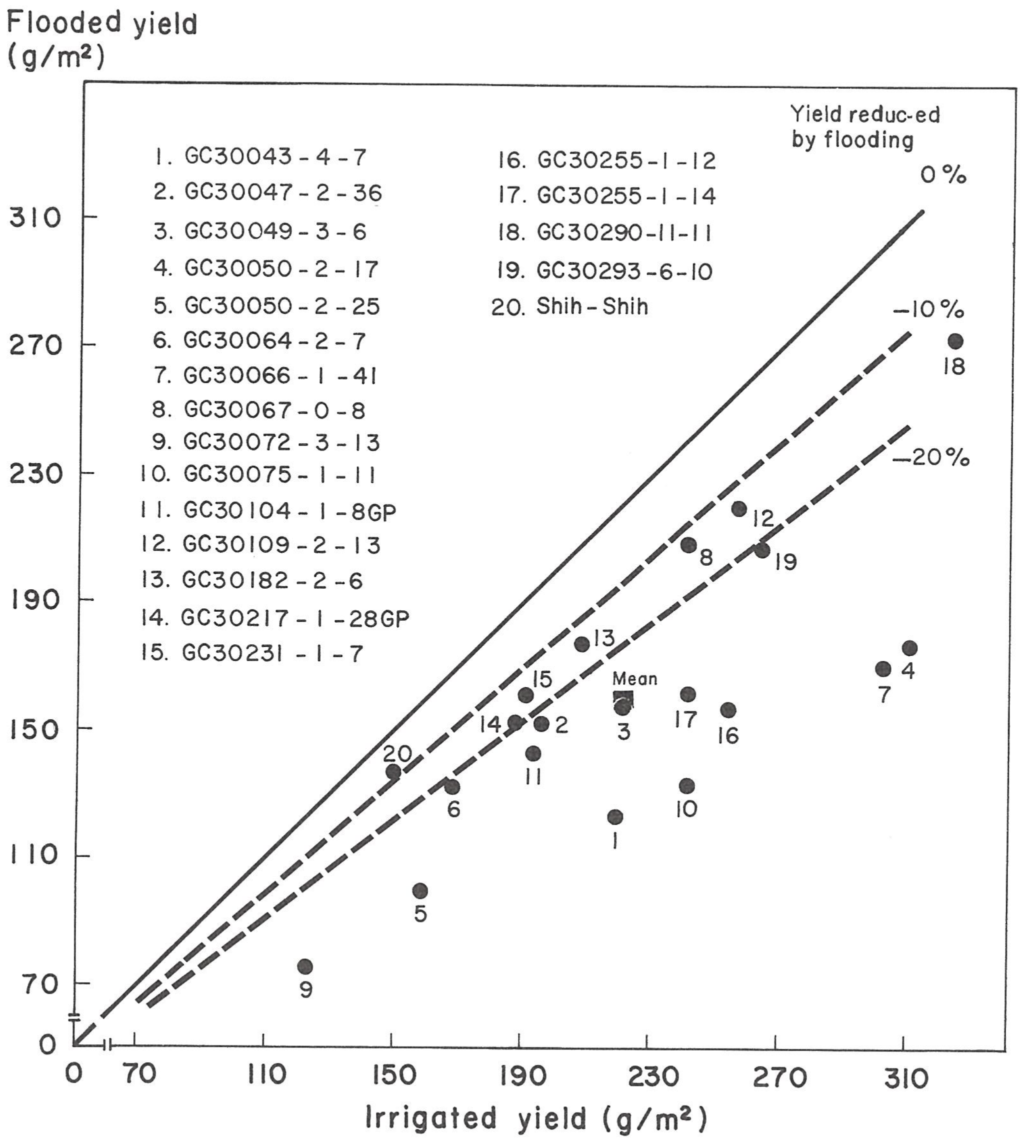


Fig. 6. Seed yield in relation to 50% pod darkening for 20 promising soybean breeding lines grown under flooding conditions.

to damping-off, however, none rated resistant to the root disease complex.

Root-knot Nematode Resistance Observed

In preliminary screening of 40 accessions and breeding lines in the spring, 7 accessions and lines (G 2035, G 87, 30116-53 (KS 469/CH

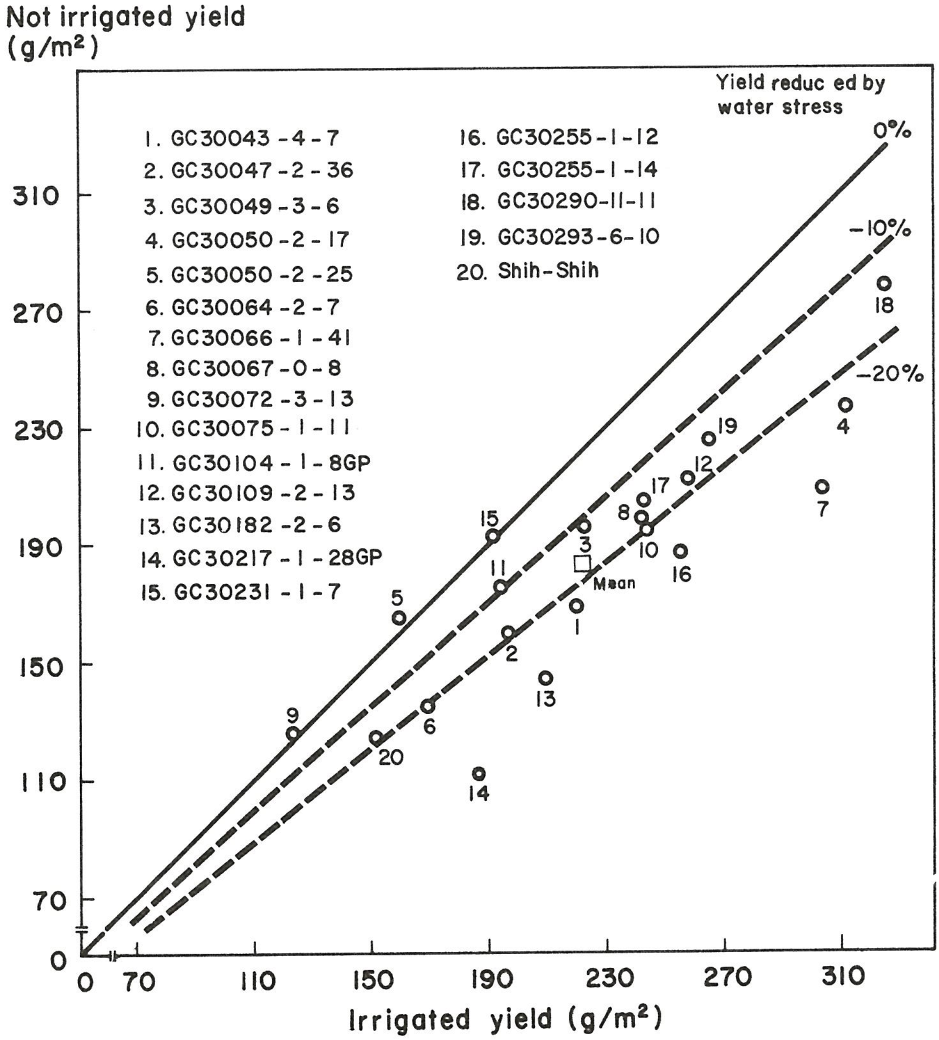


Fig. 7. Seed yield in relation to 50% pod darkening for 20 promising soybean breeding lines grown under drought stress conditions.

#1), G 2033, G 2024, KS 628, G 1673) rated resistant. In the fall, of a selection of 40 accessions and breeding lines screened in the nematode nursery, all rated resistant. Confirmation of the field data is currently under way in the greenhouse.

Breeding Lines Tolerant to Flood and Drought Stress Identifed

We evaluated 20 promising AVRDC breeding lines under 3 water regimes. Twenty days after emergence either irrigation was stopped or flooding was created to simulate drought and flooding respectively. Both moisture stresses continued for two months. The experiment was conducted from 8 Sep 1977. Breeding line GC 30290-11-11 (KS 419/KS 528) produced the highest yields under control, flooded and drought conditions. Lines GC 30182-2-6 (KS 466/Shih Shih) and Shih Shih appear to have tolerance to soil flooding (Fig. 6). Lines that seem promising for drought tolerance are GC 30050-2-25 (Higo daizu/R-10), GC 30072-2-13 (Shin 2/Shih Shih), GC 30104-1-8 GP (Tainung #4/Yagi 1) and GC 30231-1-7 (PI 153212/KS 482) (Fig. 7).

Beanfly Resistance

In 1978 we finished screening most of our soybean germplasm for resistance to beanflies (*Melanagromyza sojae,* and *Ophiomyia centrocematis*) by a non-replicated mass screening technique developed in 1976 (AVRDC soybean report 1976). Among 6775 accessions tested we selected 891 that were least affected and based on our statistical mean and standard deviation criteria fell into high resistance (HR), moderate resistance (MR), and a few in low relative resistance (LR) (Fig. 8A) catagories. During spring 1978 we evaluated them in a non-replicated trial. Again using the same statistical criteria we grouped these materials into five relative resistance categories as shown in Fig. 8B. From this we again selected 149 accessions all from HR and MR and a few promising from LR categories and planted them for the third time in a replicated (3) experiment at AVRDC in June. Three weeks after planting we evaluated their performance in the usual fashion and grouped them into various relative resistance categories as shown in Fig. 8C . Sixteen accessions fell in HR (5) and MR (11) categories.

In order to assess the consistency of the resistance reaction at various locations we planted these 16 accessions with 4 susceptible checks at 6 locations-Taitung, Hualien, Taichung, Tainan, Pingtung, and AVRDC-in Taiwan during the fall 1978 season. We evaluated their performance at 3 and 6 weeks after planting and statistically analyzed the data for each location and then performed a combined analysis for all locations. The results of combined analysis for the four most promising resistant and two susceptible accessions are summarized in Table 9.

We consider AVRDC accessions G 3089, G 3091, G 3104, and G 3122 to have high resistance and are using them as sources of beanfly resistant in our breeding program.

Aphid Resistance

Aphids (*Aphis glycines*) are sporadic in nature and under field conditions their infestation usually occurs in the cooler months of the year. During November-December we observed rather heavy aphid infestation in our multiple insect pest resistance screening field. We, therefore, evaluated our soybean germplasm for resistance to this insect.

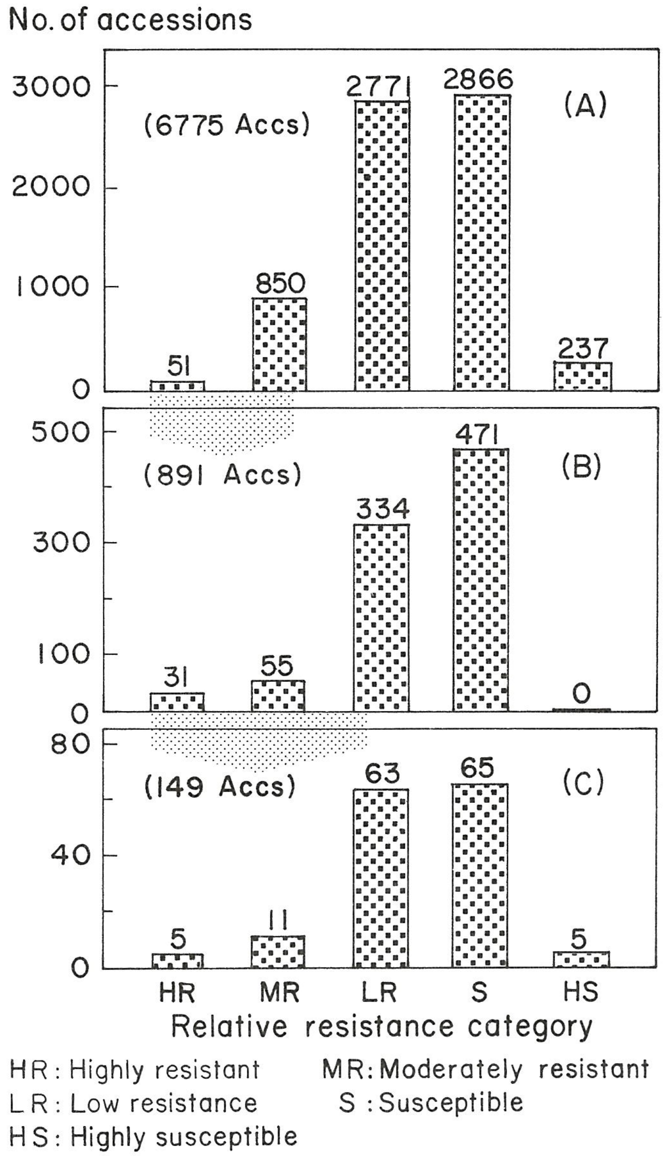


Fig 8. Relative resistance reaction of AVRDC soybean germplasm to beanflies during first (A), second (B) and final (C) screening at AVRDC, 1976-78.

Of the 3712 entries evaluated we found 689 free from aphid attack. We will test these materials once again, possibly at more than one location in Taiwan during the fall of 1979 to further select the most resistant material.

Table 9. Beanfly infestation of selected AVRDC soybean accessions at six locations in Taiwan. Data for all locations combined; 1978, AVRDC[a].

AVRDC acc. no.	No. beanfly maggots + pupae/plant weeks after planting	
	3	6
G 3089	0.04c	0.27g
G 3091	0.03c	0.11g
G 3104	0.02c	0.05g
G 3122	0.06c	0.11g
G 286 (check)[b]	0.20a	1.38b
G 3453 (check)[b]	1.41a	1.62a

[a]Mean of means of three replications at each location. Means followed by the same letter are not significantly different at 5% level. [b]Susceptible check.

Podborer Resistance

Limabean podborer, *Etiella zinckenella*, is the predominant podborer attacking soybeans in Taiwan. Its damage can be recognized by a large round hole in the pods through which the larva escapes to pupate in soil. Another species, *Heliothis armigera*, feeds on the pods and its damage can be recognized by the presence of chewed away plant tissues, usually at the base of the pod. We planted over 3000 soybean accessions in a non-replicated experiment between well established pigeon pea source row blocks during September and harvested them when senesced. We counted the number of damaged pods regardless of the insect species responsible for the damage and by a statistical mean and standard deviation criteria grouped the accessions into four relative resistance categories as shown in Table 10.

Of 439 accessions that fell in Moderate RR category, 11 accessions (AVRDC accession Nos: G 241, G 735, G 928, G 1081, G 1464, G 1757, G 1784, G 1969, G 2198, G 2574 and G 2625) were free of any podborer damage. In 10 additional accessions (AVRDC accession Nos. G 903, G 1367, G 1457, G 1537, G 1795, G 1803, G 1959, G 2101, G 2538 and G 3423) the damage was less than 1%. We will concentrate on these 21 accessions during 1979 to confirm these findings.

Table 10. Relative resistance ranking of AVRDC soybean germplasm for resistance to podborer damage; 1978, AVRDC[a].

Relative resistance (RR) category	Percent damaged pods	No. of accessions
II Moderate RR	0 to 5.68	439
III Low RR	5.69 to 14.30	1430
IV Susceptible	14.31 to 31.54	1288
V Highly Susceptible	31.55 to 85.04	141

[a]Planted; 22 Sep. Sampled (Harvested); 30 Nov to 15 Dec. No. of entries: 3298. Mean and Std. deviation for percent pod damaged: 14.31 ± 8.62

Ecology of Soybean Insect Pests

To develop a judicious insect pest management program it is important to understand the peak period of abundance of insect pests, when they are likely to require suitable control measures. We have, therefore, started to monitor the seasonal abundance of various pests of soybean since 1975. Once every two weeks we plant soybean, variety T.K. #5 (Acc. G 3453), in a 20m x 1m bed and raise the crop until harvest, using all necessary cultural practices except insecticides. At 4 weeks after planting we uproot 100 plants, dissect each and count the number of beanfly maggots and pupae in each plant. We also count the number of aphids *Aphis glycines* on each and group the plants with 0-10, 10-100, 100-1000 and > 1000 aphid per plant. From these plants we then take 100 leaves and count the number of eggs, nymphs and adults of mites (*Tetranychus truncatus*) per cm^2 leaf area. We report these data as total number of mites/cm^2 leaf area. We have installed a 15 watt Ellisco black-light trap near the field to monitor insect pest incidence. Every week we count the number of green stink bugs (*Nezara viridula*), scarabid green beetles (*Anomala cupripes*), and limabean podborers (*Etiella zinckenella*) caught. The population fluctuations of these insects are summarized in Fig. 9. Beanfly population starts building up in Feb and remains relatively high almost throughout the year before dropping to its lowest briefly in Jan. The infestation of this insect is the most serious during dry months of fall Oct-Nov. Aphids and mites are prevalent during cooler and drier Nov to Jan. The green stink bug starts appearing late in May, its population peaks in Jun and declines thereafter during the rainy summer months. Scarabid green beetle is an important foliage feeder of many legumes during Apr, May, and Jun. During the past four years it has unfailingly started appearing around the middle of Apr. Its population shoots up very rapidly during the following four weeks. It is almost nonexistant between Oct and Mar. Limabean podborer infestation starts in Oct and

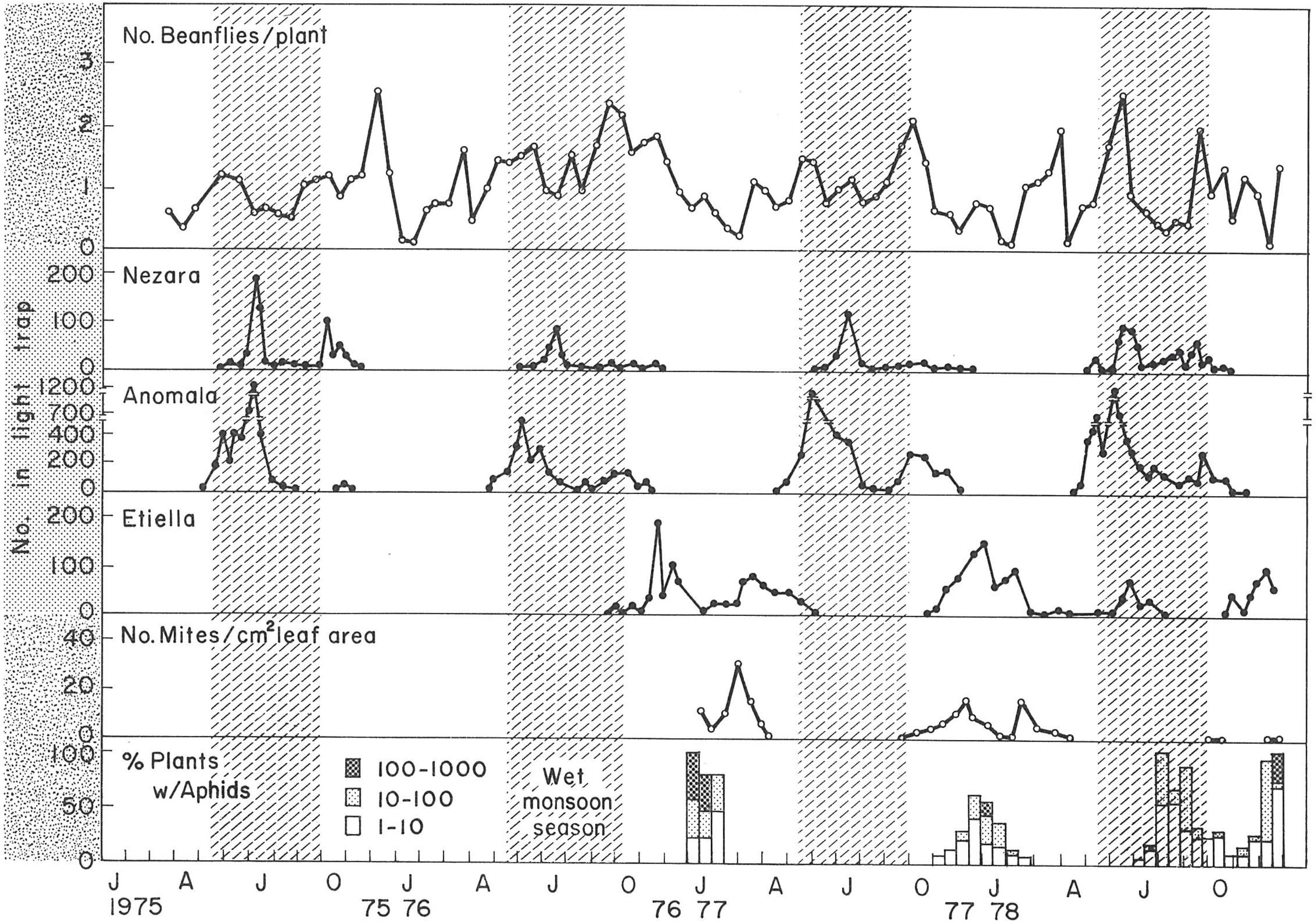


Fig. 9. Seasonal incidence of insect pests on soybean at AVRDC.

its population peaks between Nov and Dec and remains at a moderate level until Apr.

Control of Beanflies

We investigated the use of rice-straw mulch to reduce the beanfly infestation. The results suggest that it is unlikely that "no-tillage rice-stubble culture" has any effect on beanfly control.

We screened several insecticides for the control of beanflies. Triazophos spray that gave very good control of beanflies in the past causes phytotoxicity among some breeding lines under drizzling and rainy weather. We, therefore, discontinued its use. Insecticides that also gave good control of beanflies include omethoate (Folimat), dimethoate (Rogor), and monocrotophos (Azodrin), all in EC sprays. We found that timing requires the first spray at 3-4 days after germination and 3 additional weekly sprays thereafter. The earlier you spray after germination the better.

In one test we sprayed omethoate 0.25 kg a.i./ha for 9 weeks once every week, beginning at 4 days after germination. We dissected a 30 plant sample at 3 and 5 weeks after planting and counted the number of maggots and pupae. We also recorded the yield. The results are presented in Fig. 10. We found that 3 weekly sprays of omethoate are necessary for adequate control of beanflies. We also observed increased seed yield with each of the first 3 sprays, but not thereafter. The increased yield at the 8th and 9th sprays is possibly due to podborer control, although we did not take observations on this pest.

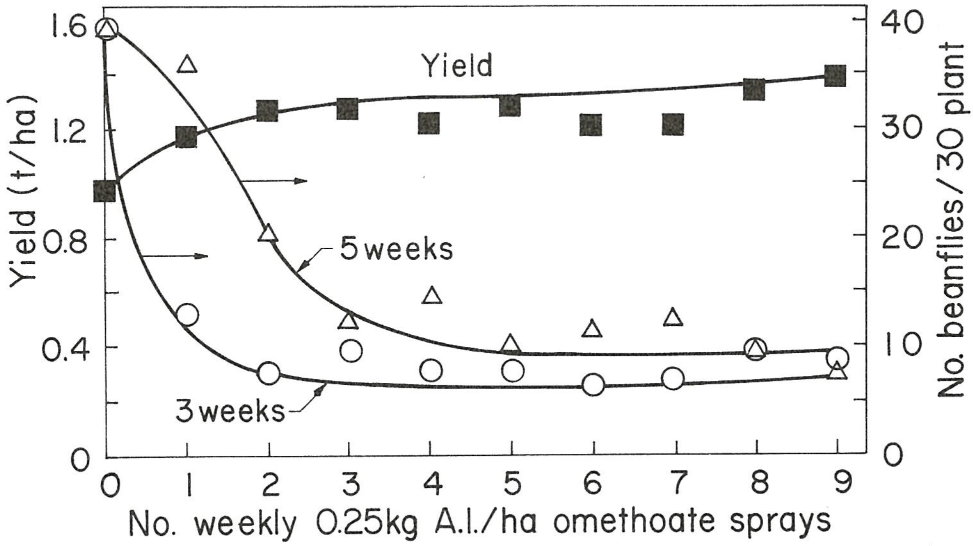


Fig. 10. Effect of omethoate treatment on beanfly control and soybean yield.

Since beanfly infestation during the first three weeks after germination reduces the crop stand and yield seriously, we used two insecticides, triazophos and carbofuran, available in seed treatment formulation, by coating 0.5%, 1.0%, and 1.5% a.i. on seeds before planting. These insecticides in other formulations have given some control of beanflies in the past. Carbofuran at 1% and 1.5% gave excellent control of beanflies for up to 3 weeks after planting, however, germination was severely reduced at these two concentrations. We are now working on the concentration of this insecticide that will give good control but not affect soybean germination.

WORLDWIDE COOPERATION

Sixty four scientists from 31 countries received 2,359 accessions and 4,196 breeding lines for evaluation and direct use in their programs.

African Countries

Ejura, Ghana

Under almost no-input conditions three out of our 25 lines gave 1.1 to 1.4 t/ha in 79 to 82 days.

Ntondo, Republic of Zaire

Our breeding lines GC 30120-49-58 and -59 gave a yield of 3.1 and 2.8 t/ha respectively. They also had good seed quality.

Causeway, Rhodesia

Our cooperator indicates that our line GC 30164-55 is promising, though a majority of our lines shattered under Rhodesian conditions.

Copperbelt Regional Research Station, Zambia

A cooperator evaluated 100 AVRDC breeding lines and found some that yield 1.9 to 2.2 t/ha with excellent seed quality. Some of our lines also combine resistance to bacterial pustule and are non-shattering.

Magoye Regional Research Station, Zambia

A record yield of 5.8 t/ha in 95 days with good seed quality was demonstrated at this location with GC 30106-2-94 though shattering was severe. (Table 11).

ASEAN Countries

Muara, Indonesia

From a preliminary yield trial of 16 selected AVRDC lines, plus 3 local breeding lines and the local check cultivar Orba, 3 of our lines, GC

Table 11. Soybean yields at the Magoye Regional Research Station, Zambia; 1978.

Cross	Parents	Yield kg/ha	Days to maturity	Remarks
GC 30106-2-94	TN #4/Bansei Kuro Daizu	5846(1708)[a]	95(113)	Good seed quality
GC 30047-2-36	Higo Daizu/KS 528	3058(1875)	95(121)	- DO -
GC 40427-0-11	Pl. 200492/Jupiter	3042(2000)	96(113)	Res. to shattering
GC 30094-2-16	66-G-3/Pl. 200492	2808(1750)	96(117)	Excellent seed quality
GC 30213-1-3[b]	HS 3/Clark 63	2737(2250)	96(125)	Non-shattering

Total number of entries evaluated: 100. Date planted: 22 Dec., 1977.
[a]Figures in parenthesis are data from Copperbelt Regional Research Station.
[b]This line had 100% shattering at the Copperbelt Regional Research Station.

30120-49-6, GC 30187-10-9, and GC 30237-6-6, were found to be most promising compared to Orba. These lines will be evaluated in a number of locations during 1979.

Sarawak, Malaysia

The yield of our lines were comparable or slightly higher than the local cultivar, Nonok. Non-lodging appears to be a decided advantage of our lines compared to Nonok.

Kuala Lumpur, Malaysia

Lines GC 30238-3-22 and GBM 32 were rated most promising in a study by a doctoral candidate. The lines were recommended to the Malaysian Varietal Development Committee for further evaluation.

MARDI, Kelantan, West Malaysia

The yield of AVRDC line GC 30213-1-3 was similar to that of local check cultivar, Palmetto. However, our line was resistant to lodging while Palmetto lodged. GC 30213-1-3 also gave high yields in Zambia.

MARDI, Serdang, Malaysia

Three of our lines GC 30252-2-7-2, GC 30252-1-14, and GC 50269-2-7 GP, appear promising and will be further evaluated.

Economic Garden, Los Banos, Philippines

Single plants were selected from segregating F_4 generation lines. Nine crosses with a high mean yield per plant were selected. Single plants with high number of pods per plant and seed weight per plant were selected (Table 12). Half the seed from each plant has been sent to Thailand for evaluation. The rest will be evaluated at AVRDC and in the Philippines.

Chainat, Chieng Mai, and Pitsanulok, Thailand

A combined analysis of seasons, locations and the genotypes showed significant first order interaction. Three of our lines, GC 30120-38-53, GC 30251-1-6 and GC 30120-38-76, were found to be higher yielding than the check cultivars. Our lines appear to have field tolerance to rust compared to the check cultivars. Final trial results are awaited.

Suwan Farm, Thailand

Of 576 lines, 5 were found to be promising. They will be further evaluated. Resistance to anthracnose and bacterial blight were also observed in our lines.

Table 12. High yielding soybean lines selected at Economic Garden, Los Baños,Philippines; 1978.

Cross	Parents	Pods/plant	Days to maturity
GC 40216-0-9	Pl. 232·901/TN #4	25	89
GC 30297-6-6	Pl. 89053·665/P 156	26	88
GC 30297-6-9	Pl. 89053-665/P 156	25	89
G 86	Clark 63 (check)	15	89
LSD .05		8	-

Number of entries evaluated: 60.
Note: The crop was damaged by typhoon and rats, therefore, no yield data could be collected.

South Asian Countries

Peradeniya, Sri Lanka

Cooperation began with 9 F_4 and 11 F_5 bulk segregating populations in 1976. Eight F_7 and 10 F_8 pedigrees were evaluated during 1977. Nine superior lines were selected. They were evaluated in a replicated yield trial from December 1977. Four lines were found promising. They will be evaluated in different locations.

Tanuku, Andhra Pradesh, India

Acc. G 2120 and one of our accession G 2572 were promising in both Sep and Feb plantings. Unfortunately, a flood and hurricane destroyed all their crops.

Tando Jam, Pakistan

Excellent yields, 3.2 t/ha, were obtained by our lines, GC 30050 GC 30213, and GC 30109-2-13, compared to 1.6 t/ha with the local check in an observational trial. Replicated trials with selected lines are planned.

MCC, Nokhali, Bangladesh

Obtaining good seed quality with high yield is the major problem in Bangladesh. Some of our lines with yields comparable to TK #5 (local check cultivar) have better seed quality than TK #5. They are being evaluated further.

Khumaltar, Kathmandu, Nepal

It was reported that three of our breeding lines, GC 30238-1-14, GC 40095-0-6 and GC 30229-8, appear promising. Narrow leaf line GC 30229-8 was impressive. All three lines will be included in the initial evaluation trial in the next season in several locations.

South Pacific Islands

Tanna, New Hebrides

Compared to the local check cultivar, Cannapolis, two of our lines, GC 30098-4 and GC 30120-38-76, were high yielding and had excellent seed quality.

South American Countries

CIAT, Cali, Colombia

All AVRDC lines matured two to three weeks earlier than the local cultivars. As a result, though the absolute yield was equal to one of the local cultivars, the productivity per day per hectare was vastly greater. For example, GC 30096-1-9 gave 34 kg/ha per day while the maximum local cultivar was Linea 106 with 27 kg/ha per day.

Korea

AVRDC lines GC 30285-11-8-2 and GC 30245-1-11 had yields comparable to Kwangkyo. Our lines were resistant to soybean necrotic mosaic virus, while Kwangkyo was susceptible.

Seeds of 8 advanced Suweon breeding lines (8.2 kg) were multiplied to 124 kg and sent to Korea in time for planting. In addition, 500 F_3 lines from 3 crosses were advanced and from 485 selected lines 2766 plants were harvested for planting in Korea.

During autumn, 1,063 F_1 seeds were planted and the crop harvested for planting in the spring.

Japan

Kyushu University, Fukuoka, Japan

The effects of temperature and photoperiod on 23 photo-insensitive soybean cultivars were examined in detail in the Biotron Institute of Kyushu University, at Fukuoka. The results suggest the presence of two growth types: (i) stable determinate growth type with the final node number almost the same regardless of temperature and photoperiod; and (ii) unstable or temperature dependent determinate growth type with the number of nodes slightly more under long-day than under short day, and more nodes with higher temperatures than with lower temperatures. Days from emergence to first flower anthesis was longer in the former under both photoperiods.

Taiwan

Hsinchu, Wu Fong County

Out of 5 AVRDC lines screened at 500 meters above sea level in the mountain slopeland, line GC 30050-2-17 gave 2.2 t/ha in 92 days.

Machia County, San Ho

Five hundred kilograms of GC 30050-2-17 seed were given to San Ho village development authorities and distributed to 60 farmers. A large area was planted with GC 30050-2-17 (17) and GC 300290-11-11 (11).

A field day conducted by the Pingtung Hsien Government and Machia County on Dec. 19, 1978, was enthusiastically attended by more than 200 people from AVRDC and Machia County. Both 17 and 11 appeared very good.


Nikon

Nutrition, Environment & Management

The nutrition, environment, and management program (NEM) of AVRDC studies the interactions between vegetable crops and their surrounding environments (including natural and social). The three major components-nutrition, environment, and management--are, in fact, inter-related. Plant nutrition is an important component of crop management. The crop environment is a major factor which affects the form of the management system. The food consumption pattern affects the nutritional status, an important factor affecting the productivity of farmers. The inter-disciplinary NEM team attempts to improve the tropical farmer's quality of life by developing appropriate technology which can be transferred by extension services in national programs.

NUTRITION

Vegetable Consumption in Urban Cities

The agricultural economics group conducted food consumption surveys in five cities in Taiwan. These were Taipei and Kaohsiung, two metropolian areas; Taichung, an intermediate sized city, and Changhua and Tai-tung, urbanized cities at the county level. One of the main objectives was to study the food consumption patterns in urban households, then to determine the consumption trends for individual food groups, especially for vegetables, as consumer income increases.

We asked 1,000 sample households about their regular spending on various food groups and subgroups, and their probable food consumption response to a potential increase in income. We found that total food expenditure increases with increased income. Generally, the vegetable group appears to have less consumer appeal than animal protein food and fruits, since the consumers in lower income groups spent more on vegetables than those in higher income groups, except those in the highest income level.

We found that more than half of the sample households, given an increased income, would maintain vegetable consumption and increase expenditures for meat, fish, and fruit. Only 13 households out of 100 would increase vegetable consumption as incomes rise. According to the response, demand for pickled, canned or frozen vegetables probably will not increase even if consumers are better off in the future.

The fruit, meat and fish groups were considered more important than rice, vegetable, milk, egg and wheat products by the polled consumers. The more urbanized areas have greater variation in income and food consumption patterns than the smaller cities.

Relative Nutrient Cost

Based on dietary pattern and food prices, we have developed "relative nutrient cost" to estimate the overall nutritional value of food commodities. This information will be useful to food policy makers, agricultural economists and nutrition workers. Relative nutrient cost is defined by the formula:

$$\text{Relative nutrient cost } (R_j) = \frac{\sum_{i=1}^{n} C_{ji} \times P_{ji}}{\sum_{i=1}^{n} C_{ji}}$$

Rj = Relative nutrient cost of nutrient component "j"

P_{ji} is the price of unit nutrient component "j" of food commodity "i" in the diet.

C_{ji} is the amount of nutrient component "j" provided from consumption of food commodity "i" in the diet.

$\sum_{i=1}^{n} C_{ji}$ is the total intake of nutrient component "j" in diet composed of the commodity 1,2,......, n.

This value is a weighted average price of each nutrient component under specific dietary patterns and food prices. With this formula, we can convert all nutrient components into a common factor whose value is a dependent variable of food consumption pattern and food price. The Relative Nutrient Cost of protein, calcium, and vitamin A of Taipei city in 1976, for instance, were 0.49, 0.09, and 2.12 respectively. This means, if a Taipei citizen pays NT$0.49 for a unit gram of protein, relatively he pays NT$0.09 per mg calcium and NT$2.12 for 1000 IU of vitamin A. Under the current consumption pattern and food prices in Taipei, nutrient components of calcium and vitamin B are relatively more expensive than other nutrient components. A male adult has to pay NT$57.7 and NT$54.5 for his diet in order to meet the recommended daily allowance for calcium and B . It is not surprising then that these two nutrients are often found to be deficient in the present diet of Taipei residents.

The nutritional value of food commodities can be calculated according to following formula:

$$\text{Nutritional value } (N_i) = \sum_{j=1}^{n} R_j \times B_j$$

N_1 = nutritional value of a given food commodity "1".

R_j = relative nutrient cost of nutrient component "j".

B_j = content of nutrient "j" in 100 grams of food commodity "i".

In Taipei, the nutritional value of rice, egg, and tomato are 25.5, 42.6, and 9.1 per 100 grams, respectively. This value is subject to food consumption patterns, food prices, and the number of nutrient components. Food items of high nutritional value and high price probably need more research on production handling and marketing. On the other hand, more research on consumption will be needed for nutritious food with a low price.

Protein Quality of Mungbean and Blackgram

As reported previously, blackgram has a higher methionine content than mungbean. Moreover, about 35% of blackgram methionine is in the form of small molecules, permeable to through a cellophane membrane. A rat -feeding experiment was conducted this year to study the availability of the methionine present in these two beans. A progeny (#5) of a cross between mungbean and blackgram was also included. Casein was used as the check source of protein (Table 1).

Since the diets of this experiment were adjusted on iso-nitrogen level for all treatments, there is more methionine in the blackgram diet than the other two diets (Table 2).

Table 1. Relative availability of protein in mungbean, blackgram and an interspecific cross between mungbean and blackgram, 1978, AVRDC.

Diet[a]	Methionine Content	Apparent Digestibility	True Digestibility	Biological Value	Net Protein Utilization
	mg/g	%			
Mungbean (Acc. V 1381)	12.9	76.7	91.3	79.9	72.9
MB/BG (#5)	13.7	72.8	84.0	74.8	62.9
Blackgram (Acc. V 3039)	16.7	66.8	78.3	88.1	68.8
Casein		86.1	100.1	79.3	79.4
LSD 5%		2.5	5.1	11.5	9.1
1%		3.6	7.4	-	16.8

[a]Diet protein level in all treatments is equal to 10%.

Table 2. Methionine digestibility in mungbean, blackgram, and mungbean/blackgram, 1978, AVRDC.

Diet[a]	Methionine Digestibility	
	Apparent	True
Mungbean (Acc. 1381)	78.6	89.7
MB/BG (#5)	75.4	85.4
Blackgram (Acc. 3039)	75.7	83.6
Casein	93.5	99.4
LSD 5%	3.4	3.7
1%	6.3	6.9

[a]Diet protein level 10%. Methionine content per unit wt. protein of MB, MB/BG, BG:1.29, 1.37, 1.67% respectively.

Fractionation reveals that 37.8% of blackgram methionine is soluble in 80% alcohol, compared to only 1.9% and 2.5% of methionine present in mungbean and the interspecific progeny. This result implies that the fraction of alcohol soluble methionine (probably from non-protein sources) in blackgram is easily digestible and nutritionally available. Fecal analysis revealed that 85% of the undigested methionine in the blackgram came from the protein.

These findings create additional work for our interspecific breeding program. We hope to find progenies which retain good digestibility of protein with high alcohol soluble methionine in order to significantly improve mungbean protein quality.

Methionine Content of Mungbean and Blackgram Sprouts

Bean sprouts are a popular food in Asian diets. Both mungbean and blackgram are commonly used to produce bean sprouts. We studied the changes of methionine in these two beans during the sprouting processes. Mungbean (Acc. No. 2184) and blackgram (Acc. No. 1446) seeds were incubated without light in petri dishes with moisted filter paper. Sprouts sampled periodically were dried at 45^{o}C and analyzed for protein and methionine contents.

Bean sprouts have a higher protein content than the original seed on a dry weight basis (Table 3). This is due to the decrease of dry matter during sprouting. The methionine content, on the other hand, remained rather constant regardless the changes on dry matter. This result indicated that part of methionine is converted to other compounds

Table 3. Protein and methionine content of mungbean and blackgram sprouts, 1978, AVRDC.[a]

Length	100 seed weight	Protein[b]	Methionine[c]	Alcohol soluble[d] protein	Alcohol soluble[e] methionine
--cm--	--- g ---	%			
Mungbean	(V2184)				
0	5.6	24.7	0.36	4.9	2.4
2	4.6	29.1	0.36	9.6	4.0
6	4.4	32.5	0.35	16.0	6.1
21	3.2	40.7	0.35	19.6	9.8
Blackgram	(V1446)				
0	3.7	25.5	0.42	8.5	37.2
2	3.1	31.4	0.40	13.3	30.1
4	2.3	33.9	0.38	15.6	30.5
23	2.2	40.6	0.32	19.1	22.6

[a] All data are expressed on dry weight basis.
Protein is determined by micro Kjeldahl method (Nx6.25); methionine determined by microbiological assay method.

[b] Protein content/dry weight x 100. [c] Methionine content/dry weight x 100.

[d] $\frac{\text{Alcohol soluble protein}}{\text{Total protein}} \times 100$. [e] $\frac{\text{Alcohol soluble methionine}}{\text{Total methionine}}$

or lost in the incubation media. Since methionine is the limiting amino acid of blackgram and mungbean protein, the protein quality of sprouts probably is poorer than that of dry beans.

Analytical Method to Determine Sugar Content of Sweet Potato Root

Our chemists developed a simple and inexpensive method to determine the sugar content of sweet potato roots. Sugar is the major component of the water soluble solids of sweet potato root. The other components are electrolytes, which can be removed easily with ion exchange resin. The sugar in the remaining solution can be measured with a refractometer. The correlation coefficient between the sugar content determined with this method and that given by the colorimetric method is 0.99, suggesting that this method can be used as a mass screening method of sugar content analysis for institutes without an autoanalyzer.

Soybean Leaf Nitrate Reductase Activity

We conducted two experiments on the response of soybean leaf nitrate reductase (NR), activity to nitrate in the rhizosphere or in stem exudate.

AVRDC breeding line GC30182-2-6 was planted in the greenhouse in potted soils with several levels of nitrogen-fertilization during the summertime. At 4, 6, and 10 weeks after planting, soils were sampled for nitrate and young trifoliates for nitrate reductase activity. Leaf nitrate reductase activity responds hyperbolically to soil nitrate concentration (Fig. 1).

The nitrate concentration in the exudate of detopped plants was significantly correlated (r=0.98) with the nitrate concentration in the nutrient solution. In addition, the leaf nitrate reductase activity was correlated (r=0.76*) with the nitrate concentration in the exudate.

Leaf nitrate reductase activity also was highly correlated (r=0.83* to 0.98 with total plant nitrogen accumulation.

Differences were found to exist between cultivars in the response of leaf nitrate reductase activity to the nitrate level in the nutrient solution. However, for a given cultivar the two were correlated (r=0.86* to 0.99**).

Therefore, measurement of the maximum induceable leaf nitrate reductase activity is a good measure of a soybean's nitrogen utilization efficiency. There is apparently enough genetic variation in this character that we should be able to identify highly efficient plant types.

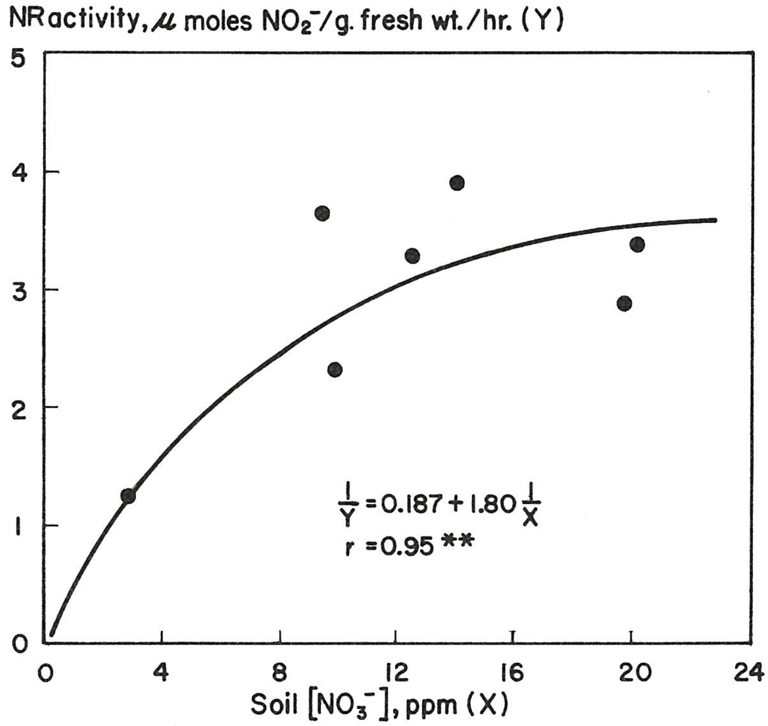


Fig. 1. Relation between soybean leaf nitrate reductase activity and soil nitrate content.

ENVIRONMENT[a]

Climate

A climate-diagram for Tainan, drawn according to Walter et al, was prepared (Fig. 2) based on the meteorological data from 1897-1970. AVRDC is located 19 km north of Tainan and has generally the same climate.

Weather

The 77-78 dry season was wetter than normal (Fig. 3) and the wet season was drier than average (Fig. 4). The rainfall measurably exceeded

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[a]For a complete description see "AVRDC Crop Environment", International Cooperators Guide, AVRDC Publication 78-66.

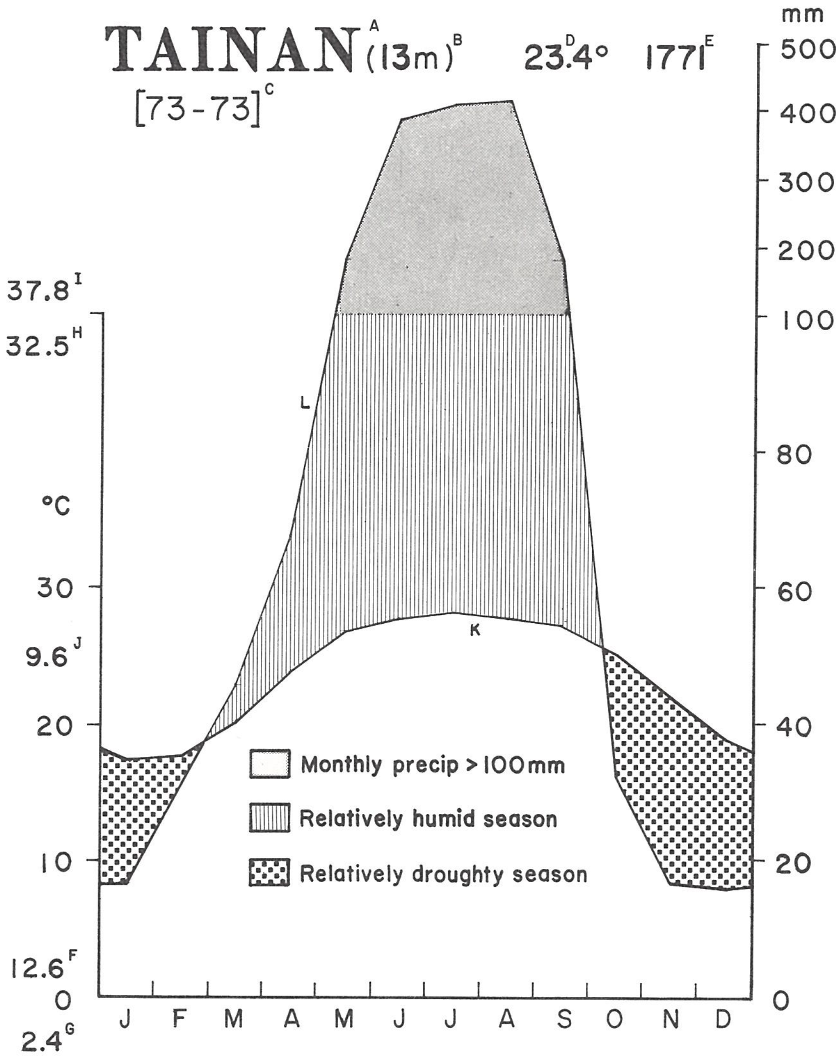


Fig. 2. Climate diagram for Tainan, Taiwan, ROC.
Sources: 1. Data: Central Weather Bureau, 1974. Summary report of meteorological data, Taiwan, v. III 1961-1970, Taipei, ROC.
2. Diagram: Walter, H. *et al*, 1975. Climate-diagram maps, Springer-Verlag, Berlin, Germany.
A=Station; B=Height above sea level in meters; C=Number of years of temperature, precipitation record; D=Mean annual temperature, °C; E=Mean annual precipitation, mm; F=Mean daily minimum temperature in coldest month, °C; G=Absolute minimum temperature on record; H=Mean daily maximum temperature in warmest month, °C; I=Absolute maximum temperature on record, °C; J=Mean daily temperature range, °C; K=Mean monthly temperature, °C; L=Mean monthly precipitation, mm.

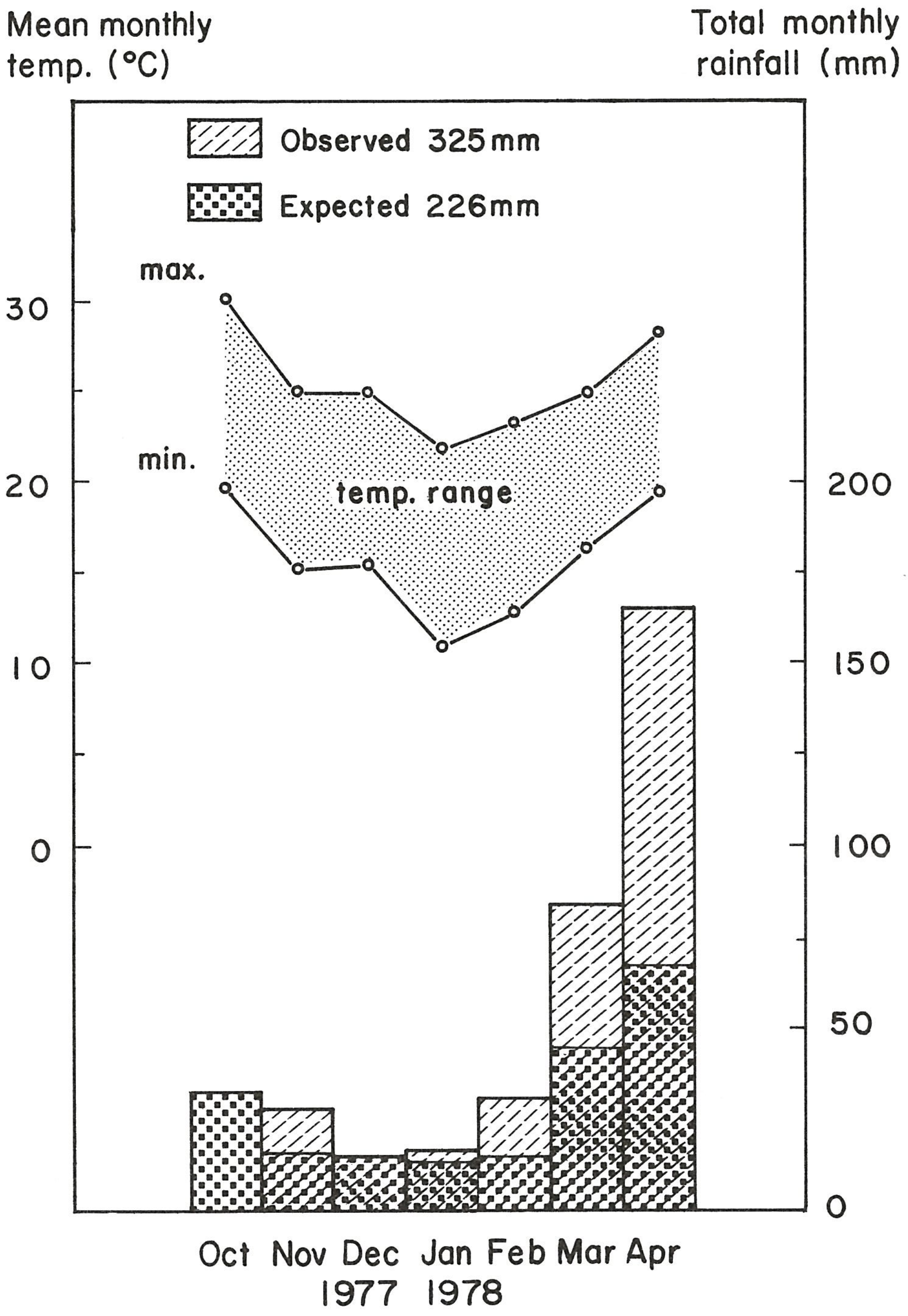


Fig. 3. Dry season rainfall and temperature, 1977-78, AVRDC.

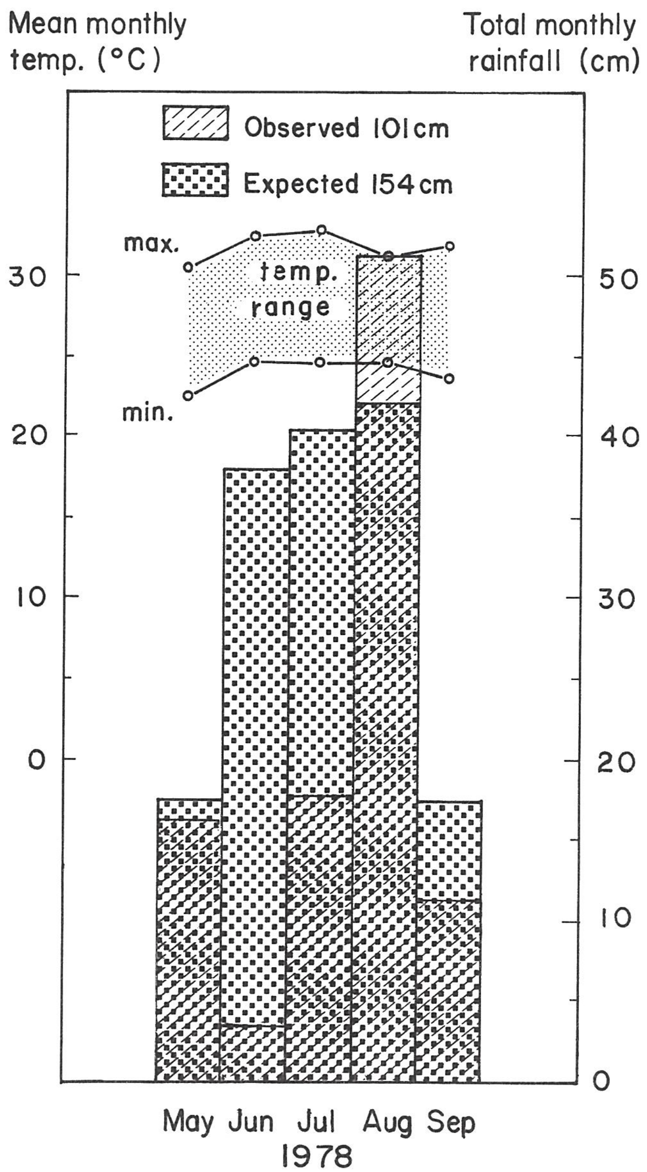


Fig. 4. Wet season rainfall and temperature, 1978, AVRDC.

the expected in Mar, Apr and Aug while Oct (77), Jun and Jul were exceptionally dry. This caused the solar radiation to be below the 1969-77 mean in Mar, Apr and Aug and above it in Oct (77), Jun, and Jul (Fig. 5).

The highest rainfall of the year occurred on Aug 19. On that day, 16.8 cm of rain fell in a few hours, causing a brief period of severe

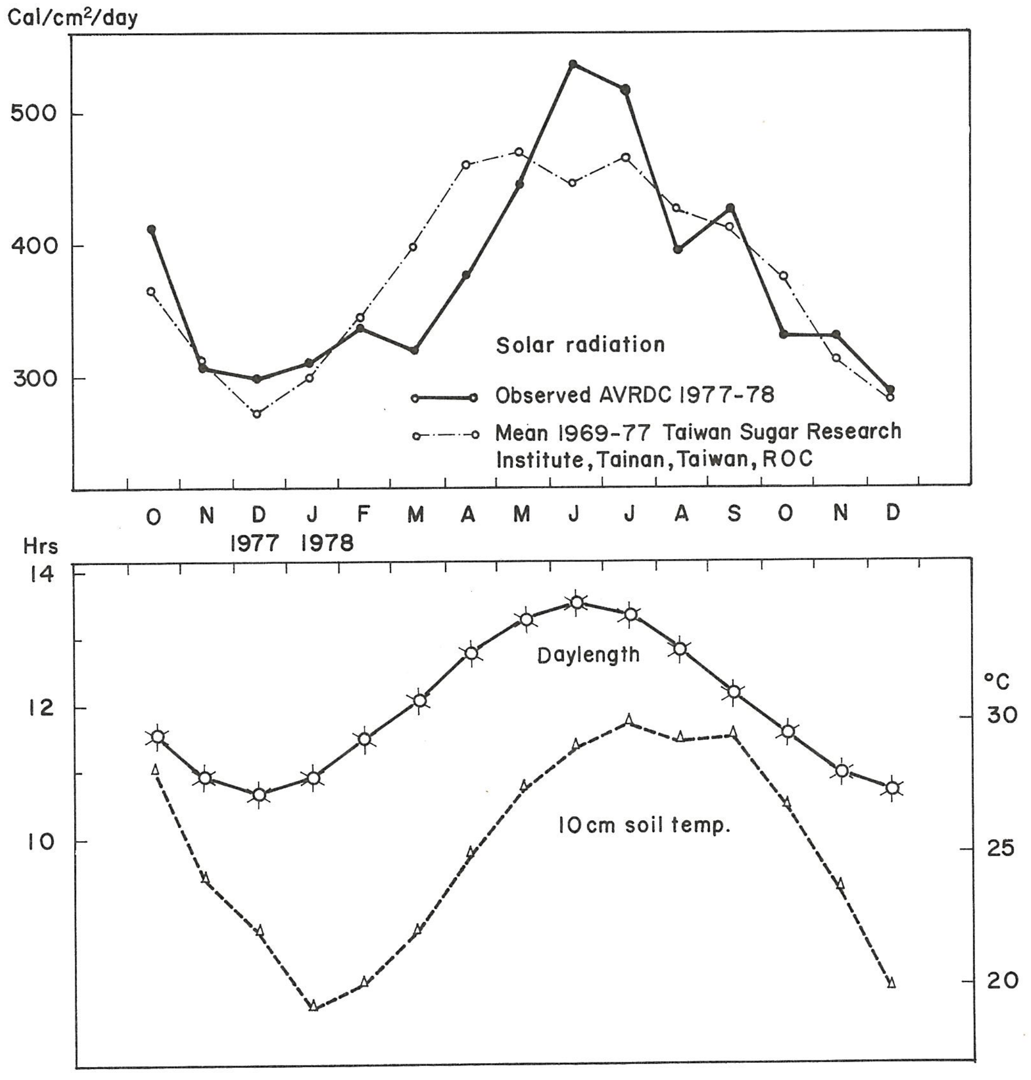


Fig. 5. Solar radiation, daylength and soil temperature, 1977-78, AVRDC.

flooding on 70% of the experimental fields. Many plants were damaged by waterlogging, particularly tomato.

Tomatoes that set fruit at temperatures above 22°C are rated "heat tolerant". Screening for heat tolerance is conducted during months when air temperatures are above 22°C. In 1978, this was from May through Sep (Fig. 4). Soil temperatures remained above 22°C from Apr through Nov (Fig. 5)

Soil

A total of 52 surface soil samples were collected from the AVRDC Experimental Farm and analyzed in 1978. The results are summarized in Fig. 6. The observed concentration of P_2O_5 and Mg were slightly above the recommended levels. The mean K_2O concentration was within the recommended range. Available N fell farthest below the recommended levels. Thus, adequate nitrogen fertilization is most critical to good crop production on the AVRDC Experimental Farm.

The mean pH value was slightly above optimum and the CEC was below the recommended level. The mean EC was below the lower limit of the acceptable range, indicating a relatively low salt content in the soil.

Summer Tomato Fruit Quality

We studied the fruit quality of 10 tomato cultivars and breeding lines in a summer trial. The properties of fruit harvested from Jun to Nov were analyzed. Ripe color was poorer than in the cool season. Summer tomato has lower pH and more titratable acidity than winter fruit. The total soluble solids content was higher in the summer season.

Seasonal Tomato Planting

Tomato breeding line CL11d-0-1-2-0 was planted at approximately 6 week intervals throughout the year. The Dec 20 plantings produced the highest yield (Fig. 7). However, both total revenue and net return were highest for the Dec 14 planting.

Fruit ripening in the hot season began 11 days earlier than in the cool season, but required approximately the same time to complete ripening (Fig. 8). Fruit drop at all stages in the hot season was higher than in cool weather. Harvesting in the breaker stage in the summer would reduce fruit loss due to dropping by 67%.

Pesticide Persistence in Tropical Soils

We started in 1974 a 4-year study of the persistance in the soil of selected insecticides and their potential for translocating into edible plant parts in harmful quantities. We used two organochlorine (DDT and dieldrin), two organophosphorus (fonofos and phorate) and one carbamate (carbofuran) insecticides. We applied organochlorines at a rate of

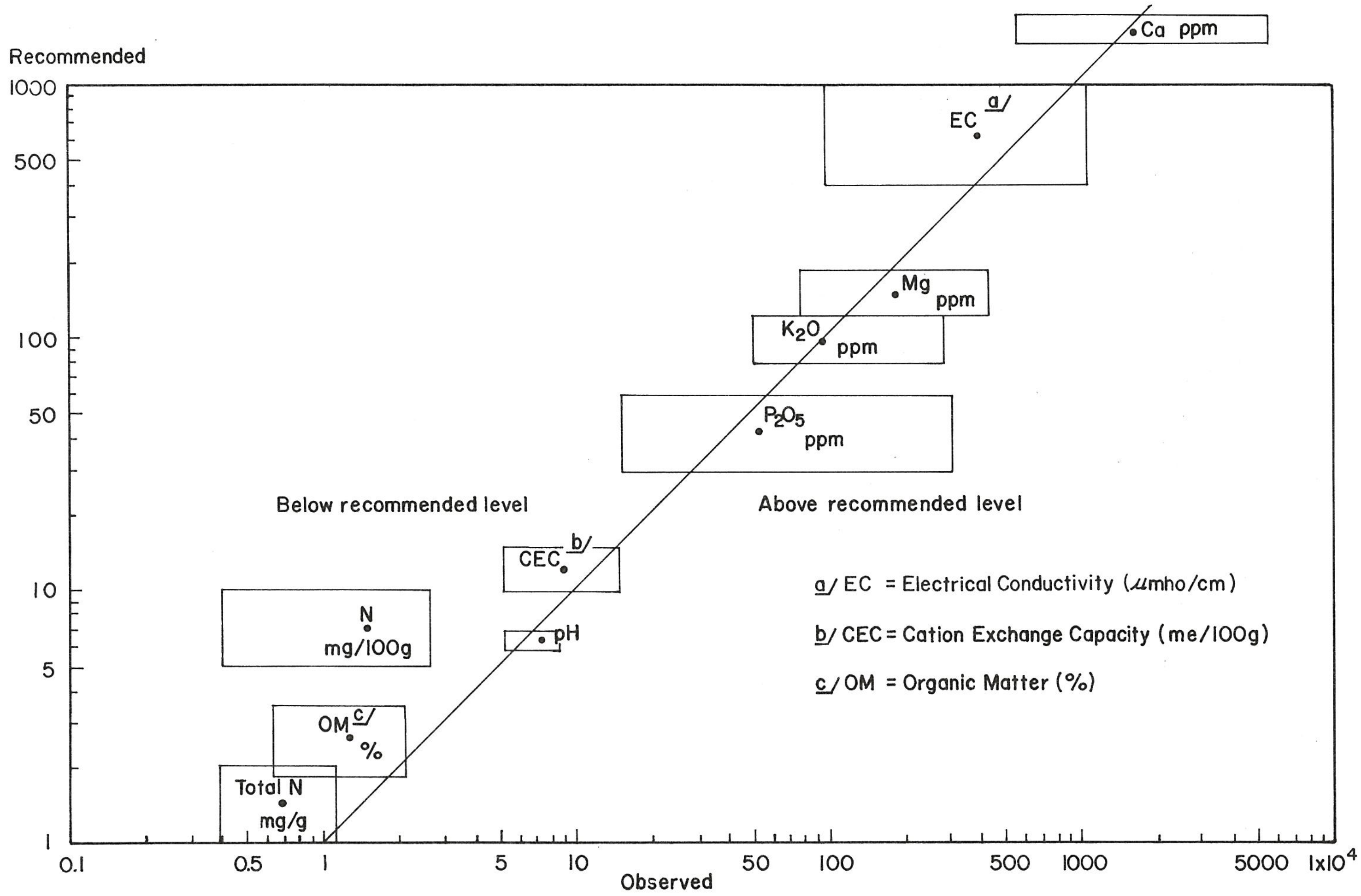


Fig. 6. Recommended and observed soil properties on the AVRDC Experimental Farm, 1978. Recommended levels based on requirements of 6 AVRDC crops. Observed values are means and ranges of 52 soil surface samples collected and analyzed in 1978. Available levels of N, P_2O_5, K_2O, Ca and Mg are indicated.

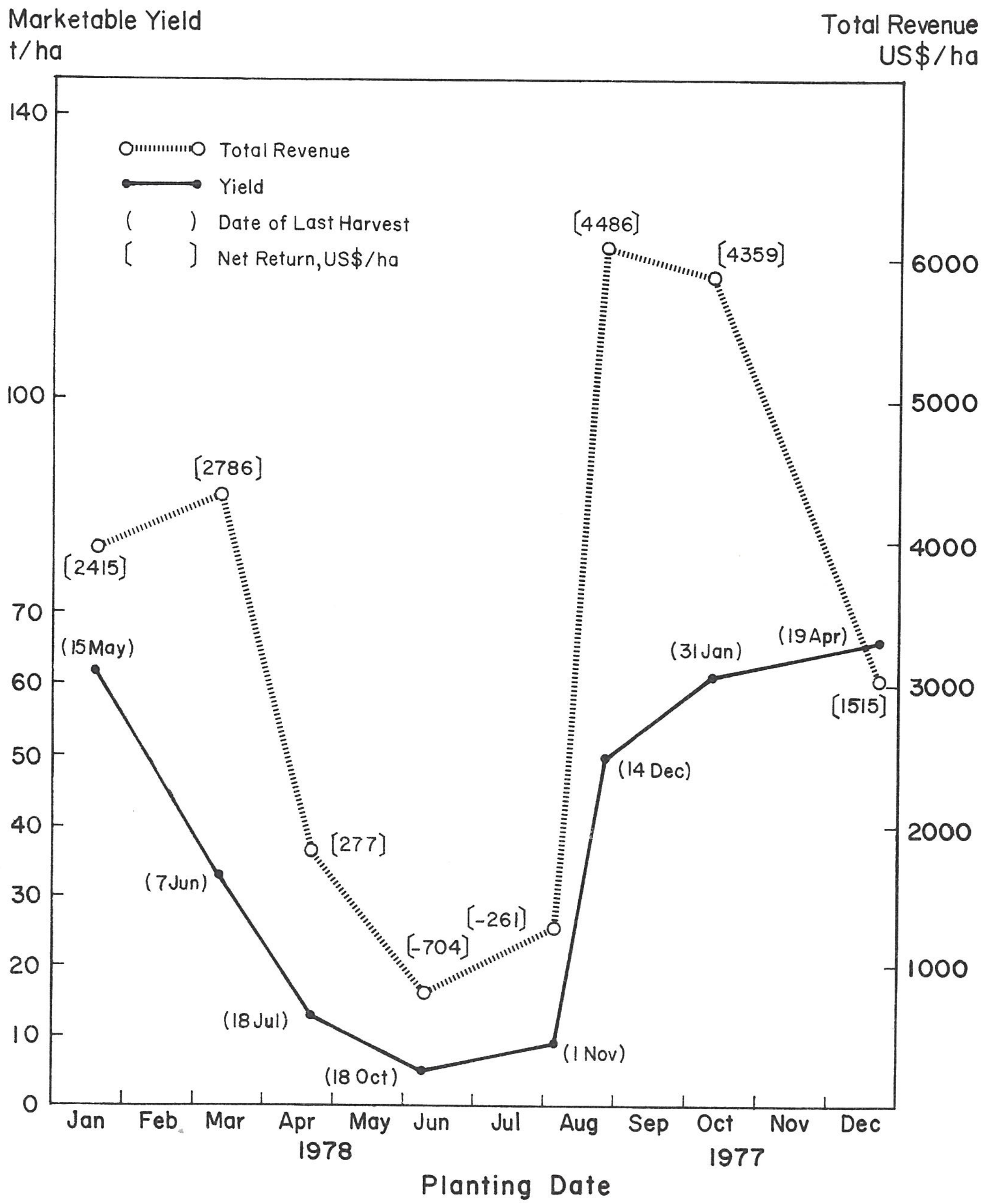


Fig 7. Plot of marketable yield and total revenue of tomato breeding line CL11d-0-1-2-0 by planting date, 1977-78, AVRDC.

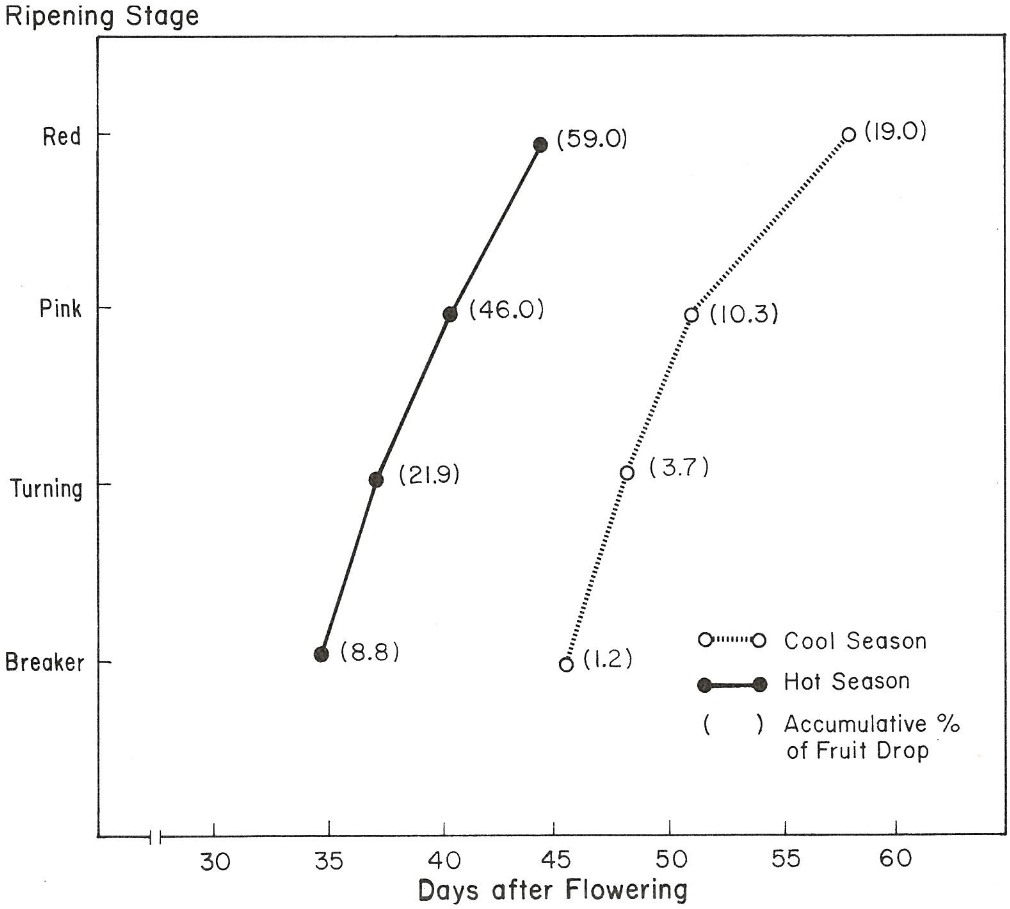


Fig. 8. Tomato ripening sequence and fruit drop in hot and cool seasons. 1978, AVRDC.

5 kg ai/ha and others at a rate of 10 kg ai/ha twice a year (spring and fall) for 4 years. The insecticides were sprayed or broadcast and worked into 15 cm depth. We analyzed soil samples from 15 cm depth for residues. We grew sweet potato following each application and white potato only after fall application and measured the insecticide residues in edible plant parts.

The results are summarized in Fig. 9 (A-E). Residues of DDT declined by 20% and that of dieldrin by 25% in the first Dec to Apr months. There was no significant accumulation of DDT residues the following May to Oct months or after three years. Dieldrin degraded more slowly than DDT, accumulating especially during Nov to Apr. Only 9% of the applied DDT could be recovered of the end of 4 years, but we could recover 35% of dieldrin. Organophosphorus and carbamate insecticides degraded much more rapidly. After four years, less than 1% of these chemicals could be recovered.

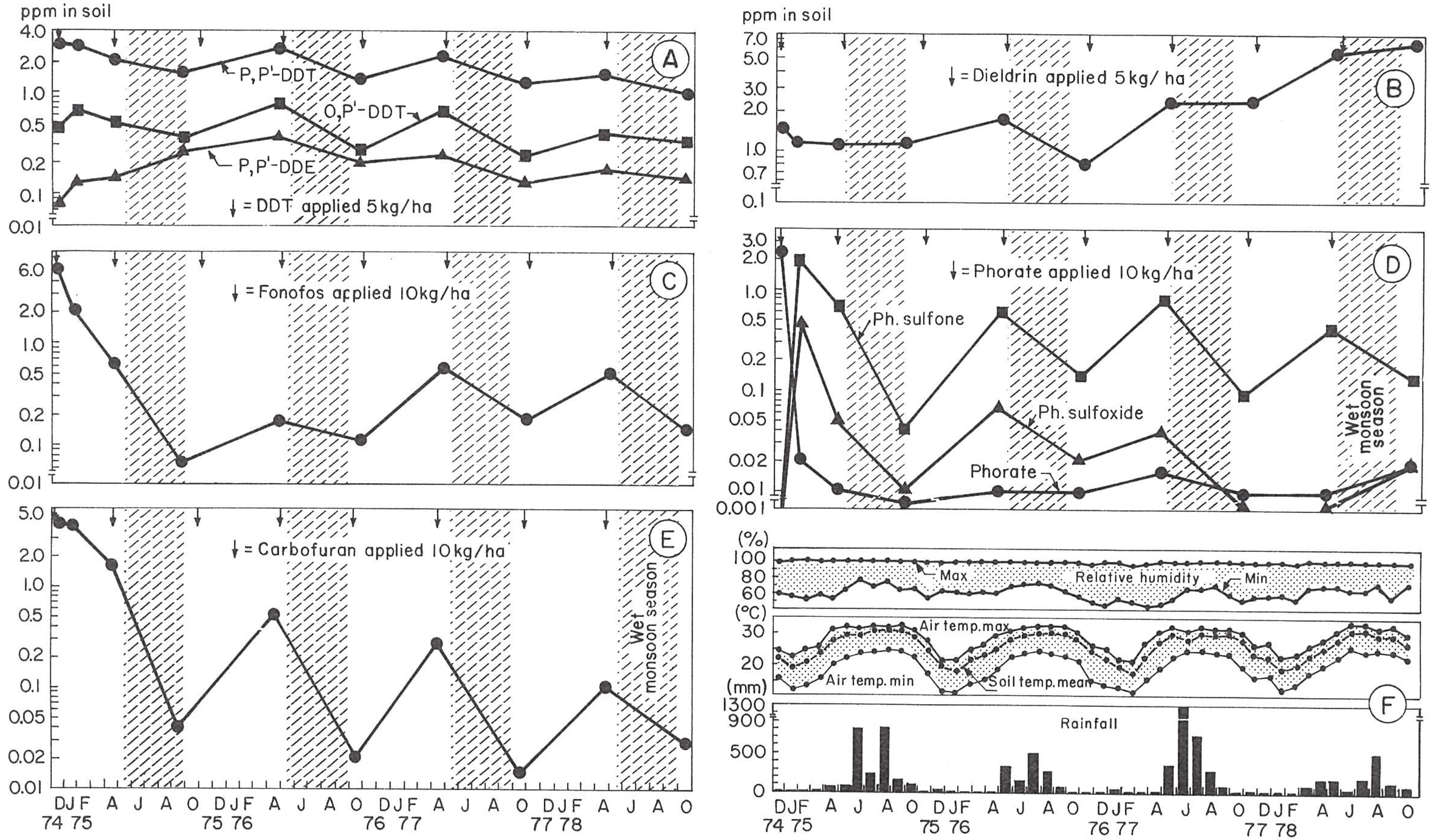


Fig. 9. (A-E) Persistence of different insecticides during 4 years. (F) Temperature, relative humidity and rainfall during the experimental period.

Climate appeared to be a decisive factor in the rapid degradation of the insecticides (Fig. 9). Insecticide degradation was faster during the hot and rainy May to Sep months (Avg. precip. 1545 mm , mean temp. 28.1^{o}C) than during cool and dry Oct to Apr months (Avg. precip. 226 mm, mean temp. 19.8^{o}C).

The range of insecticide residues absorbed from insecticide-treated soil by 8 crops of sweet potato roots and 4 crops of white potato tubers are summarized in Table 4.

Except for dieldrin no residue levels exceeded the tolerance level established by the United States Environmental Protection Agency (USEPA) for root crops.

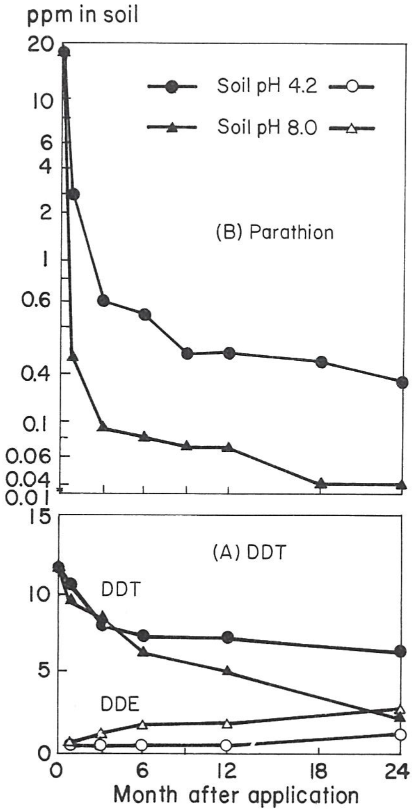
To determine if soil is a factor in the rapid degradation of insecticides, we collected a low pH laterite soil from central Taiwan and confined it in 0.5 m x 0.5 m x 0.2 m wooden cartons. As a check, we also confined our high pH soil in identical cartons. We treated these soils with either an organochlorine insecticide, DDT, or an organophosphorus compound, parathion, and analyzed the residues at various intervals up to two years. It is evident that both classes of insecticides degrade faster in AVRDC soilthan in acidic, a more typical, tropical soil (Fig. 10).

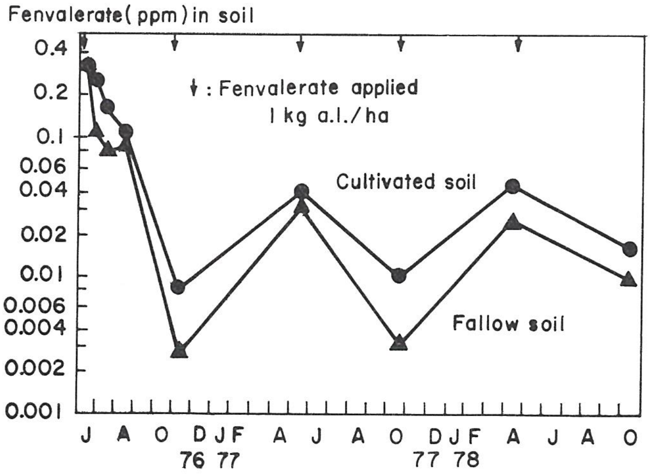
Synthetic pyrethroids are becoming more popular, especially for vegetable pest control, because their high efficacy requires low rates of application. They are likely to become more widely used in the future.

Table 4. Range of insecticide residues absorbed from insecticide-treated soil by 8 crops of sweet potato roots and 4 plantings of white potato tubers, 1975-78, AVRDC.

Insecticide (Active ingredient applied twice per year/ha)	Derivatives	Concentration range in Sweet Potato	Concentration range in White Potato	Permissible EPA limits for root crop
		------ parts per billion (ppb)[a] ----		
DDT (5 kg)	p, p'DDT	30 - 150	30 - 370	1000
	p, p'DDT	10 - 30	30 - 60	1000
	o, p'DDT	10 - 60	30 - 150	1000
Dieldrin (5 kg)		70 -1396	280 -2612	100
Fobofos (10 kg)	Fonofos	ND - 10	40 - 150	100
	Fonofos-oxon	ND	0 - 10	100
Phorate (10 kg)	Ph. sulfoxide	ND	ND - 40	500[b]
	Ph. sulfone	ND - 30	30 - 130	500[b]
Carbofuran (10 kg)		ND - 40	ND - 10	1000[b]

[a]Based on fresh weight data. [b]White potato only. ND = Not detectable.





▲ Fig. 11. (above) Persistence of fenvalerate after repeated soil applications. 1978, AVRDC.

◄ Fig. 10. (left) Degradation of DDT (A) and parathion (B) in two soils. 1978, AVRDC.

We undertook a small project in 1976 to study the behavior of one of the synthetic pyrethroids, fenvalerate (Sumicidin), in soil. We applied 1 kg ai/ha of this chemical to a 10m x 10m plot beginning Jun 1976 and split the plot into two 10m x 5m subplots. We cultivated one subplot and left the other fallow. We followed with two nearly identical treatments (spring and fall) during 1977 and 1978. In the cultivated area we grew sweet potato after each treatment and white potato only after the fall treatments. From year to year there was no accumulation of this compound either in cultivated soil or in fallow soil (Fig. 11). Residue level was consistently lower in fallow soil than in cultivated soil. We could detect no residue of fenvalerate in either sweet potato or white potato in any season.

Survey of Summer Chinese Cabbage Production in Taiwan

The economics staff collected Chinese cabbage production data from 53 producers during the summer in central Taiwan--Changhua and Yunlin districts.

We defined the crop seasons as early summer, from Jun to mid Jul and late summer, from early Jul to mid Sep. In each season the crop

Table 5. Comparison of production factors among early, late summer and winter Chinese cabbage, and rice in Taiwan, 1978, AVRDC.

Crop Season	Summer Chinese Cabbage[a] Early[b] (n=24)	Summer Chinese Cabbage[a] Late[c] (n=29)	Winter Chinese Cabbage[d]	Second Rice[d]
Yield (kg/ha)	9,234	10,665	41,945	4,129
Price (US$/ton)	139	301	31	249
Revenue (US$)	1,187	3,209	1,297	1,064
Expenses (US$)	2,106	2,508	1,394	1,139
Capital (US$)	855	871	710	556
Labor (US$)	1,251	1,637	684	637
Net return (US$)	-919	701	-97	-128
Farm income (US$)	335	2,189	311	189

[a]Survey data, 1978. [b]Planted Jun 1-Jul 15. [c]Planted Jul 16-Sep 15.
[d]Reports on Agricultural Products' Production Costs by PDAF, 1978.

is hurt by high temperature and/or excessive rainfall during at least part of the critical growth stage. The most important conclusions are:

1. Summer Chinese cabbage production is more profitable than winter production and more profitable than its major competing crop, rice (Table 5).

2. Late summer Chinese cabbage production produces more net and farm income than early summer production because of its higher price (Table 5).

3. The preferred cultivars in both the early and late seasons were "Hei-yeh" and "Chiao-p'ei".

4. Farmers consider the most serious summer production problem to be water-logging, caused by excessive rainfall and inadequate drainage. Moreover, 20% of early season producers face temperature damage at the head formation stage.

5. Farmers preferred round to oval Chinese cabbage and white with a little green to ones of other colors. Ideal size was about 1 kg.

6. Compared with last year (1977) over 50% of farmers increased their planted area of summer Chinese cabbage. Crop rotation was practiced by 65% of farmers.

MANAGEMENT

Tomato Maximum Input Yield Potential Trials

We conducted a yield potential trial using processing tomato cultivar CL143-0-10-3-0 at AVRDC. We transplanted seedlings in 1 m-wide beds at a density of 10 plants/3 m^2 with a space of 30 cm between plants on Sep 5. We followed the suggested cultural practices for tomato at AVRDC. The highest yield was 81 t/ha in total fruit yield and 71 t/ha in marketable yield.

Response of Tomato Yield and Leaf Nitrogen Content to Nitrogen

Leaf samples of three intermediate tomato cultivars planted in the winter were analyzed for nitrogen content 60 days after transplanting. Four levels of nitrogen ranging from 1 to 240 kg/ha were applied. Regression analysis indicated that there was a significant correlation (r=0.88) between marketable yield and leaf nitrogen content.

Drip Irrigation of Tomato

From Oct to Apr the monthly rainfall in Shanhua averages about 31 mm/mo. During this period irrigation is needed for vegetable crop production. Drip irrigation offers a way of conserving available irrigation water and of reducing stress on crops due to high salt concentration and high soil-moisture tension. To justify the installation cost, its use is limited to high value cash crops. Among the AVRDC crops, tomato was selected for investigation of the benefits of drip irrigation over rainfed or furrow irrigation.

JCRR funded a study on drip irrigation of tomato, which is conducted jointly by AVRDC, the Chianan Irrigation Association, and the Agricultural Engineering Research Center. Results from the first trial (Dec 31, 1976 - May 23, 1977) indicated that drip irrigation increased yield by 40% over furrow irrigation. In a second trial (Jan 11 - May 9, 1978), no significant differences in yield among the treatments were observed. The difference in the results is probably due to differences in precipitation during the trials. During the first trial, precipitation was only 60 mm, less than one half the 20-year average (124 mm); but during the second trial there was 281 mm of rain.

Chinese Cabbage Cultivation

Disc plowing followed by disc harrowing -- hypothesized to be superior to rototilling as a means of land preparation for Chinese cabbage production -- failed to produce any significant difference in yield. One month after transplanting there was no difference in soil hardness or specific soil bulk density.

Yield Response of Chinese Cabbage to Urea Applications

Increasing levels of nitrogen significantly increased marketable yield of Chinese cabbage Acc. 141 (Fung-Luh) in a trial conducted Oct - Dec. The highest marketable yield was 66 t/ha, in the treatment with 180 kg/ha of nitrogen applied as urea.

The dry matter content of the inner leaves decreased with the application of additional nitrogen increments. The total amount of nitrogen applied was more important than the method of application (foliar, soil or timing of the application) with the exception of the treatment with half foliar and half soil applications, which had higher innerleaf dry matter content.

Varietal Response of Sweet Potato Yield and Protein Content to Nitrogen

Our soil scientists found significant differences among nitrogen levels for root yield, protein content of roots (Fig. 12), and total vine weight. Cultivar AIS 209-3 had the highest yield at all nitrogen levels and had the highest mean protein content.

Sweet Potato Management Studies

There was a highly significant correlation between root yield and nitrogen level (Fig. 13). The yield trend suggests that the yield may respond to further increments in nitrogen application.

Ammonium sulfate applied at a rate of 80 kg of N/ ha gave the highest yield. The sulfate ion may lower the soil pH, thus providing a better environment for root growth.

A greenhouse study on the effect of soil compactness, soil type, and cultivar on sweet potato root initiation and enlargement indicated that there is a highly significant interaction between soil type and compactness. In sand, compaction increased yields. In compact soil, roots continued to enlarge significantly after 110 DAP but not in non-compacted soil.

In a field planting to compare different sources of planting material, highest marketable yield came from cuttings taken from a secondary nursery and lowest came from direct seeding of roots.

Soybean Management Studies

Our previous research indicated that water logging of soybean within 2 days of planting greatly reduced emergence and that the emergence rate could be increased by fungicide seed treatment prior to planting.

In trials planted in Sep, waterlogging of cultivar Shih-shih reduced yield by 51% and fungicide treatment increased yield by 100%. The yield

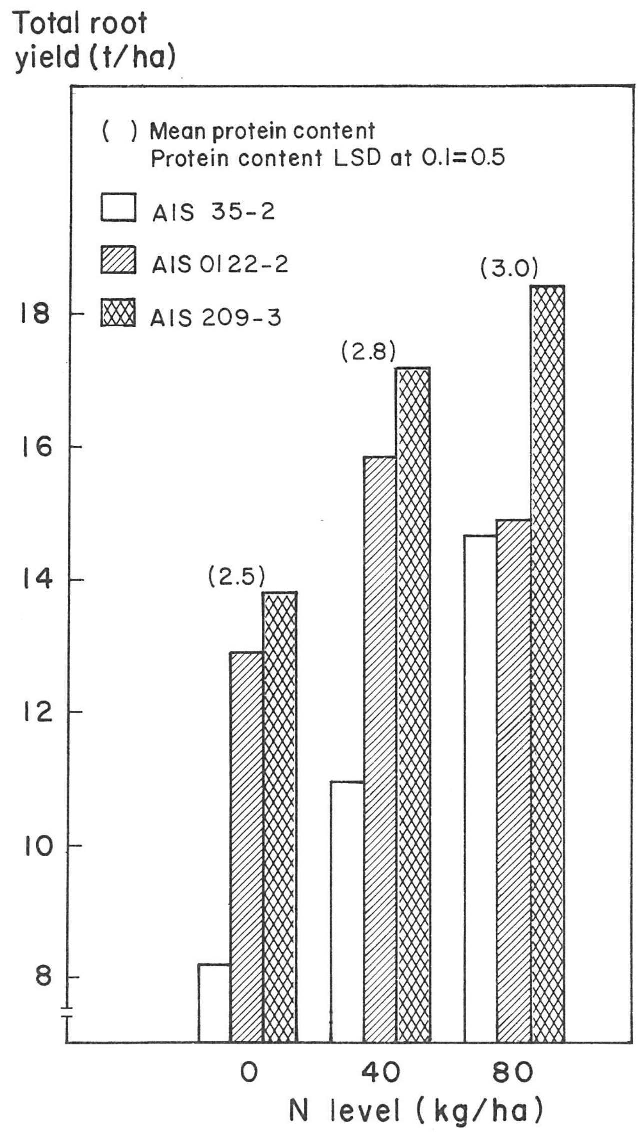


Fig. 12. The yield and protein content response of 3 sweet potato cultivars to nitrogen application. 1978, AVRDC.

of cultivar "Palmetto" was not affected by waterlogging or seed treatment.

We planted soybean in a paddy field shortly after rice harvest to study the effect of tillage and irrigation on yield. Irrigation did not influence yield. Tillage tended to lower yield (Table 6). Therefore,

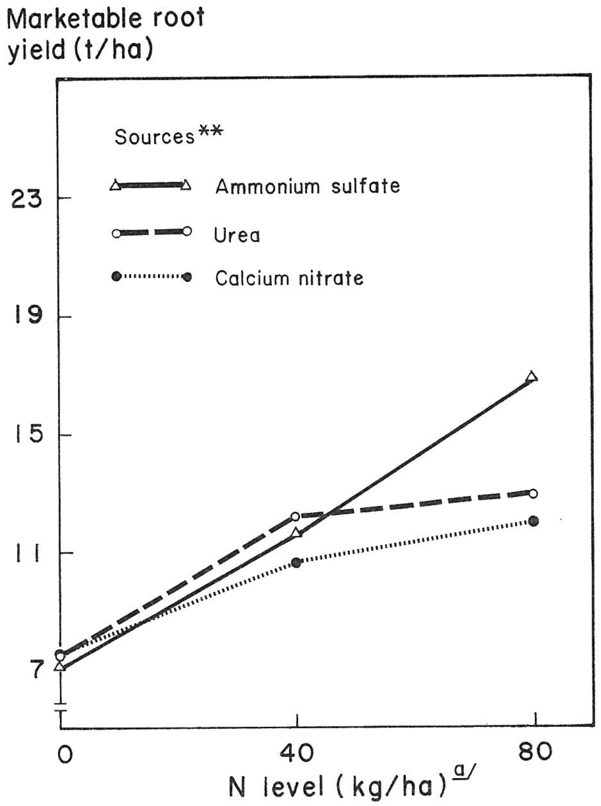


Fig. 13. Response of marketable root yield of sweet potato (AIS 35-2) to nitrogen levels and sources. 1978, AVRDC.
Note: For all treatments P_2O_5=60 kg/ha, K_2O=200 kg/ha.
[a] Interaction between nitrogen level and nitrogen source.**

Table 6. Yield response of post-rice soybean to irrigation and tillage, 1978, AVRDC.

	Tillage[b]			
	with	without	Mean	
	---------- kg/ha ----------			
Mean of irrigation treatments[a]	1980	2206	2094	
				ns
No irrigation	2020	2050	2080	
Mean	1980	2180		
LSD 5%	83			

[a]The difference between five irrigation treatments beginning at 15 day intervals in which 50 mm of water was applied every 15 days was not significant. [b]Tilled plots rotovated twice. Soybean (Shih-Shih) seeds were drilled into tilled plot and dibbled in the no-tillage plot.

Table 7. Mungbean yield response to method and level of peat applied, 1978, AVRDC.

	Control	Peat 10 t/ha		Peat 20 t/ha	
		Band	Broadcast	Band	Broadcast
	t/ha				
Yield	1.22	1.52	1.28	1.49	1.37
LSD 5%	0.10				
1%	0.14				

Harvest plot size: $12m^2$, 4 replications. N, P_2O_5 and K_2O were applied at a rate of 30, 60, and 100 kg/ha, respectively.

no-till rice stubble culture planted immediately after rice can produce good yields utilizing only residual soil moisture.

Foliar Spray Fails to Influence Mungbean Yield

A foliar spray containing N,P,K, and S had little or no effect on mungbean yield. However, mungbean plots in a field with low fertility which were sprayed with the highest level of foliar chemicals had significantly higher 1,000 seed weight.

Mungbean Cultural Management

Peat is found in a very poorly drained area in mid-Taiwan. We co-operated with Taiwan Fertilizer Company to evaluate the effect of peat dried and powdered) on crop yield.

We adopted a RCB design with combinations of peat levels (10 and 20 t/ha) and application methods (band and broadcast) for the treatments. We planted mungbean PHLV18 (Acc. V2184) at a plant population density $40/m^2$ on Sep 6, 1978. The plants developed normally until damaged by strong wind and heavy rainfall at the pod filling stage. We harvested twice on Nov 9 and 17.

Although the plants were damaged, the yield response to the treatments was still obvious. (Table 7) The band application of peat increased yields significantly either at 10 or 20 t/ha. Broadcast application at 10 t/ha gave no yield improvement. However, none of the peat treatments are currently economical in Taiwan where mungbean seed sells for 83¢/kg and peat costs about US$67/t.

In a herbicide evaluation trial only butralin selectively controlled the dominant weed Chenopodium album. At 3-4.5 kg a.i./ha butralin treated plots gave yields equal to the weed-free check.

Mungbean is a sensitive crop with unstable yield, susceptible to many pathogens and pests, and dramatically influenced by environment. Varietal performance is often inconsistent, especially on small farms, where little plant protection can be provided. Varietal blends, which are characterized by diversified genetic composition, have been used successfully to stabilize yield of many self-pollinated crops. Several combinations of 4 accessions were planted in spring and summer trials in order to evaluate mungbean varietal blend. The combination of equal amounts of V2184 and V3476 proved to be the most stable and high yielding This combination ranked 2 and 3 in spring and summer trials respectively.

Methodology for Evaluating Economic Aspects of Management

Mungbean Production

Our crop management specialists have concentrated on developing methodology for translating information on the effect of management practices and cultivars into a form that can be used for making recommendations to farmers.

Throughout Southeast Asia, extension workers complain that they lack the information needed to make decisions on cultural practices.

Using data on mungbean and tomato production systems collected from farm surveys and information obtained from local farmers working on the AVRDC Farm, we selected areas of management for investigation. Seventy-five percent of the farmers growing mungbean in Taiwan use pesticides. In 1978 pesticide application costs (chemicals + labor) averaged 19% of mungbean production inputs. The AVRDC farmer who invested more in pesticide inputs had higher revenues and income.

We selected three cultivars, one of which is resistant to Cercospora Leaf Spot and another the locally preferred cultivar, to be tested with null, moderate and high application rates of insecticide and fungicide in experiments planted in Aug 1977 and Mar 1978. For increasing levels of insecticide the number of beanfly larvae and plant damaged by beanflies decreased and yields increased. Increasing levels of fungicide application decreased disease incidence and increased yields. This was most evident in the last harvest.

To translate these results into a form that can be used for recommendations to increase the benefit to the farmer, we first calculated the net benefit for different treatment combinations. (Net benefit of a particular combination equals the product of yield and price less variable cost). Then relationships between management levels and the agro-economic data can be represented by models (mathematical equations) as in Table 8 or by graphs (Fig. 14). Note that if the farmer has no extra cash for inputs, then local cultivar V 2808 would give the highest net benefit, (i.e. US$430/ha). On the other hand, if the farmer has as little as US$46/ha for investment in inputs he should use cultivar PHLV 18, V 2184, and invest in 2 applications of fungicide, which would yield a net benefit of US$610/ha.

Summer Tomato Production

Studies at AVRDC led to the adoption of summer cultural practices for tomato which include raised beds to reduce flooding and improve drainage, compost to improve aeration and nutrient availability, and rice straw mulch to prevent soil erosion and compaction.

To evaluate these suggested practices, summer tomato production trials were conducted in 1977 and 1978 on two soil types (sand and loam). Trials were planted in May (early wet season) and Aug (late wet season). To simulate flooding conditions which occur frequently in the wet monsoon season, main-plot treatments were with and without excessive water. Sub-plot treatments were 2 cultivars -- AVRDC breeding line CL11d and White Skin, a popular local cultivar, which requires staking, pruning, and fruit setting hormone. The sub-subplot treatments were compost -- with and without. Yields for the early wet season were lower than for the late wet season plantings. Yields on loam were generally higher than those on sand, but reduction of yield due to excessive water was less on sand. The yield of CL11d averaged 3 and 1.4 times that of White Skin in the early wet season and in the late wet season, respectively. In both seasons, these were highly significant increases over the local cultivar.

On the local market, White Skin commands a higher price (US$264/t) than does CL11d (US$130/t). In the late wet season, a 30% increase in net benefit for White Skin over CL11d was significant on loam soil; but in the early wet season planting, a 297% increase in net benefit for CL11d over White Skin was highly significant. The addition of 20 t/ha of compost produced highly significant increases -- up to 25 t/ha and US$2,600/ha -- in both yield and net benefit during both seasons and on both soils.

Table 8. Models relating yield, net benefit, beanfly damage, Cercospora leaf spot and powdery mildew rating to insecticide and fungicide input level, for three cultivars; 1978, AVRDC.[a]

Cultivar[b]	Fall, 1977	Spring, 1978
All	Y** = 1609 + 227**F + 134**I	Y* =816 + 70* F + 53I
C_1	Y* = 1459 + 255* F + 168 I	Y** =806 +210**F + 74I
C_2	Y^{+} = 1964 + 109^{+} F + 81 I	NS
C_3	Y** = 1405 + 318**F + 153**I	NS
All	NB* = 821 + 79* F	NS
C_1	NS	NB* =396 + 55* F
C_2	NS	NB** =403 - 58**F
C_3	NB** = 931 + 163**F	NS
All	BFD** =25.4 -5.5**I	-
C_1	BFD** =28.6 -7.2**I	-
C_2	BFD** =17.1 -5.7**I	-
C_3	BFD^{+} =30.4 -3.6^{+} I	-
All	CLS** =53 - 23**F	CLS**= 38 - 16**F
C_1	CLS** =63 - 30**F	CLS**= 44 - 21**F
C_2	CLS** = 6 - 2**F	CLS* =1.7 -0.7* F
C_3	CLS** =92 - 38**F	CLS**= 68 - 26**F
All	NS	PM = 68 - 23**F
C_1	NS	PM = 98 - 32**F
C_2	NS	PM = 40 - 16**F
C_3	NS	PM = 66 - 22**F

[a]VARIABLE (ABREVIATION) UNITS: Yield (Y) kg/ha; Net benefit (NB) US$/ha; Beanfly damage (BFD) Plants damaged %; Cercospora leaf spot rating (CLS Plants infected %; Powdery mildew rating (PM) Plants infected %; Insecticide (I) and Fungicide (F) 0=zero protection, 1=moderate protection, 2=full protection. [b]Cultivar (designation): V 2184 (C_1), V2273 (C_2), V 2808 (C_3).

**P<.01
* P<.05
\+ P<.10
NS = non-significant

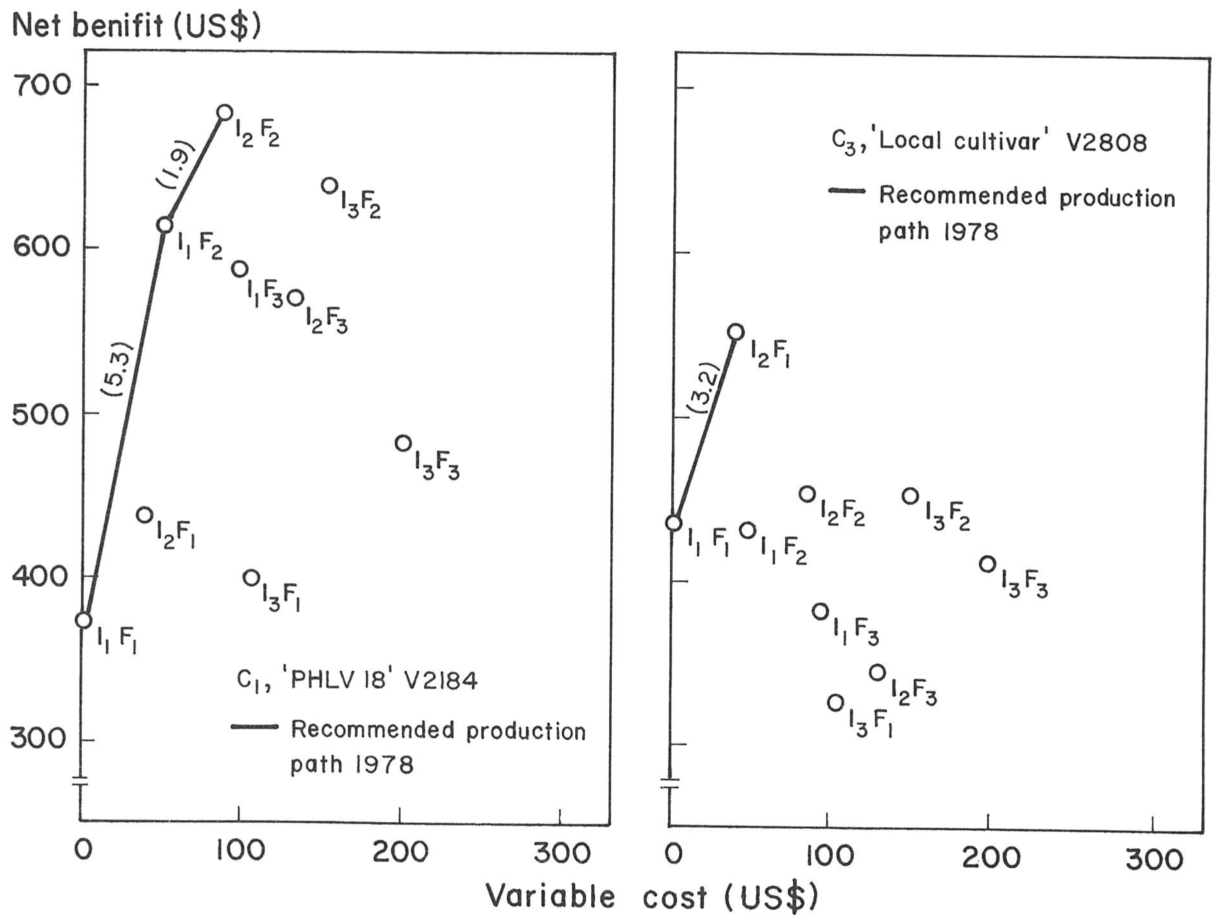
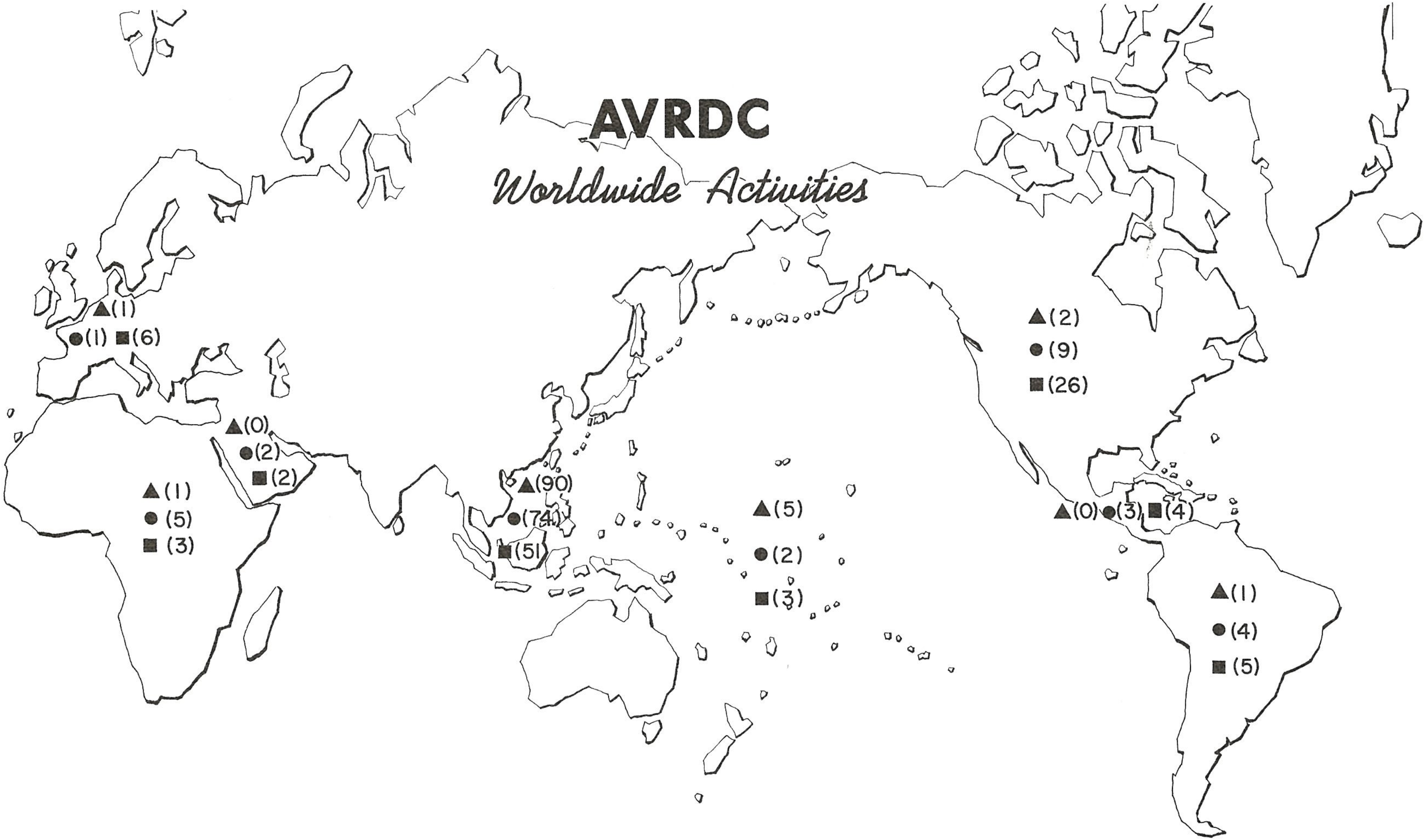


Fig. 14. Relationship between variable cost and net benefit at different insecticide and fungicide levels for C_1, 'PHLV 18' and C_3 'LOCAL CULTIVAR', planted Mar 1, 1978. Subscripts--1, 2, and 3--on I and F represent null, moderate and high levels of protection. Numbers in parenthesis represent change in net benefit with change in variable cost ($\Delta y/\Delta x$).

AVRDC

Worldwide Activities



TRAINEES since 1973 ▲(% of Total)

SEED Packets Distributed since 1973 ●(% of Total)

PUBLICATIONS Mailing List, '78 ■(% of Total)

OUTREACH PROGRAM

PHILIPPINES

The Philippines Outreach Program, now fully funded by the Philippines Government, has been assured of financial support through 1982. Funds will be provided by the Bureau of Plant Industry(BPI) and the Philippines Council for Agricultural and Resources Research(PCARR).

Most of the experiments in 1978 were conducted at the outreach program headquarters in the Economic Garden, near Los Baños, (Elevation 15m, Latitude 14°10'N and 121°15'E Longitude). The results reported here are from the Economic Garden unless otherwise noted. In Los Baños, the wet monsoon season occurs from May through October. The remainder of the year is relatively dry. The soil at the Economic Garden station is a clay-loam with a mean pH of 5.2. Temperatures were highest in May (max 33.9°C, min 23.8°C) and lowest in January (max 28.8°C, min 21.2°C). Six typhoons occurred between August and October, bringing the total precipitation in those months to 1432 mm, or over 60% of the annual rainfall in 1978 (2365.mm).

Soybean

Dry season trials were severely infected with soybean rust and moderate levels of bacterial pustule. As a result the yields during dry season were very low. The entries in the advanced yield trial, planted on April 28, showed no rust infection and few bacterial pustule symptoms. Line 50231-2-7-9 (G83/G2573) yielded 3.8t/ha, the hightest for the trial.

In a trial planted June 2 at the La Granja Experiment Station, AVRDC soybean breeding lines 50225-1-6 (KS473/SJ2) and 50136-3-11 (TN3/SJ2) had the highest yields of 2.4 and 2.3 t/ha, repectively. In another trial at La Granja, planted August 1, AVRDC breeding line 50218-8-8-B (KS737/G2120) yielded 3.9 t/ha.

Mungbean

Some 265 early generation progeny of crosses made at AVRDC were planted in an observation trial June 23. Selection of 28 early maturing entries was made for further evaluation. AVRDC breeding lines in a preliminary Yield Trial planted Jan 23 had less infection of powdery mildew and virus. Yields ranged from 1.3 to 1.5 t/ha, but no entries had yields significantly different from the check cultivars. The wet season Preliminary Yield Trial, planted June 22, had poor germination and stand. No usable data were obtained. However, in an Advanced Yield Trial planted on the same date (June 22) VC1160-22-B-2B yielded 1.3 t/ha and VC1000-45-B-10-7-1-B was least affected by *Cercospora* leaf spot.

The yields in the 7th International Mungbean Nursery ranged from 380 kg/ha for V3484 to 1170 kq/ha for V3476 (CES1D-21). AVRDC cross VC1089-B-29-3B-2-2B (ML3/Phil Coll. 1) appeared most promising of the 20 entries in overall performance, including yield and resistance to *Cercospora* leaf spot. However, VC1168-2B-7-2B (CES59/ML5) had the least *cercospora* leaf spot infection.

Blackgram

A preliminary yield trial with 70 blackgram entries planted Jan 4 had a mean yield of 1.4 t/ha. The highest yielding entry was BG3005, with 2.5 t/ha in 71 days. The wet season trial of the same material was severely damaged by typhoons. However, BG3034 managed to yield over 1.3 t/ha in 75 days.

Twenty elite blackgram lines were evaluated in dry and wet season trials. BG3110 was the highest yielding entry in the dry season trial with 1.2 t/ha. BG3115 was outstanding in the wet season, yielding 1.9 t/ha.

Heavy rains (i.e. nearly 1300 mm, Aug-Oct) favored development of Cercospora leaf spot and bacterial pustule in the wet season trials at La Granja. Consequently, yields were very low. For example, the line with the highest wet season yield at Economic Garden, BG3115, produced only 378 kg/ha at La Granja and was ranked second highest in yield.

Sweet Potato

The outreach staff distributed sweet potato cuttings to the Bureau of Plant Industry's experiment stations, the Visayas State College of Agriculture, the University of the Philippines at Los Baños, Catanduanes State College, cooperators in Minidoro Province and several private growers.

Sweet potato accession PI 318548 yielded 52 t/ha compared to 34 t/ha for the check cultivar, BNAS, in a trial planted Aug 18, 1977, and harvested Feb 8, 1978 (176 days).

Tainung New No. 10 yielded 40 t/ha, nearly 4 times the check cultivar, BNAS, in a trial planted Oct 21, 1977, and harvested after 177 days. Kadja 38 produced the highest yield of 59 t/ha in a trial planted Dec 7, 1977, and harvested 139 days later.

Tomato

Five AVRDC breeding lines outyielded the local check, Pope, but not significantly, in a dry season trial planted in Nov 1977. Pope yielded 48 t/ha and yields of the 4 AVRDC lines ranged from 52-56 t/ha. However, Pope outyielded all the AVRDC Single Seed Descent entries in a trial planted Jan 4. Pope yielded 21 t/ha in the latter trial.

Chinese Cabbage

In a Chinese cabbage trial planted Nov 18, 1977, AVRDC inbred line 76M(2)-20 had the highest yield of 47 t/ha. The check cultivar Yuan Pao #2 yielded 44 t/ha. Line 76M(2)-16 was least infected with bacterial soft rot. All the entries in the wet season trial, planted Aug 8, had low yield due to severe weather. However, AVRDC line 76M(1)-4 yielded 14 t/ha in 50 days.

KOREA

The Korean Outreach Program is based at the Office of Rural Development(ORD) in Suweon, just outside Seoul. In ORD, the Horticultural Experiment Station is responsible for research on white potato, tomato and Chinese cabbage, while the Crop Experiment Station works on soybean, mungbean and sweet potato crop improvement. The temperature and rainfall in the Seoul area in the summertime is similar to that found in the hot humid tropics (Fig. 1). Therefore, some of the materials being developed by AVRDC may be suitable for Korean summer production.

Rice is, as in all Asian countries, the most important crop in Korea. The "green revolution" has arrived in Korea. Rice yields are the highest in Asia and the country is self-sufficient in rice. Now emphasis is on achieving self-sufficiency in other cereal and legume crops. Korea imports a large portion of its wheat, barley, corn, and soybeans (Table 1). Barley is less popular among the cereals and, with more rice available, barley consumption may drop to equal production. Therefore, research is being focused on increasing corn, wheat, and soybean production. With limited arable land and growing season, increased production primarily depends on raising crop productivity (i.e. yield/ha /da). Self-sufficiency in soybean is within reach, requiring only a 50% increase in present yield levels.

Soybean

AVRDC is helping Korean scientists accelerate the generation advance of soybean breeding lines. This year, 500 F_3 soybean progeny were planted at AVRDC in February. The seed harvested in Shanhua was flown to Suweon and entered in summer yield evaluation trials. The seed of advanced lines Suweon 95 and Suweon 97 was multiplied at AVRDC to permit a wider scale of evaluation in the Korean growing season. These

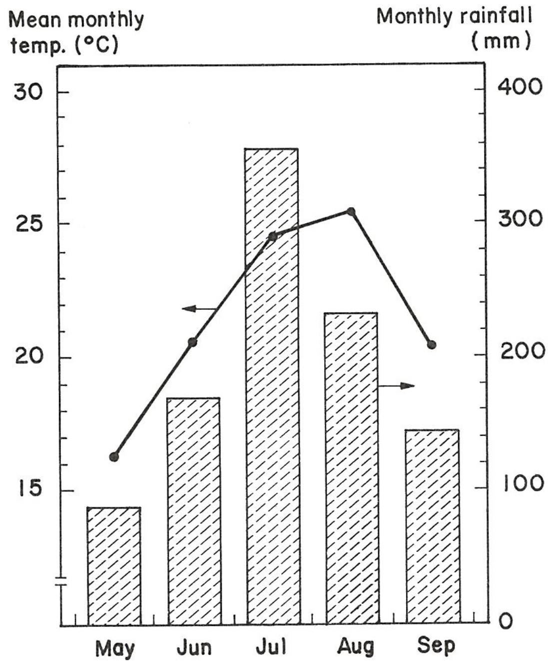


Fig. 1. Typical temperature and rainfall during summer, Seoul, Korea, 37°34' N latitude. (Average of data from 1931-1960.)

Table 1. Major crop production statistics for S. Korea, 1977.

Crop	Planted area	Yield	Total production	Imported
	-1000 ha-	-t/ha-	-1000 t-	-1000 t-
Rice	1230	4.9	6006	0
Sweet potato	77	20.2	1560	0
Barley	515	1.6	813	330
White potato	52	11.4	594	0
Soybean	251	1.3	319	151
Wheat	27	1.7	45	1900
Corn	35	1.7	58	- [a]
Adzuki bean	35	1.0	35	0
Mungbean	8	0.8	7	0

[a]1974 data.

lines have proved the most tolerant of soybean necrotic mosaic virus, one of the most serious diseases limiting yields of soybean in Korea. Suweon 95 and 97 had a mean yield of 2.3 and 2.2 t/ha, respectively, when planted at 9 research stations throughout Korea. The mean yield of the check cultivar was 1.9 t/ha.

Mungbean

Less mungbean is consumed than soybean. Although Korea is self-sufficient in mungbean, yields are low. AVRDC sent 10 mungbean lines to Korea for field evaluation. They were planted at 6 stations in July. Stations in the south had the highest yields. Mean yield of lines CES-1D-21, ML-6, VC1209-3-2-2B-1-2B (ML3 x CES55) and PHLV18 were slightly higher than the check cultivar, Krunggijaerae 5. Yield of these 5 lines averaged 1.2 t/ha, 50% above the mean mungbean yield in Korea. Yields in Suweon were low, averaging 630 kg/ha, due to high disease incidence (i.e. powdery mildew, Cercospora leaf spot and an unknown virus).

The mean yield of the 21 entries in the 7th International Mungbean Nursery planted at Suweon June 16 also was low, 425 kg/ha. AVRDC line VC1089-B-29-3B-2-B had the highest yield of 844 kg/ha.

Chinese Cabbage

Adverse weather plagued the Chinese cabbage trials in Suweon in 1978. However, results were excellent in a trial conducted at Jinju (35^o11'N latitude, elevation 25 m). The line Cheongbang / Yungching 30 Days proved superior. In a trial planted July 20 at Jinju, this cross yielded 68 t/ha. Average heads weighed 1.7 kg, or 52% more than the best commercial cultivar. This line was resistant to the predominantly occurring virus, moderately resistant to bacterial soft rot, but susceptible to downy mildew.

A disease screening trial planted in Suweon June 29 found 7 crosses resistant to soft rot and virus, the most serious diseases for lowland summer production in Korea. The cross Ta Feng Feng Lu x 60 Days produced 5 of the 7 best lines. The other two disease resistant lines resulted from Ta Feng Feng Lu x Cheongbang and Ta Feng Feng Lu x Shimoyazitose.

Approximately 100 plants from each of 33 four-way crosses were planted in Suweon in early August. Nearly 100 selections were made for disease resistance and desirable plant types. The selections are being propagated by axillary bud tissue culture.

Row covers of screen netting were evaluated as a potential cultural method for reducing virus infection by blocking out the aphid vector. The initial results appear promising and economical. Higher production costs were more than offset by higher yields.

Tomato

Fruit rotting due to contact with moist soil severely reduces tomato yields during hot, humid weather in Korea. Higher beds, to improve soil drainage, and staking, to keep fruit from touching the soil, were evaluated in a trial planted May 9, in Suweon. Both treatments significantly improved yield (Table 2). Thirty-nine processing cultivars were evaluated for yield, fruit quality, and disease resistance. Fifteen entries were selected for further evaluation.

The 3 best of 5 crosses, selected for high yield and desirable processing fruit characters last year, were evaluated at the Horticultural Experimental Station and in farmers fields near Suweon. Master No. 3, an F_1 hybrid from Japan which is widely planted for processing in Korea, was used as the check cultivar. The 3 selections outyielded the check by 14 to 25% (Table 3).

Table 2. Yield response of Heinz 1380 tomato to ridge height and staking, Suweon, Korea, 1978[a].

Staking treatment	Yield		
	Bed treatment		
	Low (30 cm)[b]	High (50 cm)	Mean
	t/ha[c]		
No staking	30.4	35.1	32.75
Staking	31.5	48.6	40.05
Mean	30.95	41.85	36.40

[a]All treatments mulched with black plastic film. [b]Conventional bed height used by farmers. [c]Mean of 3 replicates LSD=2.52, transplanted May 9, harvested Jul-Aug.

Table 3. Marketable yield of processing type tomato hybrid, farmers field, Suweon, Korea, 1978[a].

Pedigree/Variety	Marketable yield	Yield relative to check
	-t/ha-	--%--
L-142-TM x L-166-1	54	125
L-166-1 x NFR-1	49	114
NFR-1 x $FTvc_1R$-2	50	115
Master No. 3 (check)	43	100

[a]Sown March, transplanted May, harvested July-August.

In another trial, the F_1 hybrids resulting from Marioka No. 7x L 166-1 and its reciprocal cross outyielded the check, Master No. 3, by 48 to 50%.

A virus and late blight infection severely reduced the yields of a trial designed to evaluated the heat tolerance of the entries. Tamu Chico III and VC-11-1VG had the highest fruit set but yielded only 18.5 and 9.4 t/ha respectively.

In a trial of F_1 hybrids bred for bacterial wilt resistance and heat tolerance the line VC11-1 x Florida MH1 had the highest fruit set and yield, 15.6 t/ha. The susceptibility of this line to late blight and a viral disease lowered its yield.

White Potato

In a herbicide evaluation trial, metribuzin (Sencor), diphenamid (Enide) and alachlor (Lasso) plus linuron (Afalon) gave adequate weed control with little or no damage to the potato plants.

The underground storage of potato, reported last year, is being introduced to Korean farmers by extension staff.

TRAINING

AVRDC staff has trained 164 people from 15 countries in vegetable research and production techniques since the international training program was started in 1974. The program offers six kinds of training for graduate students and professionals in agriculture: Research Intern, Research Scholar, Research Fellow, Production Trainee, Summer Student Trainee, and Special Purpose Trainee. All students carry out at least one experiment or demonstration plot to completion under the guidance of an AVRDC scientist. Classroom lectures in the basic sciences involved are provided by the Training Office and scientific staff.

In 1978, 12 students worked on projects in soybeans, 4 in mungbeans, 16 in tomatoes, 12 in Chinese cabbage, 7 in sweet potatoes, and 5 in white potatoes. One Ph. D. candidate from the U.S. worked on a system for vegetable production during the rainy season, and another studied vegetable consumption among rural pre-school children in Taiwan. Two graduate students from the Netherlands did their required six months of practical field work under the direction of AVRDC scientists.

Crop Commodity Training Program

SOYBEAN

KIM, Ho Il; Res. Intern; Junior Res., Crop Exp. Station, Office of Rural Dev., Suweon, Korea.

Major project: Soybean Seed Increase and Generation Advance of Korean Breeding Lines during Off-Season.

HUNG, Ah Tien; Res. Intern; Chief of Upland Crop Section at Kaohsiung DAIS, Pingtung, Taiwan, R.O.C.

Major projects:

a. Evaluation of 45 Breeding Lines Using Disruptive Seasonal and Locational Selection.

b. The Reponse of High Yielding Breeding Lines to Varying Plant Population Densities.

c. Evaluation of Plant at Flower and Maturity as a Selection Criteria for Yield under Different Plant Population Densities.

ARSYAD, Darman M.; Res. Intern; Research Asst, Central Res. Inst. for agr., Bogor, Indonesia.

Major projects:

a. Varietal Management of Soybean

b. Heritability and Estimation of Gene Number for Days to Flowering, Maturity and Other Characters in Soybean Grown under Short-Day Condition.

LAM, Tak Chak; Summer Student Trainee; Dept. of Agronomy, Natl. Taiwan Univ., Taipei, Taiwan, R.O.C.

Major project: Comparison of Variation in Morphological Characters of Wild and Cultivated Soybean.

CHEN, Che Hong; Summer Student Trainee; Dept. of Agronomy, Natl. Taiwan University, Taipei, Taiwan, R.O.C.

Major project: Hybridization between Wild and Cultivated Soybean

Chang, Shing Yi; Summer Student Trainee; Dept. of Forestry, Natl. Chung Hsing Univ., Taichung, Taiwan, R.O.C.

Major project: Crossing in Soybean Using Hilum Color as a Genetic Marker.

T'SUI, Swu Ing; Summer Student Trainee; Dept. of Agronomy, Natl. Chung Hsing Univ., Taichung, Taiwan, R.O.C.

Major project: Inheritance of Time to Flowering and Maturity under 10-Hour Photoperiod.

FANG, Bih Liarn; Summer Student Trainee; Dept. of Agronomy, Natl. Chung Hsing Univ., Taichung, Taiwan, R.O.C.

Major project: Breeding Behavior of F_3 Plants for Time to Flowering and Maturity under 10-Hour Photoperiod.

YEH, Hwey; Summer Student Trainee; Natl. Taiwan University, Taipei, Taiwan, R.O.C.

Major project: Relationship between Leaf Nitrate Reductase Activity and Nitrogenous Compounds of Bleeding Saps of Soybean Plant.

JANSEN, Catherina M.; Res. Scholar; Student, Inst. of Plant Breeding, Agr. Univ., Wageningen, The Netherlands.

Major projects:

a. Photoperiod Experiment
b. Inter and Intra Genotypic Competition of 20 Selected Breeding Lines

TSENG, Ching Tei; Research Intern; Assoc. Pathologist, Kaohsiung DAIS, Ping Tung, Taiwan, R.O.C.

Major project: Study Epidemiology of Soybean Rust.

LEE, Yeong Ho; Res. Intern. Junior Researcher, Crop Expt. Sta., Office of Rural Development, Suweon, Korea.

Major project: Generation Advancement of Korean Soybean Breeding Lines during Winter and Spring.

MUNGBEAN

ABDULRACHMAN, Sarlan; Res. Intern; Junior Legumes Production Officer, Central Res. Inst. for Agr., Bogor, Indonesia.

Major project: Effect of Planting Date and Cultivar on Mungbean Production.

WU, Yi Ching; Summer Student Trainee; Dept. of Agronomy, Natl. Chung Hsing Univ., Taichung, Taiwan, R.O.C.

Major project: Drought Stress Effects on Proline level in Mungbean

CHIANG, Yeong Jene; Special Purpose Trainee; Dept. of Agronomy, Natl. Chung Hsing Univ., Taichung, Taiwan R.O.C.

Major project: Effect of Drought Stress on Mungbean Growth and Yield.

LEGRO, Robert J.; Res. Scholar; Student, Inst. of Plant Breeding, Agr. Univ., Wageningen, The Netherlands.

Major projects:

a. Germination of Mungbean.

b. Inheritance Studies on Hypocotyl Color, Leaf Shape, Pod Color, and Seed Coat Color, and Genetic Linkage Between and Among These Characters.

TOMATO

Sr. RUELO, Julita; Research Fellow; Assoc. Prof., Biology Dept., Fu Jen University, Taipei, Taiwan, R.O.C.

Major projects:

a. Tomato, Soybean, Mungbean Screening for Resistance to Root-Knot Nematodes.

b. Survey of the Root-Knot Problem of Taiwan and AVRDC and Differential Host Studies.

c. Host Range Studies of *Melogidogyne hapla*.

d. Integrated Control of Root-Knot Nematodes on Tomato, Soybean, and Mungbean.

CARDENAS, Danilo C.; Res. Intern; Program Specialist, Crops Res. Div., Philippine Council for Agr. and Resources Res., Los Baños, Laguna, Philippines

Major project: Effect of Bed Height and Compost on the Performance of Tomato Under Heavy Rainfall Condition.

TSAI, Eric C. T.; Res. Intern; Inst., Dept. of Botany, Chinese Culture College, Yang Ming Shan, Taipei, Taiwan, R.O.C.

Major project: Effect of High Temperature on Fruit Setting of Tomato.

AFUTITI, Salamina L.; Prod. Trainee; Senior Field Tech, Univ. of the So. Pacific School of Agr., Alafua, Apia, Western Samoa.

Major project: Summer Tomato Advanced Yield Trial

BORDA, Salvador B.; Prod. Trainee; Agronomist, Bureau of Plant Industry, Roxas City, Capiz, Manila, Philippines.

Major project: Preliminary Trial of F_6 Processing Breeding Lines (II)

CASAYURAN, Pablo R.; Prod. Trainee; Agronomist II, Maligaya Rice Res. & Tr. Center, Munoz, Nueva Ecija, Philippines.

Major project: Seed Production Studies of 5 AVRDC Breeding Lines

CAPITAN, Primitiva S.; Prod. Trainee; Agronomy II, Bureau of Plant Industry, San Andres, Malate, Metro Manila, Philippines.

Major project: Preliminary Trial of F_6 Processing Breeding Lines (II).

GEORGE, Owusu-Ansah; Prod. Trainee; Agri. Sc. Tutor, St. Andrew's College, Mampong-Ashanti, Ghana.

Major project: Pruning Study in Indeterminate Tomato.

MOLINA, Bernabe B. Jr.; Prod. Trainee; Ext. Specialist II, Bureau of Agr. Ext., Quezon City, Philippines.

Major project: Summer Tomato Advanced Yield Trial.

PASTORIL, Corsino A.; Prod. Trainee; Senior Agriculturist, Dansalan College, Marawi City, Philippines.

Major project: Preliminary Trial of F_1 SSD Breeding Lines.

PHILLIP, Jackson A.; Prod. Trainee; Agriculturist I, Agr. Dept., Ponape Dist., Micronesia.

Major project: Spacing Trial in Tomato (II)

ROSARIO, Renato del; Prod. Trainee; Farm Supervisor, Independent Realty Corp., Makati, Metro Manila, Philippines.

Major project: Spacing Trial in Tomato (I).

SHAMSUDIN, Bunsu; Prod. Trainee; Project Analyst, Kumpulan Fima Berhad, Petaling Jaya, Selangor, Malaysia.

Major Project: Ethrel Application for Tomato Ripening

YASIS; Prod. Trainee; Staff Member, Direkorat Perlindungan, Tanaman Pangan (Directorate of Food Crop Protection) Jakarta, Indonesia.

Major project: Ethrel Application for Tomato Ripening.

YU, Il Oong; Res. Intern; Solanaceous Crops Specialist, Joong-Ang Seed Co., Pusan City, Korea.

Major project: F_1 Preliminary Trial of Korean Breeding Lines.

CHANG, Chung Hwa; Summer Student Trainee; Dept. of Botany, Natl. Chung Hsing Univ., Taichung, Taiwan, R.O.C.

Major project: Effect of High Temperature on Endogenous Plant Hormones in Tomato.

TANG, Chii Fen; Summer Student Trainee; Dept. of Soil Science, Natl. Chung Hsing Univ., Taichung, Taiwan, R.O.C.

Major project: Decomposition Process in Applied Organic Materials.

WHITE POTATO

KIM, Hwa Yeong; Res. Intern; Jr. Researcher, Hort. Expt. Sta., Office of Rural Dev., Suweon, Korea.

Major projects:

a. Effect of Greensprouting, Planting Depth, Mulching, and Fungicide Application on Emergence and Survival Rate of Potato Grown During the Hot, Wet Season.

b. *In Vitro* Tuberization of Potato Seedlings

AFUTITI, Salamina L.; Prod. Trainee; Sr. Field Tech., Univ. of the So. Pacific School of Agr., Afafua, Apia, Western Samoa.

Major project: White Potato Variety Trial.

PHILLIP, Jackson A.; Prod. Trainee; Agriculturist I, Agr. Dept., Ponape Dist., Micronesia.

Major project: White Potato Variety Trial

APANDI, Euis S.; Prod. Trainee; Researcher, Lembaga Penelitian Hortikultura, Lembang, Indonesia.

Major project: Effect of Fungicide, Tuber Size and Cutting of Seed Pieces on White Potato Production.

DALLUWAY, Reynaldo H.; Prod. Trainee; Plant Pest Control Officer, Bureau of Plant Industry, Agusan Sur, Philippines.

Major project: Bed Height Study on White Potato

BANDIAN, Luisito E.; Prod. Trainee; Services Advisor, Planters Products, Inc., Philippines.

Major project: Plant Density Experiment on White Potato.

CHINESE CABBAGE

WANG, Chang Yuh; Summer Student Trainee; Dept. of Agronomy, Natl. Chung Hsing Univ., Taipei, Taiwan, R.O.C.

Major project: Tipburn in Chinese cabbage.

WANG, Lily; Summer Student Trainee; Dept. of Biology, Fu Jen Univ., Taipei Hsian, Taiwan, R.O.C.

Major project: participated in on-going research on varietal resistance screening work in Chinese cabbage.

HSU, Tseng Jan; Summer Student Trainee; Dept. of Entomology, Natl. Chung Hsing Univ., Taichung, Taiwan, R.O.C.

Major project: participated in on-going research on insecticide screening against insect pest of summer Chinese cabbage.

LEE, Yuin Wha; Summer Student Trainee; Dept. of Entomology, Natl. Taiwan Univ., Taipei, Taiwan, R.O.C.

Major project: participated in on-going research on varietal resistance screening in Chinese cabbage.

WU, Yu Ru; Summer Student Trainee; Dept. of Entomology, Natl. Chung-Hsing Univ., Taichung, Taiwan, R.O.C.

Major project: participated in on-going insect virus multiplication work.

PENG, Cheng Sen; Res. Intern; Jr. Specialist, Fengshen Tropical Hort. Exp. Sta., Kaohsiung, Taiwan, R.O.C.

Major projects:

a. Effect of Vernalization on the Bolting and Flowering of Different Seedling Stages of Chinese Cabbage.

b. Effect of Seed Vernalization on the Bolting and Flowering of Different Chinese Cabbage Varieties.

c. Effect of High Temperature on Seed Formation of Chinese Cabbage.

d. The Influence of GA_3 Treatment on the Bolting and Flowering of Chinese Cabbage.

FLORES, Thelma B.; Res. Intern; Twin Rivers Res. Cen., Davao City, Philippines.

Major projects:

a. Preliminary Screening of Additional AVRDC Chinese Cabbage Accessions for Resistance to Diamondback Moth, Cabbage Worm and Aphids.

b. Confirmation of Resistance to Various Insect Pests in Chinese Cabbage.

c. Screening of Modern Insecticides for the Control of the Insect Pests of Chinese Cabbage.

e. Determination of Seed Yield Loss Due to Insect Attack in Chinese Cabbage Seed Production.

f. Evaluation of Contact Toxicity of Various Insecticides to Sweet Potato Weevil.

JANSEN, Catherina M.; Res. Scholar; Student, Inst. of Plant Breeding, Agr. Univ. Wageningen, The Netherlands.

Major projects:

a. Modified Empty Pollen Technique for Early Detection of Self-Incompatibility in Chinese Cabbage.

b. Detecting S-allele Homozygotes among Breeding Lines.

LEGRO, Robert J.; Res. Scholar; Student, Inst. of Plant Breeding, Agr. Univ., Wageningen, The Netherlands.

Major project: Modified Empty Pollen Technique for Early Detection of Self-Incompatibility in Chinese Cabbage.

LIM, Bock Soon; Prod. Trainee; Asst. Primary Production Officer, Agr. Res. Section, Singapore.

Major project: Chinese Cabbage Variety Trial.

GARMANAG, Gabriel; Prod. Trainee; Agriculturist I, Agr. Div., Yap Dist. Micronesia.

Major project: Chinese Cabbage Variety Trail.

JOSEPH, Jimmy; Prod. Trainee; Agr. Ext. Supervisor, Agr. Dept., Marshall Dist., Micronesia.

Major project: Chinese Cabbage Spacing Trial.

PANILAN, Dominador E.; Special Purpose Trainee; Instructor and Manager, Central Mindanao State Univ., Musuan, Bukidnon, Philippines.

Major project: Direct Seeding of Chinese Cabbage.

SWEET POTATO

MURUVANDA, Devaiah A.; Special purpose Trainee; East-West Center, Univ. of Hawaii, Manoa, Hawail, U. S. A.

Major project: Orientation to Sweet Potato Research in Entomology.

CHEN, Ru Yin; Summer Student Trainee; Dept. of Agronomy, Natl. Taiwan Univ., Taipei, Taiwan, R.O.C.

Major project: Survival Rate of Sweet Potato Cuttings in Transport

GUINTU, Ricardo S.; Prod. Trainee; Agronomy Inst., Central Luzon State Univ., Philippines.

Major project: Sweet Potato Advanced Yield Trials.

LORENS, Adelino S.; Prod. Trainee; Agr. Representative II, Agr. Dept, Ponape Dist. Micronesia.

Major project: Sweet Potato Advanced Yield Trials.

MIKEL, Ismael H.; Prod. Trainee; Asst. Agriculturist, Agr. Dept., Truk Dist. Micronesia.

Major project: Sweet Potato Advanced Yield Trials.

HENGIO, Gabriel; Prod. Trainee; Marketing, Agr. Dept., Truk Dist., Micronesia.

Major project: Sweet Potato Advanced Yield Trials.

NUTRITION

LIU, Carol Pei Wei; Res. Scholar; Ph. D. Candidate, Cornell Univ., U. S. A.

Major project; Vegetable Consumption Among Rural Pre-School Children in Taiwan.

CROPPING SYSTEM

CALDWELL, John S.; Res. Scholar; Ph.D. Candidate, Dept. of Hort., Louisiana State Univ., U.S.A.

Major project: A System for Vegetable Production During the Rainy Season.

1978 Training Sponsors

1. AVRDC
2. National Science Council, ROC
3. Outreach Program, Korea
4. IADS,Indonesia
5. USAID/PCARR, Philippines
6. IAPMP, Philippines
7. Asia Foundation
8. T.T. of Pacific Islands
9. IRC, Philippines
10. KFB, Malaysia
11. Planters Products Inc., Philippines
12. Twin Rivers Res. Cen., Philippines
13. World Bank Loan, Philippines
14. E-W Center, U. of Hawaii
15. Cornell University
16. Rockefeller Foundation
17. USDA
18. Personal Funds

The IBM 2780 terminal provides AVRDC scientists access to the IBM System/370 Model 158 and greatly improves turn-around time for data analyses.

Communications and Research Services

STATISTICAL SERVICES

In August, as part of the IBM/AVRDC partnership program, an IBM 2780 terminal was installed at AVRDC and linked to the IBM System/370 Model 158 of 1.5 megabytes of core storage located at the IBM Data Center in Taipei. This terminal, together with in-house keypunch facilities, permits greatly reduced turn-around time for analysis of data.

Increased Statistical Analyses of Experimental Data

Now it is possible to produce three or four sequential experiments per year in which a following experiment may be modified, based on analyses of data from the preceeding experiment. Due to the ease of analyzing additional variables, more information is being obtained per experiment. Hence, the efficiency, or data per research dollar, has increased. Certain computer procedures are being used for the first time by many of the scientists; e.g., plotting of graphs and frequency tables.

Development of Germplasm Evaluation Systems

Basic variables (accession number, origin, yield, etc.) in the initial data sets for mungbean, soybean, Chinese cabbage, sweet potato, and white potato have been decided upon and values are being collected. The basic mungbean set, which has 5,000 entries (accessions), and the basic soybean set, which has nearly 10,000 entries , are in use at present. They are used to identify duplicates and to provide germplasm characters to AVRDC scientists and international cooperators. Chinese cabbage, sweet potato, and white potato basic data sets are in the developmental stage. As a result of planning for computerization, the entire system of germplasm evaluation, of which the computer system is only a part, has had its first interdisciplinary review. AVRDC scientists were surveyed to identify (a) which variables, e.g., yield, resistance to downy mildew, were of first or second priority; and (b) the discipline responsible for determining the values of the variables, e.g., pathologists are responsible for determining the values of resistance to downy mildew for each of the accessions. The scientists responded well to the review of the system and found the exercise enlightening.

Development of New Computer Applications

A program was written and used to evaluate the diet in rural (Shanhua) and urban (Taipei) children of pre-school age. A survey was conducted in cooperation with Cornell University. Daily meal servings were translated into nutrients per child on a per meal, per day, and per month basis. This translation involved developing a computer table of over 300 food items, each with its nutrient component per 100 grams. Nutrient components include such items as protein, vitamin A, B, iron, and Ca. The survey analysis was completed in August and sent to Cornell. The initial program is being expanded to include 100 additional food items and to handle more locations. An all-Taiwan survey to evaluate the diet of pre-school age children is being conducted jointly by AVRDC, the Administration of Public Health, National Taiwan University, and Shih Chien Home Economics College. The survey includes 100 families in each of 9 locations over 2 seasons.

One set of data was used for an initial test of the IBM Mathematical Programming System Extended (MPSX) capabilities. Plans for its use will include analyses of cropping system management for high rainfall areas in Taiwan and the Philippines. MPSX will be used to support a training project in cooperation with the Rockefeller Foundation, Louisiana State University, and the Philippine Council for Agriculture and Resources Research. Analysis of the Taiwan data has been completed. In 1979 a similar set of field trials will be conducted in the Philippines and analyzed at AVRDC.

SEED TECHNOLOGY

Germplasm Collection

AVRDC's germplasm collection now includes 9,980 soybean accessions, 4,927 mungbean accessions (with 398 other *Vigna* species -- blackgram, adzuki bean, and rice bean, in addition), 4,755 tomato accessions, 699 Chinese cabbage accessions, 389 sweet potato accessions, and 1295 white potato accessions (duplicates included). The seed laboratory distributed 20,662 samples of these accessions in 1978 to scientists in 67 countries and territories.

In producing seed for this distribution, the seed technologists made 3,980 soybean, 607 mungbean, 426 tomato, 81 Chinese cabbage, 791 sweet potato, and 1,000 white potato plantings.

The white potato collection will be turned over to the Taiwan Agricultural Research Institute at Taichung in 1979.

Field Days, 1978

AVRDC had seven field days in 1978. Two of these were soybean field days on campus, two were soybean field days in farmers' fields, one was a tomato field day in conjunction with the international symposium, and two were trainee field days.

LIBRARY REPORT FOR 1978

The library committee was organized and met for the first time in April. The function of this committee is to screen all requests received in the library except those for journal article reprints, to recommend publications most needed by the scientists, and to develop a core list of serial publications for vegetable research.

In 1978, 199 titles of periodicals were renewed, and 6 new subscriptions were added. The total periodical holdings are 847 titles plus 5673 bound volumes of back numbers. We catalogued 1926 new monographic titles to bring the total collection to 6469 titles. We indexed 3030 documents for 6 crops.

Summary of Citation Analysis of AVRDC Publications

The citations included in AVRDC papers submitted for publication in the last four years came from 182 serial publications, of which 134 (74%) are included in the AVRDC library collection. Publications from the U.S.A., Europe and the R.O.C. were most frequently cited. The referenced articles were primarily in English, Chinese and Japanese. About 80% of the papers cited were published in the last 20 years.

OIS SUMMARY

The Office of Information Services moved into a consolidated office area and took possession of a new press room early in 1978. The improved facilities were made possible by a grant from USI Far East Corporation.

Publications

In 1978, the Office of Information Services produced 20 publications of various kinds. In addition, OIS assisted in the publication of nine journal papers.

OIS also mailed about 56,000 publications of all kinds to people in 139 countries. These included 2,052 Journal Papers, 8,208 Technical Bulletins, 6,178 Annual Progress Reports, 9,162 Guides, 7,565 Proceedings, 16,000 About AVRDC, and 214 miscellaneous.

Photographic Services

Photographic services processed or handled 3324 black and white prints, 735 color prints, 7828 color slides, and 3926 blue slides in 1978.

Press Releases

OIS mailed 19 press releases during 1978.

A special article was published by Span magazine. HortScience published a cover story and used an AVRDC color photo on the cover.

Board of Directors

Personnel

Administration

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Jou-ruey Juang, B.S., *research assistant*

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Maw-sheng Lee, M.S., *research assistant*

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Ming-seh Hsu, B.S., *chemical analyst*
Sieh-te Tan, M.S., *research assistant*

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Shin Lu, M.S., *research assistant**

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Scott H.A. Hsu, M.S., *research assistant*

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Shu-yuh Huang, B.S., *research assistant**
Chiung-pi Liu, B.S., *research assistant*
Su-hua Tu, B.S., *research assistant*

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Chih-ping Chu, B.S., *research assistant*
Chin-hwa Ma, B.S., *research assistant*

Nancy L. Calkins, B.S., *research assistant**
Li-Jean Sun, B.S., *research assistant*

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Robert L. Cowell, M.S., *research associate*
Grant I. Johnson, B.A., *associate information specialist***

Teng-hui Hwang, B.S. *librarian*

Yi-sung Chen, B.S., *on leave for 3-year mission to Saudi Arabia*
Yung Liang, *farm superintendent*

Leonard I. L. Ho., M.S., *assistant seed specialist*

Su-May J. Wang, B.S., *computer services assistant*
Rouh-yun Yu, B.S., *statistical assistant*

Outreach

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

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* *Left druing 1978.*
** *Arrived during 1978.*

Finances

During 1978, contributions to AVRDC's core budget by principal donors totalled US$1,791,106.00. It was comprised of $947,320 from the Republic of China, including $150,000 in special training funds, and $600,000 from the United States Agency for International Development. The Philippines contributed $93,786 including a part of the 1977 grant. Japan and the Republic of Korea each gave $75,000. In addition, the Rockefeller Foundation contributed the salary of the Director and Japan gave the services of a Soil Scientist.

Contributions to the Center for special projects, training scholarships, conferences and symposia totalled US$157,809.00. Grants for general purposes were received from:

Campbell Soup Company
USI Far East Corporation
International Potash & Phosphorus Institute
President Enterprise Corp.
Taiwan Fertilizer Company

Special purpose projects were supported by the Asian Development Bank (outreach), Agricultural Engineering Research Institute (irrigation), Green Mountain Co., Ltd., Rohm and Haas Asia, Inc. and American Cyanamid (insecticide testing), Joint Commission on Rural Reconstruction (soybean breeding and potato germplasm), USDA Science and Education Administration (soybean rust epidemiology), International Minerals and Chemical Corp. (fertilizer use), USI Far East Corp. (soil drainage), National Chung Hsing University and others.

Interest, farm sales, overhead recovery and other income grew to a total of US$103,862.00.

Total income to the Center was $2,059,335.00 compared with a program budget calling for $2,240,100.00.

Publications Available

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, Vegetable Production in Taiwan: A Survey of 300 Farmers

TB 8, Calkins, Why Farmers Plant What They Do

TB 10, Calkins, White Potato Production in Taiwan

TB 11, Calkins, Soybean production in Taiwan: A Farm Survey.

TB 12, Riley, Evaluation of Environment Parameters

TB 13, Shanmugasundaram, Varietal Development and Germ Plasm Utilization in Soybeans

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 Soybeans

Annual Progress Reports

1972-73 Report

1974 Report

1975 Report

1976 Report

1977 Report

Crop Reports

1975 Sweet Potato Report

1975 Chinese Cabbage Report

1976 Sweet Potato Report

1976 Chinese Cabbage Report

1976 Soybean Report

1976 White Potato Report

Miscellaneous

Proceedings of the First International Mungbean Symposium

Proceedings of the First International Symposium on Tropical Tomato

These publications can be ordered from:

Office of Information Services
Box 42, Shanhua, Tainan 741
Taiwan, R.O.C.

Please either type your name and address, or print in block letters. Names and addresses which cannot be read clearly will be discarded.

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