Petersen

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 95 ARDA

1. SUBJECT CLASSIFICATION
A. PRIMARY: Serials — Y-AF00-1580-0000
B. SECONDARY: Food production and nutrition--plant production--Root vegetables--Sweet potatoes

2. TITLE AND SUBTITLE
The Asian Vegetable Research and Development Center sweet potato report, 1976

3. AUTHOR(S)
(101) AVRDC

4. DOCUMENT DATE: 1977
5. NUMBER OF PAGES: 50p.
6. ARC NUMBER: ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
AVRDC

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(Research summary)

9. ABSTRACT

Summarizes research conducted on sweet potatoes in 1976 at the Asian Vegetable Research and Development Center (AVRDC) in Taiwan. The report notes that, while sweet potatoes produce more food per hectare than does rice, and require minimal input and management, sweet potato production is at present declining rapidly in Taiwan. Increased availability of irrigation water has resulted in greater choice of crops; consequently, the durable sweet potato, long a staple item during famine years, is increasingly rejected as poor people's food. This report discusses research to improve taste and nutrition content of sweet potatoes, maintaining that sweet potatoes are an important resource in regions of fixed cultivation area and rising population. Included are an economic analysis of the declining market as well as results of tests on insect resistance and the effect of different concentrations of potassium and nitrogen in the soil. AVRDC's training programs and cooperation in international research programs are briefly reviewed. The appendix includes indexes of accessions and crosses, as well as test environment information.

10. CONTROL NUMBER: PN-AAG-210
11. PRICE OF DOCUMENT:
12. DESCRIPTORS: Sweet potatoes
13. PROJECT NUMBER:
14. CONTRACT NUMBER: AID/ta-G-1260 GTS
15. TYPE OF DOCUMENT:

AID 1330-5 (10-71)

AVRDC SWEET POTATO REPORT '76

Beautiful children. Healthy and strong in body and mind. Every parent's dream. Diet rich in protein, vitamins, and minerals are essential to the well being of growing children whether they live in Dacca or Manila. Paradoxically, vegetables constitute a most important yet usually neglected source of essential nutrients in the developing countries of the tropics.

The Asian Vegetable Research and Development Center Sweet Potato Report for 1976

About this Report

The scientists at the Asian Vegetable Research and Development Center (AVRDC) have been charged with the vital task of developing appropriate technologies and improving production of six vegetable crops in the hot, humid, lowland tropics. Although rice is the principal staple food in these lands, AVRDC's vegetable crops are effective nutritional supplements to a rice diet as they supply plant protein, vitamins, and minerals. Additionally, these vegetables offer Asian farmers opportunities to increase their incomes and, thereby, enhance the quality and security of their lives.

The Sweet Potato Report for 1976 summarizes research conducted at the Asian Vegetable Research and Development Center (AVRDC), and in cooperation with various national programs. Persons desiring additional details of the work reported may contact Dr. John N. Hubbell, sweet potato coordinator, or the research worker directly responsible.

Research reports are published summarizing 1976 activities in white potato (*Solanum tuberosum*), Chinese cabbage (*Brassica pekinensis*), tomato (*Lycopersicon esculentum*), mungbean (*Vigna radiata*), and soybean (*Glycine max*). These reports and other technical papers may be obtained by writing the Office of Information Services at AVRDC. Please be sure to give your complete mailing address.

Data are presented in metric units. Monetary values have been converted to equivalent U.S. dollars. Tomato yields are calculated as fresh weight. See page 48 in the Appendix for description of weather and soil environment at the center during 1976.

"Check" means an untreated experimental plot unless stated otherwise. A single asterisk (*) means significant at the 5% level; a double asterisk (**) means significant at the 1% level. Pedigrees in the AVRDC breeding program are identified by a slant (/), e.g. HDK 6/B 6708. If the progeny is then crossed with another parent, the pedigree would be designated with a second slant bar. Beyond three crosses, however, the designations are /4/, /5/, etc. Commercial chemical names are occasionally used for identification; such use does not imply an endorsement by AVRDC.

Information and conclusions reported herein are solely the responsibility of AVRDC.

Correct citation: Asian Vegetable Research and Development Center 1977. Sweet Potato Report for 1976, Shanhua, 741, Taiwan, Republic of China.

Contents

About this Report 2
Sweet Potato Research Objectives 5
Introduction 7
Economic Analysis of Sweet Potato Production in Taiwan 8
Attitudes of Producers and Former Producers 13
Breeding Tastier, More Nutritious Sweet Potato Varieties 18
Expanding the World Germplasm Collection 18
Segregating Populations 18
Screening for Minimum-Input Cultivation 19
Screening for Moisture Tolerance 22
Yield Trials 24
Tip Yield Trials 25
Resistance to Witches' Broom 26
Select Cultivars with Resistance to Sweet Potato Weevil 30
Chemical Control of Sweet Potato Weevil 31
Testing Molluscicides 32
Obtain Response from Nitrogen; None from Potassium 33
Sweet Potato Management Levels After Rice 34
Nutritional Progress and Potential for Sweet Potatoes 36
Analysis for Nutritional Constituents 36
Protein and Oxalate Content 38
Taste Tests 40
Relationship of Sweet Potato Yield and Protein Content 40
Training Program 43
International Cooperation 44
Philippine Outreach Program 44
Other Philippine Cooperation 46
Bangladesh 46
Thailand 46
Appendix 48
Crop Environment 48
Index to Accessions 50
Index to Crosses 51
Board of Directors 52
Personnel 53
Publications 55

The Asian Vegetable Research and Development Center Sweet Potato Report for 1976

RESEARCH OBJECTIVE

* Higher productivity of roots with more available protein and β-carotene

* Varietal resistance to sweet potato weevil and the witches' broom disease

* Development of management practices to optimize farmers' returns

* Better consumer acceptability of more nutritious roots and tips

Introduction

Sweet potatoes can produce more food per hectare than rice and they require fewer inputs and less management. Thus the sweet potato is an important crop to exploit in a world of rising population and fixed area for food production.

Sweet potatoes are popular in Papua New Guinea where people eat an average of 1 kilogram per day. In the U.S. sweet potato served as candied yams is a popular dish. The plant's tips (leaves) are popular greens in the Philippines and West Africa. But in Taiwan, demand for the crop is on the decline. Acreage is dropping rapidly. AVRDC economists conducted a survey of Taiwan farmers this year to get their point of view and gain more insight into reasons why they abandon the crop. (See page 8).

The drop in hectarage results largely from three causes: (1) People in Taiwan are showing preference for other foods as their incomes rise; (2) hog producers, who once utilized 70 percent of the sweet potato production, are switching to processed feeds because they are easier to store and handle; and (3) irrigation water is being made available to more and more farms, permitting wider choice of crops. The first two causes reduce the demand and price for sweet potatoes and speed the switch to alternative crops as the irrigation water is made available.

Sweet potatoes grow with vigor under a wide range of adverse environments. Their durability may be their greatest agronomic asset but also results in lowered esteem for the crop. Generations of Chinese have survived periods of famine by consuming sweet potatoes. Thus they generally regard the roots as food for the poor. Given a choice, they prefer rice. In Taiwan, the sweet potato is a victim of a healthy economy.

Taiwanese first planted sweet potato for human food, then for animal food, and now the trend is toward starch manufacturing as a major use. This progression might be followed to advantage in other developing countries.

The sweet potato may need a selling campaign in Taiwan, including development and promotion of new recipes before demand will influence farmers to expand production again. Work might also be done on fitting sweet potato into processed feed formulas for livestock. Researchers at AVRDC are working on making the sweet potato tastier, more nutritious and more appealing, as well as more productive. By increasing the vitamin A content in sweet potatoes, they are also providing a food that can prevent xeropthalmia, a blindness found in children in many Asian areas, caused by vitamin A deficiency.

Economic Analysis of Sweet Potato Production in Taiwan

Over the period 1971-5 the area planted to sweet potatoes in Taiwan declined dramatically. Yields per hectare have shown a steady increase, averaging 214 kg gain per year from 1970 to 1975 but the hectarage has declined so rapidly that the volume of total production also shows a steep decline (Fig. 1).

A survey was made in 1976 to evaluate changes in yield and planted area from the farmers' point of view and shed more light on these trends. Sweet potatoes are grown as first, second, fall, and fall relay (planted in rice) crops. We chose the six districts listed in Table 1 because they best represented the island-wide trends in planted area for each of these seasons or planting method. In each district, a sample of farmers was interviewed between June and September, 1976. Fig. 2 shows the location of the villages where interviews were made.

Three types of questionnaires were used. One type was given to 129 current producers of sweet potatoes. This was a production-cost questionnaire. Another 122 growers were given a production factor questionnaire designed to determine producer attitudes. The third type, designed to seek reasons for abandoning sweet potatoes, was answered by 68 former growers.

Fertilizer

The survey indicated farmers might be putting more fertilizer on the fall relay crops than is profitable. (Note high fertilizer investment

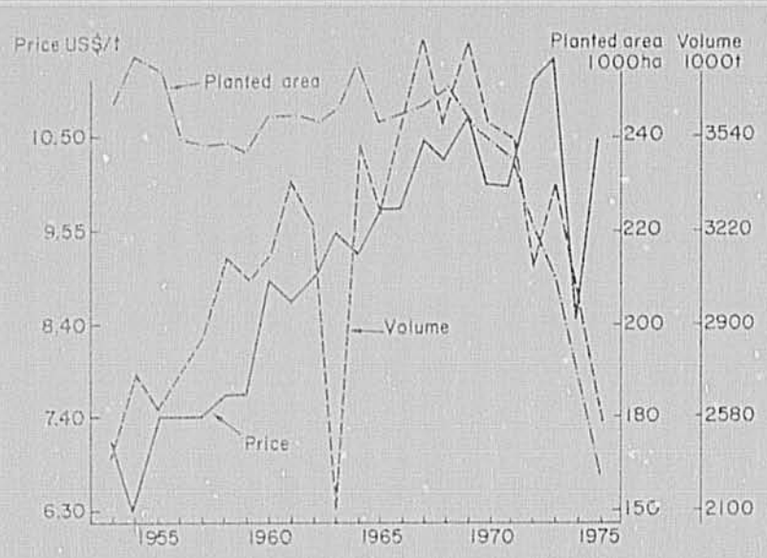


Fig. 1. Area planted to sweet potatoes has declined rapidly in Taiwan since 1970. Volume of production hasn't declined quite as much because yield per hectare has shown a good increase.

Table 1. Crops represented in the sampling by district.

District	Crop name[a]	Duration in the field	Average yield	Percent change in planted area, 1971-5
			t/ha	
Taitung	first	Feb-July	14	-11
Pingtung	second	June-Oct	12	- 1
Miaoli	second	Aug-Jan	14	- 1
Kaohsiung	fall	Oct-Apr	22	- 6
Tainan	fall	Oct-Apr	28	-18
Changhua	relay	Oct-Feb	13	- 9

[a]These terms are the ones in current use in Taiwan.

and low yields in Changhua in Table 2). Their nitrogen applications averaged 3.6 times more nitrogen and 1.6 times more potassium than the standard recommended for sweet potato by the Chiayi Agricultural Experiment Branch Station (Table 3). Farmers may intend some of this fertilizer for subsequent crops.

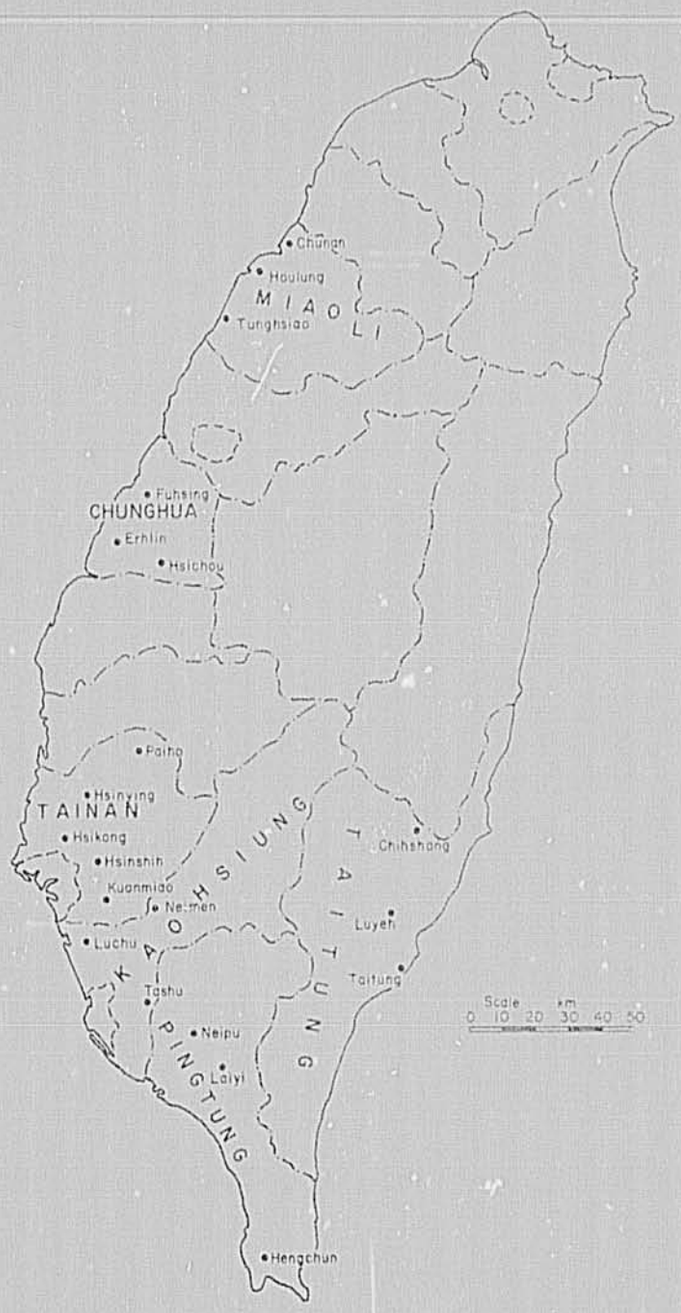


Fig. 2. Location of sample municipalities for AVRDC sweet potato survey, 1976.

Yield Rank by Season

The fall crop ranked highest with an average yield of 25 t/ha. This was expected, because climatic conditions are the most favorable in the fall. The first crop yielded 14 t/ha, the relay crop 13 t/ha, and the second crop 13 t/ha. The farmers interviewed explained that wind and inadequate water reduced second crop yields, shading by the rice reduced

Table 2. Production budgets for sweet potato by district.

Item	District					
	Taitung	Pingtung	Miaoli	Kaohsiung	Tainan	Changhua
No. farmers interviewed	22	17	20	20	30	20
Season	1st crop	2nd crop	2nd crop	Fall crop	Fall crop	Relay
Yield (kg/ha)	14,275	12,662	14,101	21,794	28,163	13,284
Price (US$/100 kg)	4.2	4.7	3.4	4.5	3.7	2.9
Revenue (US$)	601	600	482	975	1,038	385
Expenses (US$)						
A. Cash (US$)						
Human labor	54	55	33	82	91	54
Animal power	34	18	14	64	28	14
Machine power	15	43	0	67	50	12
Chicken manure	0	0	1	5	0	0
N	32	18	16	42	34	60
P	14	5	6	18	12	22
K	15	8	8	21	21	21
Seedling	32	24	30	83	131	48
Pesticide	3	3	< 1	2	5	8
Fuel	3	42	0	4	16	< 1
Water fee	11	1	16	0	47	29
Land tax	14	8	24	38	42	40
Subtotal	227	226	148	427	480	305
B. Non-cash (US$)						
Family labor	157	115	217	172	141	206
Animal power	110	121	128	40	49	70
Machine power	3	3	0	22	17	0
Compost	30	46	24	50	86	166
Interest on land	25	23	71	128	87	139
Interest on capital	6	5	3	13	14	8
Subtotal	331	313	442	424	394	590
Total	558	539	590	852	874	894
Farm Return (US$)	374	374	335	548	558	80
Net Profit (US$)	43	61	-108	123	164	-510

Table 3. Fertilizer use in relay sweet potato, fall crop compared with Chiayi Agricultural Experiment Station standard and the relay crop in Changhua.

Item	N	K
	--------- kg/ha	--------
Experiment station standard	66	110
Relay sweet potato (Changhua district)	239	173
Fall crop (Tainan)	122	145

relay crop yields, and unfavorable temperatures reduced first crop yields. These perceptions are generally supported by environmental data.

Effect of Irrigation Availability

Sixty-seven percent of the farmers surveyed planted sweet potatoes on irrigated fields. Eighty-four percent of fall crop farmers, 48% of second crop farmers, 42% of first crop farmers, and 100% of relay crop farmers used irrigation. Overall, the irrigated crops yielded more than rainfed crops.

Type of Soil

On the farms included in the survey, best yields came from clay loam and loam soils, followed by sandy loam, clay, sandy, and gravelly soils (Table 4).

Table 4. Mean yield[a] of sweet potato root grown in several soil types and seasons in Taiwan.

Season	Soil type				
	gravel	sandy	sandy loam	loam & clay loam	clay
	----------	----------	t/ha	----------	----------
First	14.0	14.0	15.5	14.0	10.0
Second	8.4	12.5	10.6	12.5	
Relay	-	18.5	7.9	13.5	13.8
Fall	-	24.3	17.2	28.9	19.5

[a]Average based on replies of farmers in the survey.

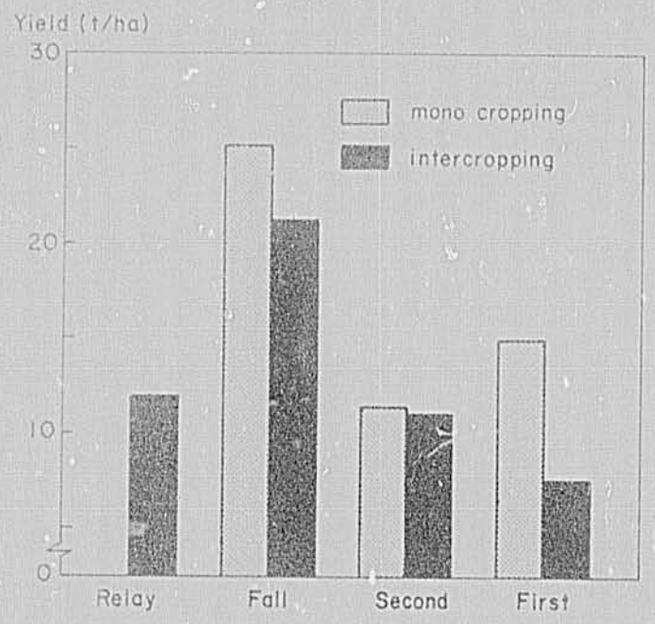


Fig. 3. Average yield of sweet potato, intercropping compared with monocropping.

Intercropping

Yields were higher for single cropping the sweet potatoes than for intercropping them with rice (Fig. 3).

Costs and Returns

Table 2 shows the average costs and returns for a subsample of farmers in each of the six districts. The fall season samples (in Tainan and Kaohsiung districts) showed decided yield advantage. Net profit followed yield trends for the different seasons, with the exception of the second crop in Pingtung. There the costs of second crop were low enough to raise the crop from bottom in yield to third rank in net profit.

Labor

Labor costs are depicted in Table 2 and hours of labor, in Tables 5 and 6. Planting, seeding, and harvesting were the most labor consuming practices. Forty-one percent of the labor cost is for harvesting.

Influence of Inputs

Influence of various input mixes for the farms was explored by computer, using the mathematical technique, mutivariate regression analysis. Assuming no interdependencies, we concluded that:

1. Season and district differences (rainfall, elevation, latitude) influence yield more than soil type.

Table 5. Labor hours per hectare for sweet potato production, 1975-76.

	District (No. of farmers interviewed)											
	Taitung (22) 1st crop		Pingtung (17) 2nd crop		Miaoli (20) 2nd crop		Kaohsiung (20) fall crop		Tainan (30) fall crop		Changhua (20) relay	
	hrs	%	hrs	%	hrs	%	hrs	%	hrs	%	hrs	%
Land preparation	0	0	8	2	0	0	0	0	0	0	3	0
Bed formation	0	0	0	0	25	5	3	1	5	1	14	2
Basal fertilizer	12	2	20	5	20	4	34	6	42	7	126	19
Planting	81	17	82	20	50	9	128	23	112	20	152	23
Intertillage & weeding	84	17	42	10	128	24	89	16	135	29	95	15
Top dressing	21	4	25	6	7	1	5	1	0	0	29	4
Vine turning	56	12	17	4	42	8	31	6	41	7	38	6
Irrigation	19	4	17	4	3	1	19	3	17	3	2	0
Pest control	4	1	7	2	1	0	3	1	8	1	7	1
Harvest	208	43	189	46	267	49	240	43	204	36	181	28
Total	485	100	407	100	543	100	552	100	564	100	647	100

Table 6. Measures of sweet potato production efficiency and income in six districts of Taiwan.

Measure	District					
	Taitung	Pingtung	Miaoli	Kaohsiung	Tainan	Changhua
Season	1st crop	2nd crop	2nd crop	fall crop	fall crop	relay
Number farmers reporting	22	17	20	20	30	10
Average field size (ha)	0.46	0.53	0.44	0.44	0.48	0.43
Value of output/ha (US$)	601	600	482	975	1,038	384
Human labor/ha (hrs)	485	407	543	552	564	647
Animal power/ha (hrs)	136	146	94	81	58	72
Machine power/ha (hrs)	6	14	0	28	16	4
Compost/ha (kgs)	5,797	5,818	1,577	5,045	8,546	12,774
N/ha (kgs)	74	39	36	87	84	132
P/ha (kgs)	41	13	15	46	38	57
K/ha (kgs)	75	40	41	105	106	93
AVP*/human labor (hrs)	1	1	1	2	2	1
AVP/animal power (hrs)	4	4	5	12	18	5
AVP/machine power (hrs)	100	43		35	65	96
AVP/kg of compost	1	1	1	1	1	1
AVP/kg of N	8	15	13	11	12	3
AVP/kg of P	15	46	32	21	27	7
AVP/kg of K	8	15	12	9	10	4

*AVP = Average value product.

2. The contribution that inorganic fertilizers made to increase in yield did not differ significantly according to soil type. However, analysis on a seasonal basis showed significant influence of fertilizer on yield in two districts. In the second season crop in Miaoli, potassium fertilizer increased yields an average of 411 kg per $1 invested. In the Kaohsiung district fall season crop, the addition of $1 worth of phosphorus increased yield by 1042 kg.

3. Compost was found to have little influence on sweet potato yields in any of the regions.

4. Other investments such as those in insecticides and seedlings had a significant influence on sweet potato yield only on sandy soil and loam soil.

Attitudes of Producers and Former-Producers

Based on the interviews with 122 producers of sweet potato and 68 former producers who have now abandoned the crop we came to the following conclusions:

1. The farm size of current sweet potato producers is 1½ times that of former-producers, but the cropping intensity index per unit area on the land of current producers is higher than that of former-producers. This suggests a very high use of labor in producing households.

2. The family size of producers is 1.2 members larger, and their families have almost 1/3 more members in the agricultural work force. They work 33 percent more hours per week in the summer and 34 percent more hours per week in the winter, which suggests that the entire farm operation of sweet potato producing households is more labor intensive than that of former producers.

3. Sweet potato producers tend to grow less rice and more field crops than those who quit, suggesting that the availability of irrigation water is a key factor in decisions to switch from sweet potato and dry land crops.

4. Low yields of sweet potato are not a significant determinant of abandonment, as shown by the fact that producers are getting only 17 tons per hectare while former-producers got 20 tons per hectare. Only 29 percent of former-producers said they stopped planting sweet potato because of low yield.

5. Current sweet potato producers raise 72% more hogs than former-producers and use a much higher percentage of sweet potato chips in their feed mixture. Thus, hog-raising is directly related to the cultivation of sweet potato.

6. The management background of producers is not significantly different from that of former-producers. Producers have about one year less of education, are one year older, and have only slightly

lower general levels of education in the family than former-producers.

7. The main crops which have replaced sweet potato are sugarcane, rice, corn, tomato, and peanut, in that order. The main competing crops cited by current producers are corn, sugarcane, peanut, tomato, and soybean.

8. Sweet potato is intercropped by about 37% of current producers as compared to a similar percentage for former-producers. More of the former-producers, however, said their purpose in intercropping was to increase income.

9. Fifty-four percent of the producers rotate their sweet potato production plots. The main reasons they give for rotating are to improve soil conditions and because there is a larger system of rotation on the farm. The main reasons given for planting in the same plot were: (a) limited number of parcels, and (b) wanted to plant sweet potato only on rainfed land.

10. Thirty-eight percent of the farmers are willing to add more fertilizer (although we have seen that this may not necessarily contribute to higher income), while 20 and 32 percent, respectively, are willing to increase their use of insecticides and irrigation.

11. The major problems of growers in 1976 were natural constraints, insects, low yield, and low price, in that order.

12. Only 48% of all the farmers interviewed listed insect problems in the 1975-76 growing season. The main pests they cited were weevil, sweet potato leaf folder, and aphid.

13. The conditions under which current producers would plant more sweet potato are (a) an increase in sweet potato price (which is unlikely in view of the downward shift in demand over time), (b) an increase in farm land area, (c) an increase in hog price, and (d) an increase in sweet potato yield.

14. Farmers seem unaware of the possibilities of reducing production costs as an alternative to increasing yields in making sweet potato production more profitable.

The cost and return pattern revealed in the survey poses a dilemma for researchers. Should they try to elevate yields under optimum conditions (fall) still further? This would tend to increase the peak season production and lower prices to farmers. This might or might not benefit consumers and starch manufacturers because low prices eventually cause farmers to switch to other crops.

An alternative is to concentrate on developing low cost input technology for the first and second season crops. The country's increase in production might be negligible but the farmers who lacked alternatives to growing sweet potatoes would be more likely to benefit.

The new AVRDC variety 35-2 is giving excellent yields and has a high beta carotene content.

Breeding Tastier, More Nutritious Sweet Potato Varieties

EXPANDING THE WORLD GERMPLASM COLLECTION

We received additional cultivars in 1976 from the Philippines, Singapore, and Indonesia, giving us a total of 374 cultivars. A large seed collection of improved populations was also received from the USDA Vegetable Breeding Laboratory, Charleston, South Carolina.

Fifty-nine crosses were made in early 1976, most of them single crosses involving cultivars with one or more desirable traits (Table 7). This was fewer than usual because some parental lines did not flower at all and other lines didn't flower simultaneously.

Our entomologist identified six cultivars which showed low preference by weevil and fair yield. We are now using these cultivars in our crossing program, along with six lines which flower more readily to allow interpollenation among them.

SEGREGATING POPULATIONS

The seeds we produced and received gave us 3,269 genotypes (Table 8). All genotypes were increased and planted in replicated trials for preliminary observation.

Table 7. Sweet potato crosses made in 1976.

Kind of crosses	No. of crosses
Resistance to witches' broom	14
High β-carotene	10
Good eating quality	17
High yield and protein content	18
Total	59

Table 8. Summary of information on segregating populations, 1976.

Populations		No. of genotypes
Cross-combinations		259
Open-pollinated seeds:	IITA	1,828
	USDA	1,182
Total		3,269

Screening for Minimum-input Cultivation

The cropping intensity in Asia and the Far East is low because about 80% of the arable land is dependent upon seasonal rains, lasting about 5 months. Rice is the dominant crop during the monsoon season. After the rainy season the residual moisture may be just enough for a month's growth of another crop but not sufficient to bring a crop to maturity. Also, many of the farmers cannot afford the high cost of inputs for crops other than rice. Therefore, a drought-tolerant, minimum input sweet potato could probably increase the present low cropping intensity in these areas.

We examined field performances of our sweet potato materials to determine if minimum input varieties can be developed for planting immediately after a rice harvest. We grew 194 cultivars and 495 breeding lines in a field previously planted to rice to select for genotypes that would give good yield under low level fertility, low management, and water stress (Trial I in Table 9). After the rice harvest the field was rotovated, bedded, and planted. No irrigation, pesticide, or fertilizer was applied. The materials with the best yields in this screening were

In trials to screen accessions for performance under minimum input, a number of lines were found that produced well in spite of little weeding and no irrigation, pesticides, or fertilizer investment.

evaluated further (Trial II) following the same procedure. In our first screening yields ranged from 0 to 17.8 t/ha for the cultivars and 0 to 19.5 t/ha for selections. In Trial II, the yields ranged from 0 to 12.9 t/ha for the cultivars and 0 to 8.4 t/ha for selections. The yield difference between Trial I and Trial II could be attributed to the colder weather and excessive weed competition for food, water, and light from *Chenopodium* sp. which characterized the growing conditions in Trial II. The weeds grew to a height of about 1.5 m and probably reduced drastically the solar radiation that the sweet potato received. The experimental plots, however, were weeded three weeks before harvesting for ease of gathering yield data.

The yields were impressive considering that the only inputs involved were minimal land preparation and planting of sweet potato cuttings. Average sweet potato yield in most tropical Asian countries is about 8 t/ha.

In both trials, the crops depended on residual moisture and natural precipitation to meet their water requirements. In Trial I, natural precipitation was 97 mm during the entire cropping season with 604 mm of evaporation. In Trial II it was 128 mm with 646 mm of evaporation. Optimum yield is generally obtained with 530-660 mm of precipitation during the growing seasons.

Most of the minimum input selections were either yellow- or white-fleshed. We are looking for orange-fleshed lines, which are rich in β-carotene. The flowering selections can facilitate our breeding program since non-flowering types may not flower even with appropriate treatments. Selection 0122-2 has both these characters.

During the wet season of 1976, the good yielding accessions and selections from Trial II were classified into table and industrial

Table 9. Highest yielding sweet potatoes under minimum input conditions.

Varietal name	Marketable yield Trial[a] I	Trial[b] II	mean	Root flesh color	Flowering habit[c]
	t/ha				
Cultivars:					
Tainung 31	18	7	12	White	F
Taiwan 2	17	9	13	"	NF
PI 315342	14	5	10	"	F
PI 344129	14	14	14	"	NF
PI 318548	14	4	9	Yellow	F
Tainung 10	14	9	11	Yellow	NF
Tainan 14	13	5	9	White	NF
PI 344123	13	13	13	Yellow	NF
PI 318849	12	-	12	Yellow	F
Tainung New 10	12	9	10	White	NF
Tainung 57 (check)	11	4	8	White	F
Selections:					
278-1	20	8	14	Yellow	NF
277-1	18	5	12	Yellow	F
0122-2	16	8	12	Orange	F
272-8	15	2	8	Yellow	NF
015-10	15	2	8	Orange	NF
010-2	14	4	9	Yellow	NF
272-2	13	8	11	Yellow	F
171 (check)	4	2	3	Orange	NF

[a]Planted November 15, 1974 and harvested April 19, 1975 (155 days); based on yields from 10 hills. [b]Planted Nov. 19, 1975 and harvested April 21, 1976 (153 days); based on yields from 20 hills. [c]NF=non-flowering; F=flowering.

varieties on the basis of flesh color and entered into preliminary yield trials in a field previously planted to rice. After the rice harvest, the field was rotovated, bedded, and planted. Again, no pesticide or

supplemental irrigation was applied. A total of 30 kg N/ha, 60 kg P/ha, and 90 kg K/ha, however, was supplied in one basal application and one side dressing. The results are in Table 10.

In both groups, some breeding lines outyielded the local checks. These yields too, were impressive considering the amount of inputs invested.

Table 10. Performance of minimum input selections (table cultivars i.e. orange root flesh) compared to local cultivar; 1976, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree (or varietal name)	Marketable yield (t/ha)	Pest rating score (T)[b]	Rat damage counts (T)[b]
Table cultivars (orange root flesh)				
0122-2	B 6708 (OP)	26	1.8	4.6
209-2	B 6708/OK-9-3	24	2.0	2.4
272-9	Red Tuber Tail/Allgood	21	1.5	1.5
016-2	HDK 12 (OP)	20	1.7	3.8
171 (check)	Tainung 63	14	1.8	3.2
	L.S.D. 0.05	5	0.3	1.5
Industrial cultivars (white of yellow root flesh)				
(154)	Tainung 10	27	1.9	1.6
(5)	Tainung New 10	25	2.0	2.3
(57) (check)	Tainung 57	19	1.7	2.2
(115)	PI 344123	18	1.5	1.1
276-2	Red Tuber Tail/OK 6-3-1-6	17	1.8	1.7
	L.S.D. .05	6	0.3	1.4

[a]Planted July 28 and harvested Dec. 6 (130 days). [b]Data were transformed using $\sqrt{X + 0.5}$ before analysis.

Screening for Moisture Tolerance

In 1975, we were not able to obtain reliable marketable yield data because our experimental plots were under water many times. We observed that while the tops showed luxuriant growth, numerous small roots were produced which failed to enlarge. We had also observed that our yields were better when we planted during the wet period and harvested during the dry period. In 1976 our screening trials for marketable yield were planted in the latter part of the wet season.

In the moisture tolerance screening, we included 124 and 203 cultivars for table and industrial use, respectively. The table varieties were

Typhoons and heavy rainfall are an annual summer threat to vegetables in much of the tropics. Sweet potatoes are the least damaged and go ahead and produce suitable yields after waterlogging at AVRDC.

divided into 2 sets, the industrial varieties, into 4. All entries were planted in a 5-meter, single-row plot spaced at 0.30 meter between hills and one meter between rows. The randomized complete block design with two replications was used. The experimental plots were irrigated prior to bedding. After that, no additional irrigation was applied. No pesticide application was made. A total of 30 kg/ha, 60 kg P/ha, and 90 kg K/ha was supplied in one basal application and one side dressing. Marketable yields varied from 0 to 9 t/ha for the table and 0 to 4 t/ha for the industrial cultivars.

Yield Trials

Our yield trial entries were divided into two groups: table and industrial varieties. Within each group two sets of trials based on maturity (early and late) were conducted. Trials were conducted in spring and summer of 1976. Each entry in all the trials occupied a 6-meter, 4-row plot, spaced at one meter between rows and 0.3 meter between plants. The randomized complete block design with 3 replications was used. The fertilizer rates were 30 kg N/ha, 60 kg P/ha, and 90 kg K/ha. Split application of fertilizer was followed. Just before making the beds, fertilizers at the rate of 60 kg P/ha and 45 kg K/ha were incorporated in the soil and then at about 1½ months after planting 30 kg N/ha and 45 kg K/ha were side dressed. No pesticide was applied in any of the trials. In the winter trials, two supplemental irrigations were given; the summer trial did not receive any supplemental irrigation.

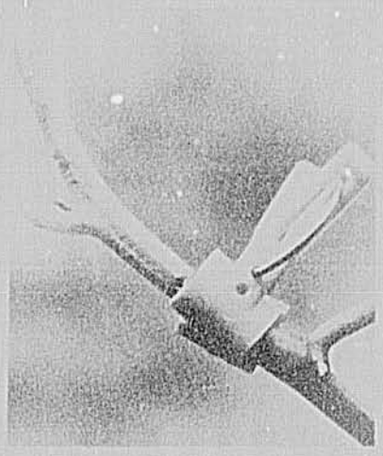
Significant differences in marketable yields were observed, except for the early maturing industrial selections. Combined analysis of variance

Table 11. Best performing sweet potato selections compared to local cultivars; 1975-76, AVRDC.[a]

AVRDC selection (or acc. no.)	Pedigree or cultivar name	Marketable yield[b] winter	summer	average	Pest[c] rating score	Rat damage counts
		---------- t/ha ----------				
Early maturing						
Table selections:						
35-2	HDK 6/B 6708	15	19	17	1.6	4.0
35-1	HDK 6/B 6708	6	24	15	1.3	4.8
171 (check)	Tainung 63	2	14	8	1.7	2.8
LSD (.05)		3	5	4	0.5	2.4
Industrial selections:						
010-2	HDK 8 (OP)	14	20	17	1.6	3.1
57 (check)	Tainung 57	10	16	13	1.8	3.2
LSD (.05)		4	8	4	n.s.	n.s.
Late maturing						
Table selections:						
209-3	B 6708/OK 9-3	5	33	19	1.9	3.2
171 (check)	Tainung 63	3	19	11	1.1	2.2
LSD (.05)		n.s.	4	2	2.7	1.6
Industrial selections:						
243-2	B 6708/Tainung 56	21	19	20	1.8	2.6
272-9	Red Tuber Tail/allgood	19	21	20	1.9	0.7
152 (check)	Red Tuber Tail	17	16	17	1.5	0.7
LSD (.05)		6	5	4	0.4	0.9

[a]Data are means of 3 replications; combined analyses of variance were conducted for yield after variances were found homogeneous using Bartlett's test for homogeneity of variance. [b]Winter trial planted Oct. 28 (1975) and harvested April 6 (160 days); summer trial planted July 28 and harvested Nov. 15 (119 days). [c]Data are based from summer trial only; data were transformed to $x + 0.5$ before analysis of variance.

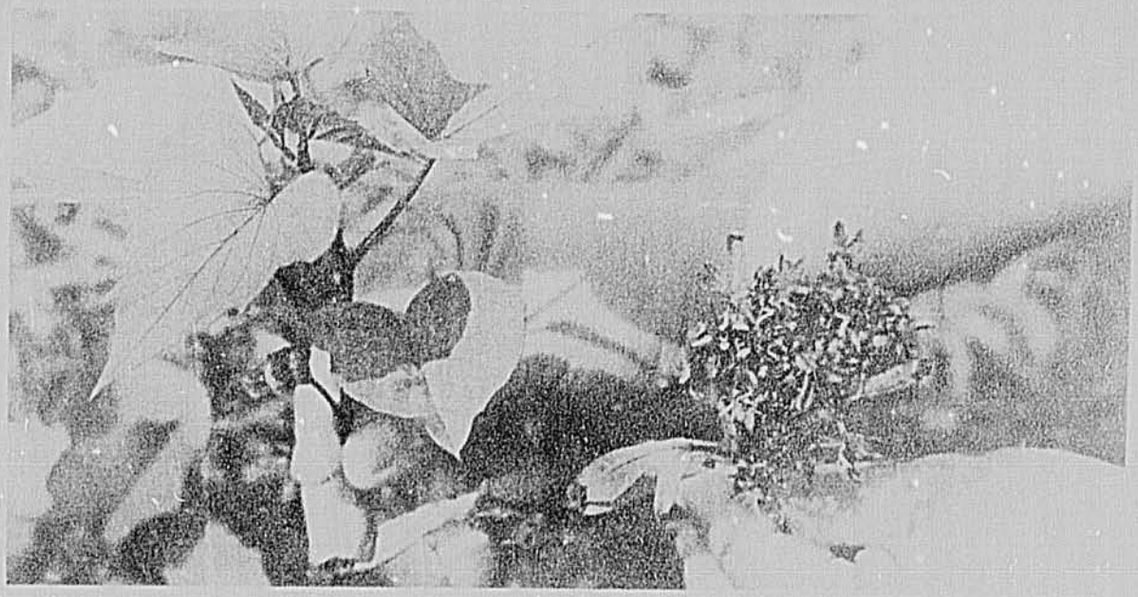
Some sweet potato varieties do not flower naturally in Taiwan. To encourage flowering for breeding purpose, workers graft nonflowering varieties to root stock of varieties that flower. Clockwise: making the cut in root stock stem, inserting stem of nonflowering variety, clamped graft, and the workers.



showed significant interaction between season and cultivars which indicates that some cultivars yield better in summer and some yield better in winter. In general, however, the yields were higher during the summer trial than during the winter trial (Table 11). This may be accounted for since selections were made for warm weather production. There were, however, a few selections which yielded equally well regardless of season.

Tip Yield Trials

Sweet potato leaf tips serve as additional green leafy vegetables during the wet season when it is difficult to grow other leafy vegetables



AVRDC accession 117 continued to show resistance to witches broom in heavily infected fields at Penghu Island (the Pescadores).

efficiently. Tips are commonly eaten in the Philippines, Indonesia, and other parts of Southeast Asia. We conducted a second productivity evaluation (the first was conducted in 1975) of cultivars which we found to posses tips having acceptable attributes for human consumption. Ten cultivars were included in this trial. We used a randomized complete block design with three replications. All 15-cm long tips were harvested six consecutive times at 14-day intervals, except the last harvest which was carried out after 25 days.

The yield and other horticultural traits of the promising entries are given in Table 12. Tip weight yields varied from 10 to 16 t/ha, and number of tips varied from 613,000 to 1,176,000 per hectare. (The eating quality evaluation will be discussed under a separate heading below.) When the roots were dug 130 days after planting, we found that some entries could yield as high as 15 t/ha in spite of the high tip harvesting frequency. The effect of the high harvesting frequency was quite noticeable in the case of Dilaw, Kinangkong, and HM 16 which gave little root yield.

Resistance to Witches' Broom

Cuttings of five sweet potato accessions that were selected for resistance to witches broom in 1975 screening trials at Chi Din were planted at a heavily infested area in 1976 at Penghu Island to confirm their resistance.

Alternate spreader rows of mycoplasma-infected susceptible sweet potatoes were used to amplify the spread of the causal organism. Only one of the 5 accessions (acc. no. 117) was confirmed as resistant to sweet potato witches' broom under the epiphytotic conditions of Penghu (Table 13).

Table 12. Tip yield, tip acceptability scores, and root yield of 10 sweet potato cultivars; 1976, AVRDC.[a]

AVRDC acc. no.	Cultivar name	Tip yield[b] wt	Tip yield[b] no.	Tip yield[b] T[c]	Acceptability of tips[d]	Marketable root yield[e]	Flesh color of root
		(t/ha)	(1000/ha)		(7 to 1)	(t/ha)	
212	Dilaw	16	1415	38	4.3	2	Yellow
229	Kinangkong	14	3525	59	4.7	1	White
119	PI 344138	14	1863	43	5.2	15	Yellow
112	PI 344120	14	2082	46	5.5	15	Yellow
8	Daja 380	13	744	27	4.6	10	Yellow
104	PI 318856	12	1250	35	5.0	16	Orange
33	Earlyport	11	968	31	4.7	9	Orange
127	HM 16	11	1307	37	4.9	3	Orange
31	Rose Centennial	10	613	25	5.0	6	Orange
1	BNAS-White (check)	11	1233	36	4.9	12	Yellow
	LSD 5%	3		5	ns	3	

[a]Planted Jul 28; data are means of 3 replications. [b]Harvest 6 times at 14-day intervals from Sep 6 to Nov 23. [c]Transformation using square roots of the no. of tips/ha. [d]Means of scores of 21 taste panel members with 2 replications; 7 (highly acceptable) to 1 (highly unacceptable). [e]Harvested Dec 6 (130 days).

Table 13. Disease rating of 5 cultivars of sweet potato to the witches' broom infection planted at Penghu, 1976.

Accession no.	Varietal name	% infection[a]
117	PI 344129	0
8	Daja 380	14
172	American Yellow Skin	28
115	PI 344123	33
12	HDK 3	100

Planted: April 15, 1976. Inoculation: Natural epiphytotic conditions. Reading taken: July 16, Aug 10, Aug 20 and Sept 10, 1976. [a]Cultivars exhibiting less than 8% infection are considered resistant; 8 to 20%, intermediate; and 21 to 100%, susceptible.

Sensory Evaluation of Leaf Tips and Roots

Three organoleptic evaluations were conducted to assess the eating quality of leaf tips and roots of promising cultivars. Twenty-one panel tasters were involved in the leaf tip evaluation; 51 and 30 tasters participated in the two root tasting panels.

Samples for leaf tip evaluation were prepared by blanching about thirty 10 cm tips for each entry for 3 minutes in boiling water. Then they were placed on white plates and served to the taste panel for evaluation. The eating quality characteristics assessed by the panels were tenderness, flavor, stem color, leaf color, hairiness, and general acceptability.

The root samples were prepared by slicing the roots into pieces about 5 mm in thickness and steaming them in a pressure cooker for 15 minutes. The steamed samples were placed on white plates and served to the taste panels for evaluation of their flavor, dryness, stickiness, color, and general acceptability. Analysis of data suggests that for subsequent tasting it would be appropriate to separate the panel by nationality.

In the root evaluation, two check cultivars were used, one from the Philippines and the other from Taiwan (Table 14). Taste panels compared selections 031-3 and 35-2 favorably with Tainung 63 and rated them better than BNAS-white as far as flavor was concerned. Except for selection 128, all other entries had better flavor than BNAS-white, the Philippine check. Selections 031-3, 272-6, and 35-2 were scored as dry as BNAS-white.

All entries were comparable in stickenss with the checks except selection 35-1. The panels scored selections 031-3 and 35-2 as more acceptable in color than BNAS-white but comparable with Tainung 63. They scored selection 128, which was purple, the lowest under this category. Other entries were rated slightly acceptable, except for selection 031-3 and Tainung 63, which were generally rated acceptable.

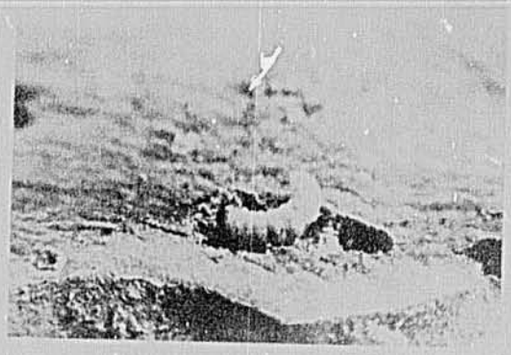
Table 14. Average eating quality scores of seven sweet potato cultivars.[a]

AVRDC selection or acc. no.		Eating quality characteristics				
		flavor	dryness	stickiness	color	acceptability
		-- scores:1 unacceptable to 7 highly acceptable ---				
031-3	Rose Centennial (OP)	5.61	5.21	5.26	5.71	5.73
35-2	HDK 6/B 6708	5.32	5.09	5.16	5.24	5.19
35-1	HDK 6/B 6708	4.78	4.58	4.61	5.09	4.82
272-6	Red Tuber Tail/allgood	4.84	5.05	5.03	4.08	4.69
128	PI 315345/Acadian	4.03	4.78	4.86	3.58	4.10
171 (check)	Tainung 63	5.35	4.98	5.06	5.48	5.61
1 (check)	BNAS-white	4.39	5.12	5.06	4.73	4.60
LSD (.05)		0.26	0.19	0.20	0.38	0.23

[a] All values are means of scores of 51 taste panel members over 3 replications.

As in the leaf tip evaluation, nationality exhibited the greatest difference in mean squares for eating quality characteristics. The Chinese registered considerably higher mean squares for flavor and color, indicating their difficulty in assessing these characteristics.

In our taste evaluation, we used mostly the research staff of AVRDC. It would be desirable to use some large consumer panels in the future. However, we also hope to select a small group of 5 to 10 panel tasters for their acuity and consistency in recognizing differences among samples. We also plan to use other methods of preparation such as baking of the roots and use of sauce in evaluating leaf tips.



Weevils, the chief sweet potato insect pests, attack both roots and stems.

Select Cultivars with Resistance Sweet Potato Weevils

During 1976 we screened 65 cultivars at two locations for resistance to the sweet potato weevil (*Cylas formicarius elegantulus*). Thirty-three cultivars, selected for resistance in earlier field screening at AVRDC were planted at Penghu Island, a substation of Kaohsiung District Agricultural Improvement Station. The selections were planted in a randomized complete block design with 3 replicates and a plot size of 1 x 6 m. Sweet potato weevils were released into the field one month after planting and marketable size roots of each cultivar were evaluated at harvest. According to our evaluation criteria, i.e., number of weevil larvae, pupae, adults, and percent damaged root, 3 cultivars were ranked as resistant, 17 moderately resistant, and 11 susceptible.

Another field screening was conducted at AVRDC in the spring of 1976 in which 32 cultivars were evaluated for weevil resistance using the same procedures as in the previous experiment. Four cultivars were ranked as resistant, 12 as moderately resistant, and 15 as susceptible. Table 15 lists the infestation levels of resistant and susceptible check entries screened at both locations.

Thirteen cultivars from Penghu screening and seven from AVRDC screening were sent to our cooperators in the Philippines and Thailand for testing.

During the summer of 1976 we studied the biology of sweet potato weevils in storage to find out whether their life cycle under our storage conditions differed from what has been observed in other places. We found that the female weevil excavates a cavity just beneath the surface of the roots and deposits eggs singly or in groups of up to 26 eggs in the cavity. The egg is oval in shape with creamy-white color and grainy surface and measures about 0.50 x 0.80 mm. The incubation period lasts from 4 to 13 days. The larva is a legless grub with a light-brown head and is

Table 15. Infestation levels of resistant cultivars along with susceptible checks in two field screenings during 1976.

AVRDC acc. no.	Varietal name	Mean number of weevils/kg sample	Weevil damage rating(%)
		Penghu screening	
143	OK-8-72	0	0
108	PI 320453	0	0
134	HM-606	2.2	3.0
5	Tainung New No. 10 (check)	55.2	32.0
		AVRDC screening	
15	H-D-K-6	0	0
110	PI 324886	0	6.1
155	Tainung No. 17	1.4	0
53	PI 315345	2.6	2.6
16	H-D-K-12(check)	44.3	67.4

nearly pure white in color when hatched but changes to ivory white when it becomes mature. We observed three instars during the larval period of 18-20 days before the grub becomes a pupa. The pupa is about 5 mm long, initially pure white in color but later the eyes, wing pads, and legs turn brown to near black and the remainder of the body becomes yellowish. During the entire larval and pupal period the insect remains within the sweet potato root. The adults emerge after a pupal period of 2 to 9 days.

Chemical Control of Sweet Potato Weevil

Although five tests of insecticides for the control of sweet potato weevil were conducted in the field during 1976, none provided control that was statistically significant at the 5% level. However, from subjective comparison of the data, it was apparent the Primicid 5 G and Dyfonate 5 G banded at 3 kg and 2 kg a.i./ha, respectively, and Thiodan and Surecide sprayed monthly at 2 kg and 0.5 kg a.i./ha, respectively provided some population suppression.

We also evaluated the use of phostoxin fumigant for the control of weevil in storage. Various sizes of weevil infested roots with a total weight of approximately 0.5 kg were placed in 12-liter containers. Phostoxin tablets were added at the rate of 1.6 and 3.2 g/liter volume. The roots were dissected and weevil counts were made after a treatment holding period of 72 hours. Table 16 summarizes the results.

Table 16. Mortality of different stages of the sweet potato weevil following treatment with phostoxin.

Phostoxin dose mg/liter	Mortality (%)		
	larvae	pupae	adults
3.2	100	100	100
1.6	98	96.3	100
-	1.3	0.7	4.7

It was found that both levels of phostoxin were effective in killing this insect. Phostoxin fumigation thus appears to be an effective way of eradicating the weevil in storage. Caution must be observed in its use, however, because the phosphene gas is very toxic to mammals. A prolonged fumigation period at high humidity also tends to encourage the decomposition of the roots.

Testing Molluscicides

Giant African snail (*Achatina fulica*) is a polyphagous mollusc that attacks sweet potato in the field, especially during summer. It feeds mainly on leaves and tender stems. Among the 4 molluscicides (Mesural, Metaldehyde, Luxan Slakken, and Temik) utilized in one experiment during 1976, we found application of Luxan Slakken around sweet potato vines at a rate of 1 kg a.i./ha gave the best control.

Obtain Response from Nitrogen: None from Potassium

The first of a series of crop management experiments to determine the response of sweet potato root yield to nitrogen and potassium was conducted at the Center from November, 1975 to May, 1976. Nitrogen levels ranged from 0 to 150 kg/ha with 30 kg/ha increments, and potassium levels from 0 to 150 kg K2O/ha with 45 kg K2O/ha increments. A highly significant linear response to nitrogen was observed (Fig. 3), given by the following equation:

$$Y = 21.4 + 0.1 N$$

where Y = root yield in tons/ha and N is amount of nitrogen applied in kg/ha. No response to potassium was observed in this first

Use with Wider Range of K

Next, a sufficiency experiment was initiated with three nitrogen levels (0, 30, 60 kg/ha -- the same as in the previous trial but four potassium levels -- 0, 100, 200, and 300 kg K2O/ha -- which gave an increase in range from 100 to 300 kg/ha. Another trial was conducted with 200 kg K2O/ha distributed in four separate combinations of basal and top dressing at 30 or 50 days after planting. There was no response of

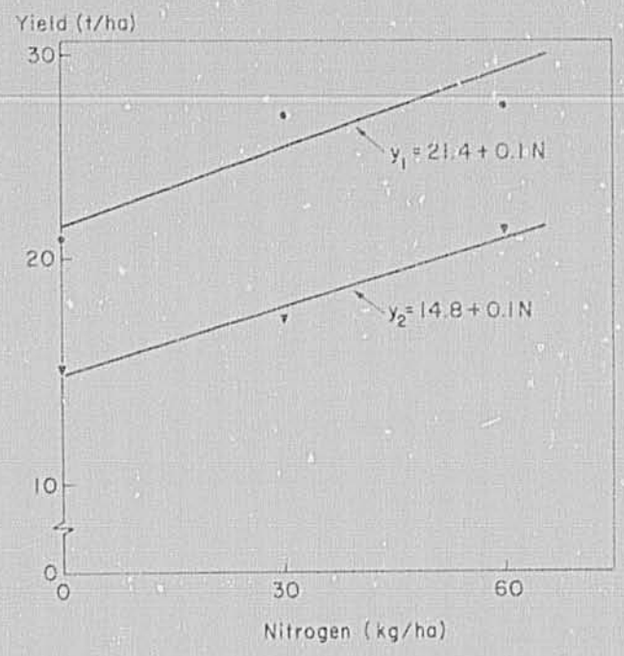


Fig. 4. Sweet potato yield response to applied nitrogen, y_1, Nov. 26, 1975 to May 26, 1976 and y_2, Sept. 6 to Dec. 12, 1976, AVRDC.

root yield to the potassium applications. There was a significant linear response of root yield to the nitrogen applications (Fig. 4) given by

$$Y = 14.8 + 0.1\ N$$

Where Y denotes root yield in tons/ha and N is amount of applied nitrogen in tons/ha. Both trials indicate that within the range of applied nitrogen studied, an addition of 10 kg N/ha increased root yield by 1 ton; or $1 invested in nitrogen produced an increase in yield of 287 kg worth about $13.50.

Sweet Potato Management Levels after Rice

To determine the most important input requirements for sweet potato production under low levels of management after the second rice crop, a series of experiments was initiated in 1975. The first experiment was designed as a randomized complete block with 3 replications and a split plot arrangement of treatments. Main plot treatments included planting methods and supplemental irrigation, and the subplots included weed control, supplemental fertilizer, and vine turning. The first experiment was harvested in 1976.

Lowest yields occurred in plots with no weed control (Table 17). *Chenopodium album* and a few other weeds predominated in the weedy plots. Where weed control was practiced, there was a significant difference in root yields between the management treatment with no fertilizer plus vine turning and the treatment with fertilizer and no vine turning. Vine turning may not be necessary during the cool-dry season. This experiment failed to indicate differences in yield between rice-stubble culture and bed culture. Supplemental irrigation and fertilizer applied at banking time both failed to increase yield.

Table 17. Yields of sweet potato roots, vine, and weed fresh weight on plots, given various management, AVRDC Dec 1975-May 1976.

Management treatments[a]			Yields		Weed
weed control	fertilizer[b]	vine turning	root	vine	fresh weight
			---------- t/ha	----------	
-	-	+	3.2	4.2	7.3
-	+	+	3.4	7.8	9.6
-	+	-	4.0	7.0	8.6
+	-	+	17.7	22.3	1.8
+	+	+	19.8	26.9	0.4
+	+	-	21.3	31.6	1.5
LSD 5%			3.2	7.0	3.2

[a]+ = Yes - = No [b]Fertilizer was 20 kg/ha N, 100 kg P_2O_5, and 60 kg/ha K_2O_5 basal; and 30 kg/ha N and 90 kg/ha K_2O side dressing at banking.

Nutritional Progress and Potential for Sweet Potatoes

Sweet potato tips were evaluated as a leafy vegetable. The terminal portions of the vines with the tender leaves are popular greens in some countries. Materials (ten cultivars) were obtained from a sweet potato tip yield trial to evaluate the nutritional constituents of selected leafy vegetable type sweet potato lines.

Analysis for Nutritional Constituents

Sweet potato tips (15 cm) were harvested at 40 days after planting. Various nutritional constituents were analyzed and compared with (Table 18) the nutritional constituents of five common leafy vegetables. The experiments led to the following conclusions:

1. There are significant varietal variations of dry matter content, vitamin B_2, vitamin C, ash content, fiber content, and oxalate content among the varieties tested.

2. Compared with other leafy vegetables, sweet potato tips provide good vitamin A, B_2, iron, and protein sources. The vitamin B_2 content of sweet potato tips probably is one of the richest vitamin B_2 sources among vegetables (including fruits and root vegetables) and this vitamin is deficient in most Asian countries including Taiwan, Korea, and possibly Japan.

Table 18. Nutritional constituents of leaf tips of 10 sweet potato cultivars[a] and of five common leafy vegetables.[b]

AVRDC acc. no.	Entry	Water	Protein	Fiber	Ash	Ca	Fe	Vit A	Vit B_2	Vit C	Oxalate
		%				mg/100g		IU/100g	mg/kg	mg/100g	
112	PI 344120	87.1	2.8	1.8	1.41	67	3.4	5390	3.7	43	3.6
33	Earlyport	87.7	2.4	1.9	1.51	72	3.6	4870	3.6	41	2.8
119	PI 344138	86.3	2.7	1.8	1.51	72	3.9	5740	3.1	35	3.4
229	Kinangkong	87.1	2.9	1.9	1.63	71	3.4	5390	3.6	37	3.9
212	Dilaw	87.8	2.7	1.9	1.65	84	3.6	3520	3.1	33	3.9
(check)1	BNAS-White	83.6	3.0	2.3	2.14	58	4.8	5290	2.9	39	3.3
8	Daja 380	86.3	2.4	2.0	1.63	72	3.6	4850	4.1	36	4.4
31	Rose Centennial	85.5	2.8	2.0	1.82	90	3.7	8320	3.6	73	4.5
127	HM 16	85.4	2.8	1.9	1.69	73	5.0	5780	3.4	32	3.0
104	PI 318856	83.9	2.8	2.2	1.79	87	4.4	6650	3.5	44	4.2
Mean		86.1	2.74	1.96	1.68	74.4	3.94	5580	3.5	41.07	3.7
LSD 5%		1.23	ns	0.28	0.26	ns	ns	ns	0.5	10.68	0.9
Nutritional constituents of five common leafy vegetables[b]											
Water convolvulus (EP)		91.8	2.3	0.9	1.0	94	1.4	4200	2.0	43	-10.0
Spinach		92.3	2.3	0.8	1.7	70	2.5	10500	1.8	60	
Amaranth, green (EP)		87.8	1.8	1.3	2.1	300	6.3	1800	2.3	17	17.5
											Amaranthus hybridus
Head lettuce		96.3	0.9	0.3	0.2	14	0.2	4300	0.3	6	-
Leaf mustard		91.7	1.6	0.6	0.8	138	0.7	2700	1.9	94	-

[a]10 cultivars were planted July 28, 1976 and 15 cm tips were harvested Sept 6, 1976. All values are means of 3 replications. [b]Adapted from T.C. Tung, P.C. Huang, H.C. Li, and H.L. Chen, "Composition of foods used in Taiwan"; from Sidki Sadik, "Oxalates contents of some leafy vegetables." Proceedings of International Institute of Tropical Agriculture Seminar 1971.

3. Oxalate is present in sweet potato tips, although the content is not so high as in amaranth and spinach.

4. The fiber content is relatively higher than in other leafy vegetables, especially when the plant is getting older (Table 19). This may reduce its acceptability.

Table 19. Fiber content of sweet potato tips at various harvest times*.

Acc. #	Entry	Days after planting 40	79	118	Mean
112	PI 344120	1.81	1.75	2.35	1.97
33	Earlyport	1.85	1.83	2.01	1.90
119	PI 344138	1.79	1.89	2.20	1.96
229	Kinangkong	1.85	2.14	2.42	2.14
212	Dilaw	1.83	1.75	2.11	1.90
1	BNAS-White (check)	2.26	2.26	2.42	2.31
8	Daja 380	2.01	2.11	2.00	2.04
31	Rose Centennial	2.03	1.99	2.57	2.20
127	HM 16	1.94	1.95	2.40	2.10
104	PI 318856	2.24	2.09	2.29	2.21
	Mean	1.96	1.98	2.28	2.07
	LSD (between harvest mean) 5%		0.08		
	LSD (between entry means) 5%		0.20		

*Date planted: July 28, 1976. 15 cm tips were harvested. All values are means of 3 replications.

Protein and Oxalate Content

Above ground portions of two sweet potato cultivars were analyzed for the distribution of protein and oxalate content. The tips consisting of the vine and leaves in the first 15 cm from the apex and the remaining leaves were separated into groups of 15 cm intervals. The distribution of each of the nutritional constituents along the stems is presented in Figure 5. Note that the oxalate contents of both varieties increased basipetally.

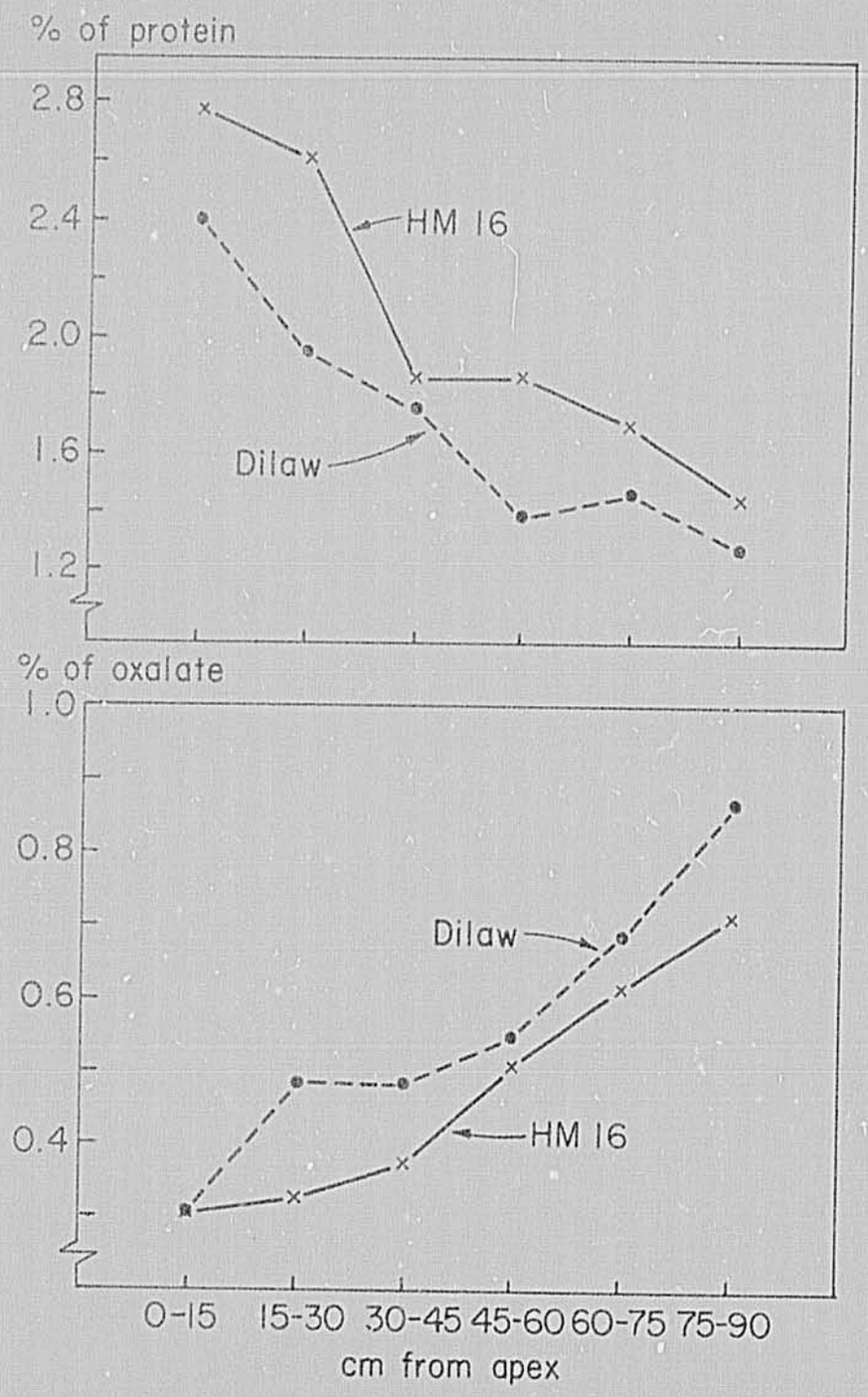


Fig. 5. Distribution of protein content and oxalate content of sweet potato leaves at various positions along the stem from 0, the tip, back toward the base.

A difference of three-fold may be obtained between the tip and older leaves. The protein content further supports the idea that only young tips of sweet potato should be eaten.

Taste Tests

Relationships were studied between physical and morphological characteristics and eating quality scores by test panels.

Some chemical or morphological characteristics of sweet potato tips were measured in the laboratory. Those analytical data were compared with the results obtained from an organoleptic evaluation in which panels failed to detect differences in the flavor, hairiness, and general acceptability. Thus tenderness was the only eating quality characteristic we used in this study. There was a significant negative correlation between tenderness and dry weight per leaf ($r=-0.717$) and diameter of stem at cutting point ($r=-0,672$). Tenderness was not significantly correlated with fiber and dry matter content in this experiment.

Relationship of Sweet Potato Yield and Protein Content

Many crops have a negative correlation between yield and protein content. The usual argument against breeding for high-protein in the staple crop is that any increase in protein is accompanied by a corresponding decrease in yield. We wanted to see if this relationship exists in sweet potato.

Four trials were associated with this project. The first trial was a yield trial conducted in 1974. Seventeen varieties were planted in AVRDC fields with three replications. The second trial was conducted in the spring of 1975. Nine varieties selected on the basis of their protein content were planted in AVRDC fields under a higher management level. The third trial was conducted in the winter of 1975 by a contracted Pingtung farmer. Ten varieties were included in this experiment. Again a higher management level was applied. The fourth trial was the fertilizer experiment conducted by crop management in the winter of 1975. Only one line was planted under 15 different fertilizer treatments.

Sweet potato samples were analyzed for their dry matter content and protein content with the over (105°C) dry method and the micro-kjeldahl method.

The ranges of yield and protein content of these four trials are summarized in Table 20. The correlation coefficients between yield and protein content are also given. First trial yields were relatively low but had a wider range of protein content among lines. The negative correlation coefficient between yield and protein count was not significant in the first trial but was highly significant in the second and third trials (Table 20). In the fourth trial we found a highly significant positive correlation. In the second trial yield was improved by better management but the protein content was reduced. Results of the first three trials indicate that there is a negative correlation between yield and protein content.

Table 20. Range of root yield and protein content in four sweet potatc trials.

Trials	No.of entries	Root yield dry	Root yield fresh	Protein content of dry	Protein content of wet	Correlation coefficient dry	Correlation coefficient wet
		----- t/ha ----		----- % ------			
1	17	0.4- 6.3	1.1-24.4	4.6-8.6	1.3-2.3	-0.40	-0.30
2	9	1.8-10.0	5.8-41.1	1.6-6.5	0.4-1.7	-0.78**	-0.83*
3	10	3.2- 7.1	12.5-30.8	4.5-6.6	1.0-1.8	-0.82**	-0.87**
4	1	4.9- 7.6	4.9-31.9	3.0-4.4	0.6-1.1	0.75	0.68

*Significant at the 5% level. **Significant at the 1% level. [a]Trial 1 - 3 replications low management level. Trial 2 - 3 replications, high management level. Trial 3 - 6 replications, high management level. Trial 4 - 3 replications, 15 management treatments.

The fourth trial shows a different side of the picture. One line (AVRDC selection 35-2) was planted under different levels of nitrogen and potassium. Nitrogen significantly increased both the yield and the protein content of the root (Fig. 6). A highly positive correlation between these two characteristics was observed in this experiment.

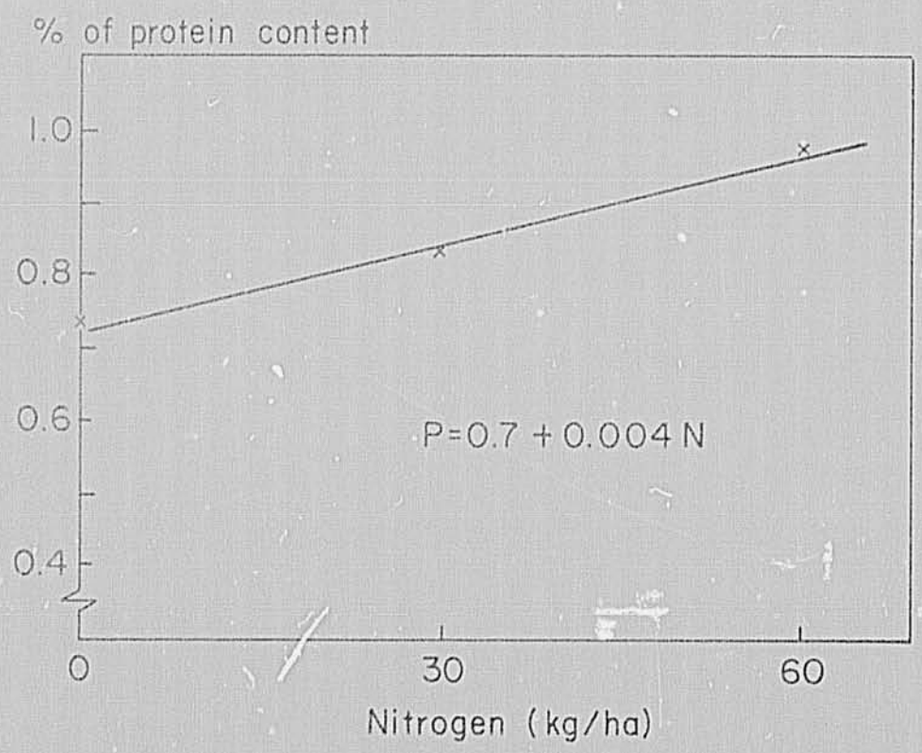


Fig. 6. Swee' potato protein content response to applied nitrogen; Nov. 26, 1975 to May 26, 1976, AVRDC.

Three of the accessions used were included in the first three trials. The yield performances of those lines and their protein contents are summarized in Table 21.

Table 21. The root yield and protein content of three accessions included in three sweet potato trials.[a]

Acc. no.	Trials					
	I		II		III	
	yield	protein[b]	yield	protein[b]	yield	protein[b]
	t/ha	%	t/ha	%	t/ha	%
30	5.4	2.3	5.8	1.7	12.5	1.7
171	10.2	2.1	13.5	1.7	14.9	1.5
167	1.1	1.32	41.1	0.4	23.9	0.9

[a]Some trials as first 3 trials in Table 20. [b]Fresh weight basis.

Trainees enrolled in AVRDC's vegetable research and production short courses study in the classroom and do at least one field experiment under direction of scientists.

Training Program

AVRDC's research and production training programs offer a wide range of opportunities to vegetable research workers and production specialists in tropical countries. The participants learn by doing at the side of AVRDC's scientific staff. Upon their return home, they strengthen national programs and serve as valuable cooperators in the testing of AVRDC breeding materials and technology under local conditions.

During 1976, 57 trainees from 9 countries participated in various training programs. Trainees working on sweet potato research included:

Chaiyerg Saguansupyakorn, Thailand - Effects of photoperiod, grafting, and some chemicals on flora induction in sweet potato.

Concepcion E. Magboo, Philippines - Yield and yield components of two sweet potato varieties at three harvest periods.

Rong Sheng Liu, R.O.C. - Yield trial of promising sweet potato selections.

Su-hua Chen, R.O.C. - Heat stability of sweet potato trypsin inhibitors.

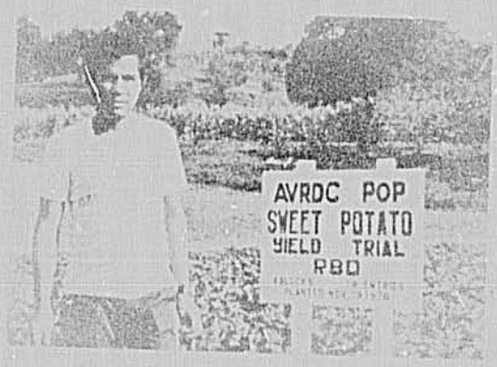
Kuo-Chin Lin, R.O.C. - A preference test of sweet potato weevil for selected sweet potato varieties at the AVRDC controlled-environment room, 27°C, 65-89% RH.

International Cooperation

Philippine Outreach Program

Promising plant material was selected from an initial collection of 400 sweet potato accessions and breeding lines from AVRDC planted at the Economic Garden in Los Baños and saved for increase. Along with later additions from Taiwan and from the Philippines, this material served as a basis for distribution to 11 different agencies in the Philippines as well as 2 agencies outside the Philippines for increase and further testing in different locations (Table 22). Visayas State College of Agriculture, where the Root Crops Research Center of the Philippines is located, received the largest collections -- a total of 503 accessions.

At the Economic Garden, 6 preliminary yield trials were planted in November and December, 1975 with minimum input under rainfed conditions; they were harvested in May, 1976. As usual for sweet potato, the results were variable. Entry PI 344129 did well under both minimum and conventional input conditions, but AVRDC selection 1-2 which produced the highest yield under minimum input did not rank well in the conventional input trial



AVRDC sweet potato lines are being tested in many countries. Upper left, Q. E. Eusebio, BPI researcher stands beside the test plots of AVRDC's Philippine Outreach project at Los Baños. Upper right, selections at the Los Baños field are checked for diseases. At right, AVRDC scientist (left) checks roots of AVRDC lines being tested by researchers at the Taiwan Agriculture Research Institute near Chiayi.

Table 22. Sweet potato material distributed in 1976 by the Philippines Outreach Program.

Date	Organization	Material distributed
Jan. 14, 1976	Central Luzon State University (Dr. F.F. Campos)	Varietal increase 40 cultivars.
March 2, 1976	Don Severino Agricultural College (M. Ocampo & M.B. Matel)	Varietal increase 54 varieties
March 3, 1976	Development Academy of the Philippines (M. Gunzi)	Varietal trial 5 varieties
March 3, 1976	Central Mindanao University (J.D. Escarlos)	Varietal trial 5 selections
March 14, 1976	Visayas State College of Agriculture (Dr. M. Villanueva)	Sweet potato germplasm collection 446 varieties
March 4, 1976	V I S C A (Dr. M. Villanueva)	Sweet potato germplasm collection 57 varieties of tubers
March 22, 1976	C M U (J.D. Escarlos)	Varietal increase 16 varieties
March 22, 1976	Mindanao State University (Dr. A. Bautista)	Varietal increase 16 varieties.
April 2, 1976	United States Agency for International Development (R. Wackernagel)	Small yield trial 12 varieties
Sept 6, 1976	Davao Fruit Corporation (R. Castro)	Varietal increase 78 entries
Nov. 14, 1976	AVRDC Taiwan (Dr. R. L. Villareal)	Germplasm collection 10 varieties
Nov. 25, 1976	Palawan National Agricultural College (Dr. James Eder)	Varietal increase 6 entries
Dec 9, 1976	Bangladesh Agricultural Research Council (Dr. M.A. Mannan)	10 entries 10 cuttings each
Dec. 17, 1976	Philippine Packing Corporation (Dr. W. Schnitzler)	89 entries 5 cuttings each

(Table 23). Central Luzon State University reported 143-1 as yielding 41 t/ha in 110 days during which time the local check failed to prodece fleshy roots.

Other Philippine Cooperation

Francico E. Mercado, scientist II, and his associates of the Philippine Sugar Institute conducted a yield trial of some AVRDC sweet potato breeding lines as intercrop with sugarcane. Only one of 18 cultivars, selection 14-1, produced a suitable yield, 10 t/ha.

Servillano R. Gumasing reported a study he conducted to determine the yield of some AVRDC breeding lines when harvested at different maturity dates. The experimental plots were neither fertilized nor irrigated. The yields were generally low for all entries except for selections 015-9, 0125-1, and the check, BNAS-white. For some selections, yield continued to increase up to 140 days. However, most entries appeared physiologically mature in 120 days. In the groups left 140 and 160 days, most entries started to sprout.

At the Institute of Plant Breeding, IPB, Dr. Azucena L. Carpena grew 14 entries in a rice paddy. No tillage was done and cuttings were planted in dug-out hills at 45,000 plants/ha. Fertilizer rates applied were 60-90-90 kg of N, P, and K/ha. Watering of single hills was done only once, immediately after planting. Only two entries, selection 35-1 and the check, BNAS-white, gave suitable yields of 15 and 11 t/ha, respectively. These yields were very impressive considering the extreme hardness of the paddy soil. It was observed that selection 35-1 produced roundish roots and developed at the upper layer of the ground surface as opposed to the subterranean types which had elongated roots that burrow deeper into the ground. The former type fits better under highly compacted clay paddy soils.

Bangladesh

Andy Ryskamp, agriculturalist of the Mennonite Central Committee, Bangladesh, obtained some of our sweet potato breeding lines. The interest of their group in sweet potato is to introduce to Bangladesh varieties that are richer in vitamin A, since local varieties are white-fleshed ones that are low in this vitamin. Orange fleshed selections 35-1 and 200-2 gave the highest yields, 16 and 11 t/ha respectively, in 118 days.

Thailand

In Thailand, two trials were conducted by Mrs. Somporn Drabyasara and her associates. One trial was conducted at Pachong Training Farm and the other at Kampangsan Station. Our breeding materials were comparable with the check cultivar as far as yields were concerned. Mrs. Sompaorn reported, however, that our selections were softer and had poorer keeping quality than Okud. The most serious defect of all entries, including Okud, was susceptibility to weevil damage. We plan to send them either seeds or seedlings of our materials with improved resistance to weevil.

Table 23. Mean yields of marketable fleshy roots for the top 2 entries and the check from rainfed sweet potato trials located at the Economic Gardon, Philippines.

Trial	No. of entries	Rank of entry within trial	Name of AVRDC no.	Cross	Mean marketable yield t/ha	Mean marketable yield % of check	Mean total root yield (t/ha)
MINIMUM INPUT A Nov. 1975	12	1	1-2	BNAS WHITE/HDK 8	13	130	18
		2	BNAS(check)	-	10	100	14
		3	HDK-12	-	10	96	14
		...					
MINIMUM INPUT B Nov. 1975	12	1	PI 318548	-	13	167	15
		2	PI 153907	-	12	154	13
		3	BNAS(check)	-	8	100	9
		...					
MINIMUM INPUT C Nov. 1975	12	1	DAJA 380	-	11	215	13
		2	PI 344129	-	10	200	11
		...					
		7	BNAS(check)	-	5	100	6
		...					
CONVENTIONAL INPUT Nov. 1976	19	1	PI 344129	-	32	107	33
		2	BNAS(check)	-	30	100	31
		3	PI 318548	-	29	97	30
		...					
		12	1-2	BNAS WHITE/HDK 8	14	47	15
		...					

Appendix

Crop Environment

Weather. The amount of precipitation in 1976 (1357 mm) at AVRDC was 42% less than that occuring in 1975 (2380 mm) and 23% below the 73-year mean of 1771 mm/yr (1897-1970)[a]. There were 75 rainy days (normal is 107) and most of the rainfall occured in July and August (Fig. 1). In addition, available solar energy for 1976 was 1.3% above the 5-year average for Tainan City (Fig. 2).

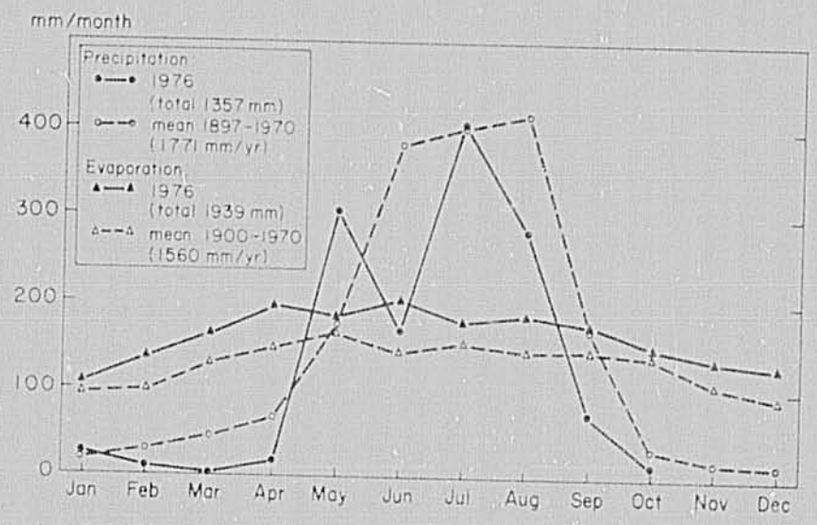


Fig. 1. Monthly precipitation and evaporation data for 1976 at AVRDC compared with means from 1897 to 1970 and from 1900 to 1970, respectively, for Tainan City. (Reference: Central Weather Bureau, 1974, Summary to meteorological data -- Taiwan. Vol III).

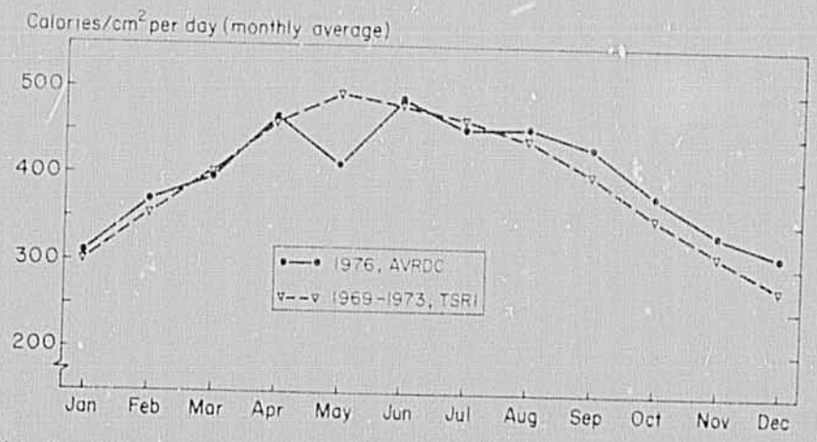


Fig. 2. Solar radiation during 1976 at AVRDC compared with 5-year average at Tainan City.

---

[a] Central Weather Bureau. 1974. Summary of Meteorological Data-Taiwan, Vol. III. Taipei, Taiwan, R. O. C.

Daytime temperatures were high from May through October (above 30°C), and minimum temperatures were above 21°C (Fig. 3). During the winter months (Dec, Jan, Feb), temperatures often dropped below 14°C, and daytime maximum temperatures ranged from 22°C to 25°C. Soil temperatures (10 cm depth) were slightly cooler than the mean daytime temperatures.

The day length at AVRDC ranges between 13 hr and 33 min on Jun 21 to 10 hr and 43 min on December 21. If civil twilight is considered, an additional hour and 20 minutes should be included.

During 1976, three weak tropical storms occured; however, damage to experimental crops in the field was minimal.

Soil. Although four soil series are present in the Experimental Farm, 80% of the area consists of the Take series. In general, the soil is moderately well drained and is derived from a calcareous alluvial parent material. The soil type is a silt loam with approximately 1.4% organic matter.

The mean bulk density of the soil is 1.67 g/cm^3. The water available to plants ranges from 23% (field capacity) to 8% (wilting point). The experimental fields are irrigated, when necessary, from wells ranging in depth from 20 to 50 m.

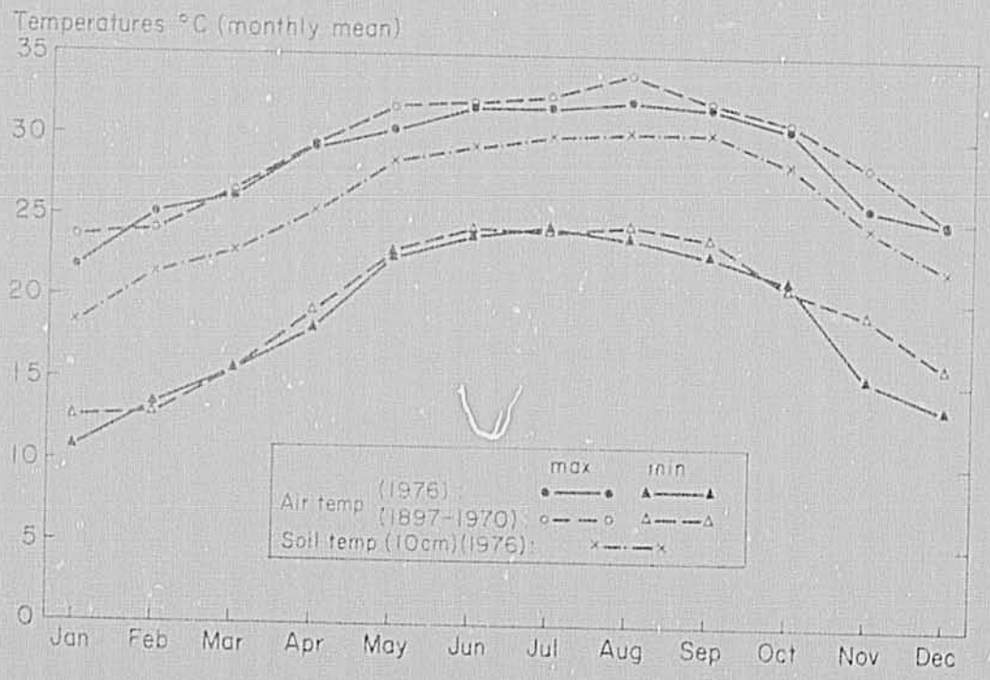


Fig. 3. Temperature ranges for 1976 compared with the means for Tainan City (1897-1970). Soil temperatures (10 cm depth) for 1976 are also included.

Index to Accessions

Acc. no.	Country of origin	Variatal	Pages
1	Philippines	BNAS-White	27,28,29,37 38, 46, 47
5	Taiwan, ROC	Tainung New 10	21, 22, 31
6	Taiwan, ROC	Tainung New 21	21
8	Indonesia	Daja 380	27, 28, 37, 38, 47
10	Laos	HDK 8	47
12	Laos	HDK 3	28
15	Laos	HDK 6	23, 29, 31
16	Laos	HDK 12	31, 47
18	Taiwan, ROC	Taiwan 2	21
25	USA	Acadian	29
26	USA	Allgood	22, 23, 29
30	USA	Centennial	42
31	USA	Rose Centennial	27, 37, 38
33	USA	Earlyport	27, 37, 38
53	USA	PI 315345	29, 31
54	USA	PI 318548	21, 47
57	Taiwan, ROC	Tainung 57	22, 23
58	Taiwan, ROC	Tainan 14	21
71	Japan	PI 153907	47
93	Philippines	PI 315342	21
104	Peru	PI 318856	27, 37, 38
106	Peru	PI 318859	21
108	Peru	PI 320453	31
110	New Hebrides	PI 324886	31
112	Thailand	PI 344120	27, 37, 38
115	Ryukus Island	PI 344123	21, 28
117	New Guinea	PI 344129	21, 26, 28, 44, 47
119	New Caledonia	PI 344138	27, 37, 38
122	USA	B 6708	23, 29
127	USA	HM 16	26, 27, 37, 38
134	USA	HM 606	31
136	USA	OK-6-3-106	22
143	USA	OK-8-72	31
151	USA	OK-9-3	22, 23
152	Taiwan, ROC	Red Tuber Tail	22, 23, 29
154	Taiwan, ROC	Tainung 10	21, 22
155	Taiwan, ROC	Tainung 17	31
164	Taiwan, ROC	Tainung 56	23
167	Taiwan, ROC	Tainung 60	42
171	Taiwan, ROC	Tainung 63	21, 22, 23, 28, 29, 42
172	USA	American Yellow Skin	28
212	Philippines	Dilaw	26, 27, 37, 38
229	Philippines	Kinangkong	26, 27, 37, 38

Index to Crosses

Breeding no.	Parentage	Pages
1-2	BNAS-White/HDK 8	44, 47
10-2	HDK 8 (OP)	21, 23
14-1	Sweet Potato 45/HDK 12	46
15-9	HDK 6 (OP)	46
15-10	HDK 6 (OP)	21
16-2	HDK 12 (OP)	22
31-3	Rose Centennial (OP)	28, 29
35-1	HDK 6/B6708	23, 28, 29, 46
35-2	HDK 6/B6708	18, 23, 28, 29, 41
122-2	B 6708 (OP)	20, 21, 22, 23
125-1	B 7078 (OP)	46
128	PI 315345/Acadian	28, 29
143	Tainung 57/Tainung 63	46
200-2	B 6708/Centennial	46
209-2	B 6708/OK 9-3	22
209-3	B 6708/OK 9-3	23
243-2	B 7078/Tainung 56	23
272-2	Red Tuber Tail/Allgood	21
272-6	Red Tuber Tail/Allgood	28, 29
272-8	Red Tuber Tail/Allgood	21
272-9	Red Tuber Tail/Allgood	22, 23
276-2	Red Tuber Tail/OK 6-3-106	22
277-1	Red Tuber Tail/OK 6-3-118	21
278-1	Tainung 27/HDK 8	21

Board of directors

Dr. T. H. Shen (Chairman)

Consultant, Joint Commission on Rural Reconstruction
Taipei, Taiwan, Republic of China

Dr. Arturo R. Tanco, Jr. (Vice Chairman)

Secretary of Agriculture and Natural Resources
Manila, Republic of the Philippines

Dr. Prakorb Kanjanasoon

Director General, Dept. of Agri., Ministry of Agriculture and Cooperatives,
Bangkok, Kingdom of Thailand

Dr. Chung-Il Choi

Director, Horticultural Experiment Station, Office of Rural Development
Suweon, Republic of Korea

Dr. Tadayoshi Sugiyama

Professor of Horticulture, Tokyo Agricultural College
Japan

Dr. Nyle C. Brady

Director, International Rice Research Institute
Los Banos, Laguna, Republic of the Philippines

Dr. Vernon W. Ruttan

President, Agricultural Development Council, Inc.
Singapore

Dr. Robert F. Chandler, Jr.

Route 1, Petersham Road, Templeton, Mass. 01468
United States of America

Dr. Hsiung Wan

Director, Taiwan Agricultural Research Institute
Taipei, Taiwan, Republic of China

Dr. James C. Moomaw

Director, Asian Vegetable Research and Development Center
Shanhua, Tainan, Taiwan, Republic of China

Personnel

Administration

James C. Moomaw, Ph.D., *director*
C. L. Luh, M.S., *associate director (administration)*
James J. Riley, Ph.D., *associate director (research)*
Michael Chin, B.S., *executive officer*
David I. K. Chi, B.A., C.P.A., *comptroller*
J. H. Chen, B.S., *superintendent, buildings and grounds*
Christina Chang, B.S., *manager, food and dormitory services*

Horticultural Crops Program

Ruben L. Villareal, Ph.D., *program leader & plant breeder (tomato & sweet potato)*
- Sen-Hsiung Lai, B.S., *research assistant*
- Tai-Lih Hu, B.S., *research assistant*[+]
- Long-Sheng Chang, B.S., *research assistant*

Romeo T. Opeña, Ph.D., *associate plant breeder (white potato & Chinese cabbage)*
- San-Ho Lo, *research assistant*
- Cheng-Feng Hsieh, B.S., *research assistant*

Wa-Lee Lim, Ph.D., *post doctoral fellow in plant pathology*
- Oi-Cheng Ng, B.S., *research assistant*
- Lih-Chyong Su, B.S., *research assistant*[+]
- Hsiao-Lin Hu, B.S., *research assistant*
- Lee-Yun Pai, B.S., *research assistant*[+]
- Su-Yi Lee, B.S., *research assistant*

James J. S. Tsay, M.S., *research assistant (plant physiology)*
- Li-Jean Wang, M.S., *research assistant*

Robert I. Rose, Ph.D., *entomologist*
- Chich-Yeong Su, M.S., *research assistant*
- Chin-Lin Wang, M.S., *research assistant*
- Shang-Ping K. Luo, B.S., *research assistant*

Legume Program

Charles Y. Yang, Ph.D., *program leader & plant pathologist*
- Chung-Chuan Yen, M.S., *research assistant*
- Wang-Ching Ho, M.S. *research assistant*[+]
- Tian-Chen Wang, B.S., *research assistant*
- Li-Fan Hu, B.S., *research assistant*
- Li-Ping Yan, B.S., *research assistant*[+]
- Morgan H. M. Ueng, B.S., *research assistant*

Hyo-Guen Park, Ph.D., *associate plant breeder (mungbean)*
- Nung-Che Chen, M.S., *assistant plant breeder*[+]
- Chien-Nan Yang, M.S., *research assistant*
- Shing-Huan Wu, B.S., *research assistant*
- Tai-Yun Chyau, B.S., *research assistant*

S. Shanmugasundaram, M.S., *scientific associate in plant breeding (soybean)*
Tong-Shroung Toung, B.S., *research assistant*
Chao-Chin Wang, B.S., *research assistant*

George C. C. Kuo, Ph.D., *associate plant physiologist*
Mei-Chu Hsu, M.S., *research assistant*[+]
An-Ching Cheng, M.S., *research assistant*
Fu-Hsing Hsu, M.S., *research assistant*[+]
Min-Ho Chou, B.S., *research assistant*

Hsueh-Wen Kao, M.S., *research assistant*[+] *(entomology)*
Chang-Yuang Chang, B.S., *research assistant*
Chun-Rong Wei, *research assistant*
Shih-Shin Chiang, M.S., *research assistant*

Tsai-Sheng Teng, B.S., *research assistant (chemistry)*

Nutrition, Environment, and Management Program

Samson C. S. Tsou, Dr., *program leader & associate chemist*
Su-Ching L. Chiu, B.S., *chemical analyst*[+]
Min-Seh Hsu, B.S., *chemical analyst*
Shieh-Te Tan, M.S., *research assistant*

N. S. Talekar, Ph.D., *scientific associate in pesticide residue analysis*
Lian-Tien Sun, M.S., *research assistant*[+]
Ehr-Min Lee, B.S., *research assistant*

Raymond D. William, Ph.D., *crop management specialist*[+]
Mou-Yen Chiang, B.S., *research assistant*
Yu-Chi Roan, B.S., *research assistant*
Jing-Ju Chen, B.S., *research assistant*[+]
Steve S. M. Lin, M.S., *research assistant*

Merle R. Menegay, M.S., *scientific associate in agricultural economics*
Peter H. Calkins, Ph.D., *associate agricultural economist*
Kuang-Rong Huang, M.S., *research assistant*
Han-Chou Liaw, M.S., *research assistant*[+]
Hu-Mei Wang, M.S., *research assistant*
Shu-Yuh Huang, B.S., *research assistant*
Chiung-Pi Liu, B.S., *research assistant*
I-Jean Cheng, B.S., *statistical assistant*

Takashi Yoshida, Ph.D., *soil scientist*[+]
Takayuki Yoshizawa, Ph.D., *soil scientist*
Maw-Sheng Lin, M.S., *research assistant*
Ray-Kuen Lin, B.S., *research assistant*
Chih-Ping Chu, B.S., *research assistant*
Chi-Min Huang, B.S., *research assistant*

Outreach Program

John N. Hubbell, Ph.D., *associate horticulturalist, Philippine Outreach Program*

TRAINING, COMMUNICATIONS, AND RESEARCH SERVICES

Diosdado V. Castro, M.S., *associate training specialist*
Mou-Sung Lin, M.S., *training assistant*[+]
Cheng-Ching Kuei, *training assistant*
Henry H. J. Lee, *training assistant*[+]
Sui-Ting Chen, B.S., *training assistant*

Charles S. Taylor, M.Mg't., *associate information specialist*
Tsui-Hsia A. Menegay, M.A., *coordinator of vegetable preparation manual project*

Teng-Hui Hwang, B.A., *librarian*

Yi-Sung Chen, B.S., *farm superintendent*[++]
Yung Liang, *acting farm superintendent*

Leonard I. L. Ho, M.S., *seed technologist*

Su-May J. Wang, B.S., *computer services assistant*

[+] Left during 1976

[++] On leave for 2-year mission to Saudi Arabia.

Publications

AVRDC makes available, upon request, reprints of technical papers written by its staff members. The annual Progress Report, and reports detailing research activities with AVRDC's six vegetable crops are also available. These publications may be obtained by writing to the Office of Information Services at AVRDC. Be sure to include your complete address. All AVRDC publications are free and will be sent by surface mail.

AVRDC mailing address: P. O. Box 42, Shanhua, Tainan 741, Taiwan, Republic of China

AVRDC Technical Bulletin Series (TB):

TB 1 Menegay, M. R. 1975. Taiwan's specialized vegetable production areas: an integrated approach.

TB 2 Menegay, M. R. 1976. Farm management research on cropping systems.

TB 3 Calkins, P. H. 1976. Four approaches to risk and uncertainty in farm management extension.

AVRDC Journal Paper Series (JP)

JP 1 MacKenzie, D. R., L. Ho, T. D. Liou, Henry B. F. Wu, and E. B. Oyer. 1975. Photoperiodism of mungbean and four related species. HortScience, Vol. 10(5):486-487.

JP 2 MacKenzie, D. R., N. C. Chen, T. D. Liou, Henry B. F. Wu, and E. B. Oyer. 1975. Response of mungbean and soybean to increasing plant density. Journal of American Society of Horticultural Sciences, 100(5):579-583.

JP 5 Mew, I-Pin, C., T. C. Wang, and T. W. Mew. 1975. Inoculum production and evaluation of mungbean varieties for resistance to *Cercospora canescens*. Plant Disease Reporter, 59:397-401.

JP 6 Mew, T. W. and W. C. Ho, 1976. Varietal resistance to bacterial wilt in tomato. Plant Disease Reporter, 60:264-268.

JP 7 Mew, T. W., W. C. Ho, and L. Chu. 1976. Survival and infectivity of soft rot bacteria in Chinese cabbage. Phytopathology, 66:1325-1327.

JP 8 Talekar, N.S., L. T. Sun, E. M. Lee, and J. S. Chen. 1977. Persistance of some insecticides in subtropical soils. Journal of Agricultural and Food Chemistry, 25(2):348-352.

JP 10 Talekar, N. S. Gas-Liquid Chromatographic Determination of Alphacyano-3-phenoxybenzul alpha isopropyl-4-chlorophenylactate residues in cabbage. Accepted by Journal of Association of Official Analytical Chemists.

JP 16 Villareal, R. L., F. C. Mercado, S. H. Lai, and T. L. Hu. Fruit-setting ability of heat-tolerant, moisture-tolerant, and traditional tomato cultivars grown under field and greenhouse conditions. Accepted by Philippine Journal of Crop Science.

Editor : Paul Gwin, Prof.

Design, artwork, and layout : Chang Foo-Fu

Typesetting : Mrs. Emma Wun

Photography : Shao Li-Ting

Darkroom work : Cheng Bor-Fu

Printing : Tsai Jung-Huei

Distribution : Christine Huang

Cover printed by Chiu-Yu Printing Co., Ltd., Tainan

Published by the Office of Information Services
at AVRDC, Feb. 1978

FOR MORE INFORMATION, WRITE

OFFICE OF INFORMATION SERVICES
AVRDC, P.O. BOX 42
SHANHUA, TAINAN, 741
TAIWAN, R.O.C.