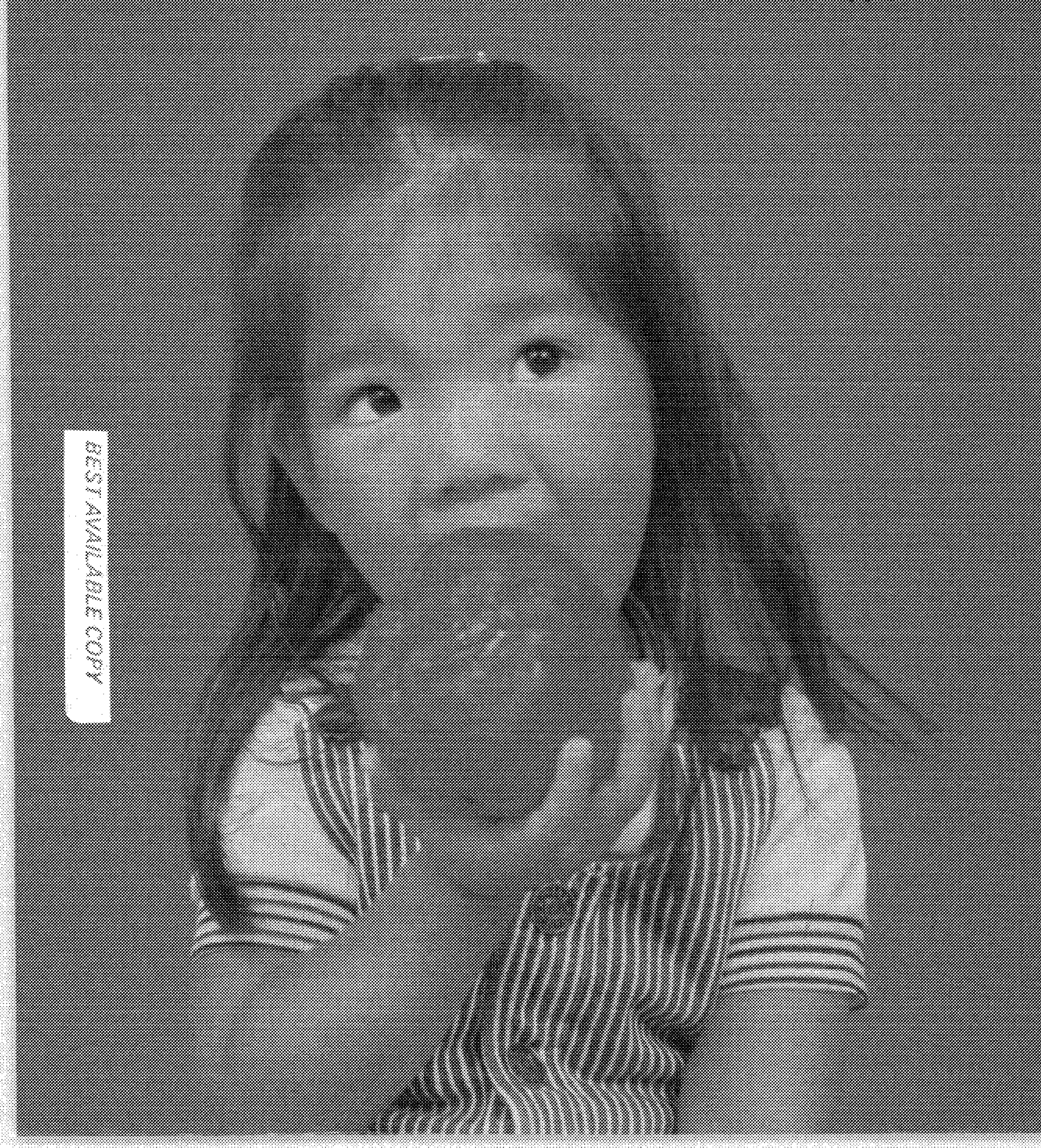
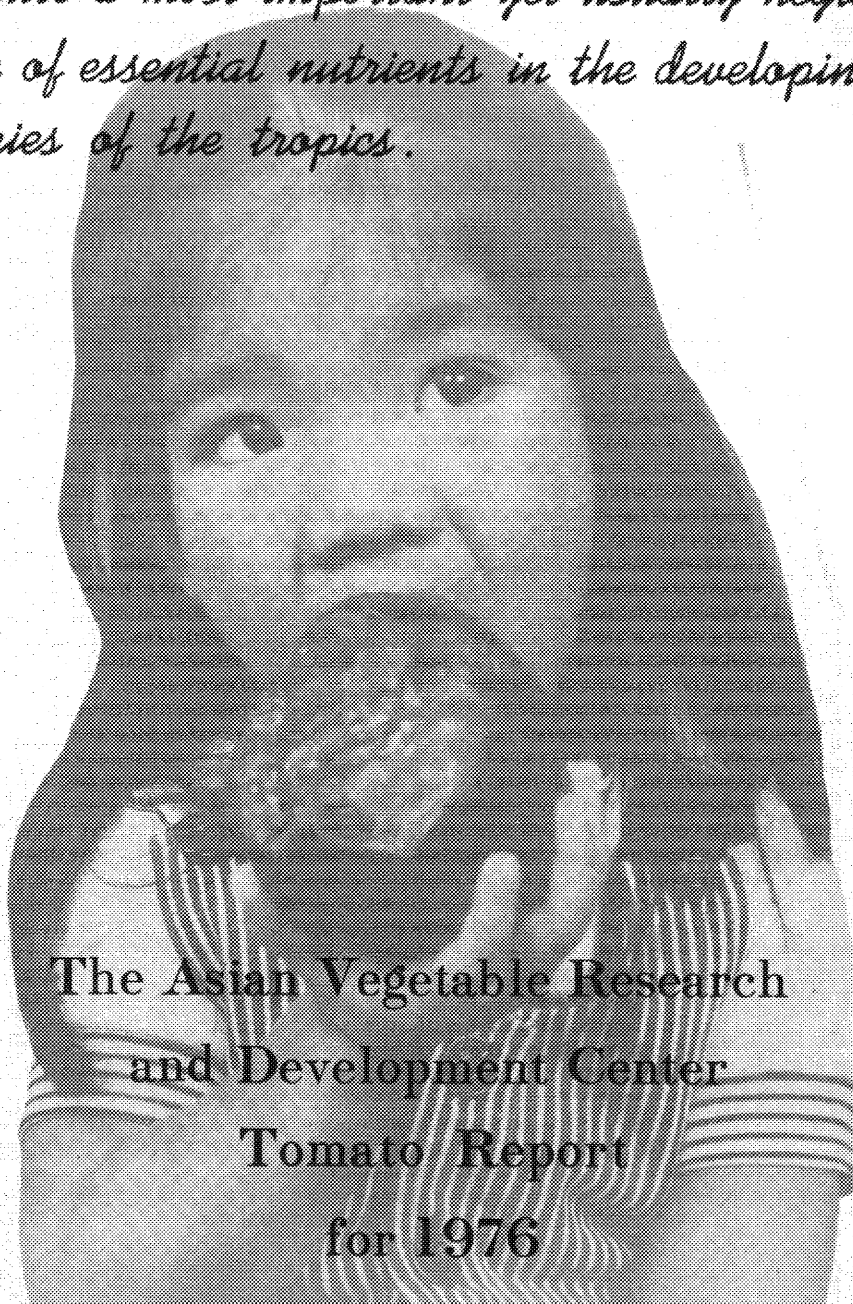
VRDC TOMATO REPORT '76



PN-AAG-213

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 Tomato 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 Tomato 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. Ruben L. Villareal, tomato coordinator, or the research worker directly responsible.

Research reports are published summarizing 1976 activities in white potato (*Solanum tuberosum*), Chinese cabbage (*Brassica pekinensis*), sweet potato (*Ipomoea batatas*), mungbean (*Vigna radiata*), and soybean (*Glycine max*). These reports and other technical papers (see page 44) 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 44 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 bar (/), e.g. VC 48-1/Manalucie. 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.

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

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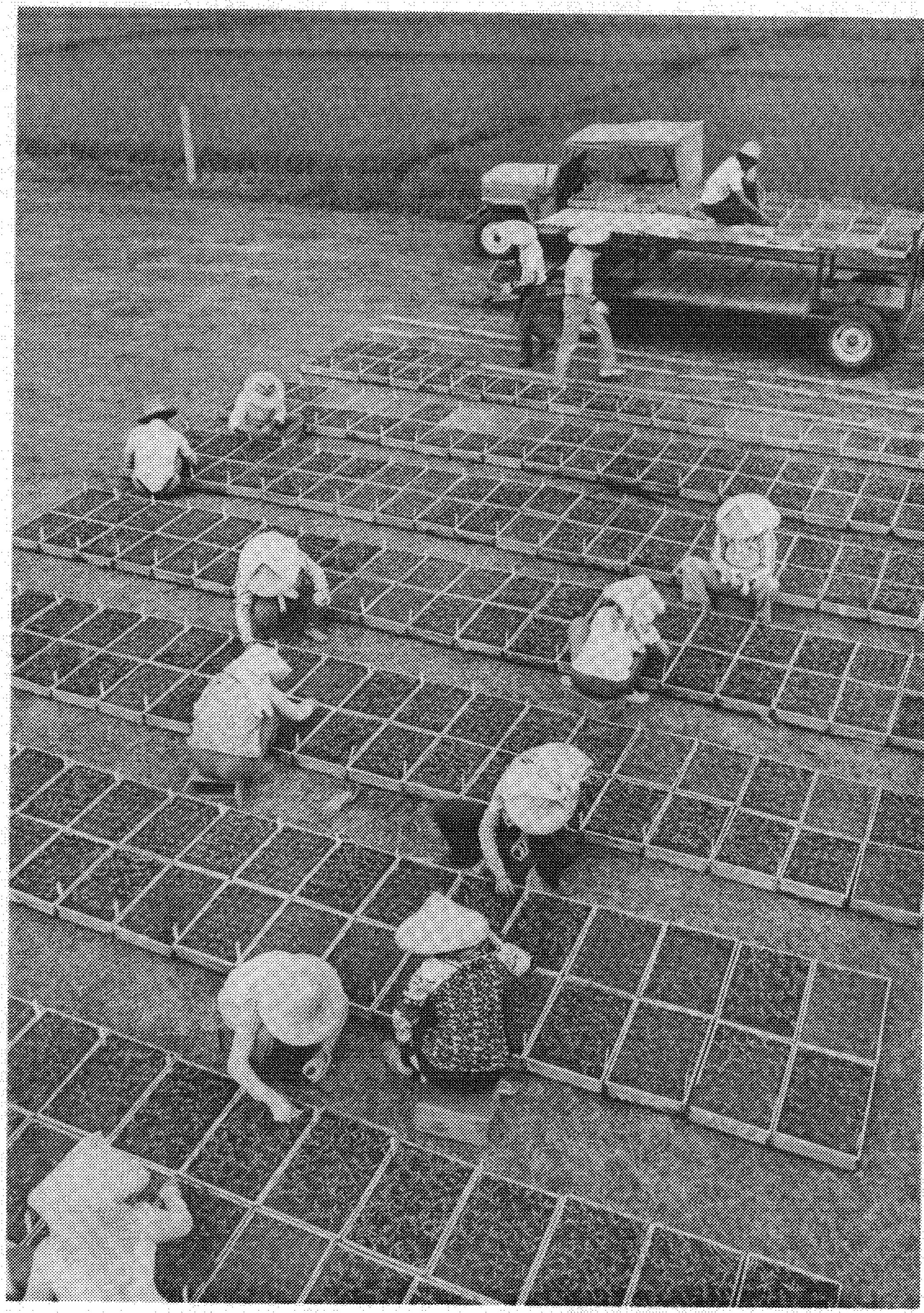


AVRDC workers inoculate thousands of tomato seedlings with bacteria each year in search of wilt resistant strains.

The Asian Vegetable Research and Development Center Tomato Report for 1976

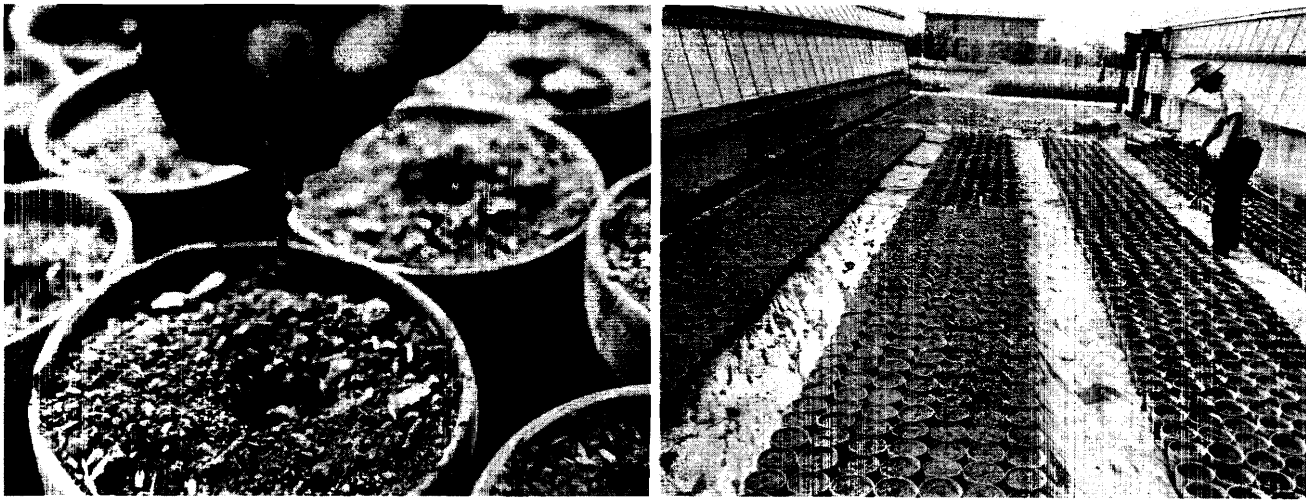
Tomato Research Objectives

*Greater yields under the humid conditions of the lowland tropics

*Varietal resistance to bacterial wilt, tomato mosaic virus, late blight, and other tropical diseases

*Increased size and quality of tomatoes produced during the hot season for both the fresh market and processing

*Development of management practices to permit genetically improved cultivars to flourish under tropical monsoon conditions



The world's germplasm collection (more than 4050 accessions to date) is methodically planted and searched at AVRDC for heat tolerance, disease resistance and yielding ability in the tropics.

Breeding

Objective in the tomato breeding program is to develop new varieties that will set fruit during the hot, rainy season in the tropics and have high resistance to such diseases as bacterial wilt, tobacco mosaic virus, and to a number of fungus diseases.

Segregating Populations

Thousands of early and advanced generation lines have been screened for resistance to bacterial wilt, leaf molds, gray leaf spot, and late blight. Our tomato segregating populations are either pedigreed or bulked especially those materials that we intend to introduce to the national tomato industry.

This year a modified single seed descent was used as a method of advancing generations of segregating populations. (See 1974 AVRDC Annual Report for description). By fall, 1977, we plan to advance 1000 genotypes of the crosses in Table 1 to the F_4 generations so F_5 single seed descent lines will be available to cooperators throughout Southeast Asia and some other tropical countries by early 1978.

Screening for Heat Tolerance

Another 8 cultivars with heat tolerance potential were found in 1976 AVRDC screening (Table 2). Planting was done between July 8 and 15 so fruit would have to set at a time when minimum night temperatures were above 22°C, our definitive criterion for heat tolerance.

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Table 1. List of segregating populations advanced through SSD, AVRDC.[a]

AVRDC cross no.	Pedigree
1084	VC 48-1/Saturn// ah TM-2a/VC 11-1
1094	VC 9-1/Florida MH-1// ah TM-2a/VC 8-1-2-1
1104	VC 9-1/Saturn// ah TM-2a/VC 11-1
1131	VC 48-1/Tamu Chico III //ah TM-2a/VC 11-1
1154	VC 9-1-2-1/Venus// VC 11-1-2-1/Venus
1169	Floradel TM-2nv/VC 9-1-2-9// VC 9-1-2-9

[a]1000 genotypes per cross are being advanced. Crosses were made to recombine selections with heat tolerance, bacterial wilt resistance, and resistance to leaf diseases such as TMV, grey leaf spot and leaf molds.

Table 2. Distribution of tomato germplasm according to fruit-setting ability when minimum night temperatures were above 22°C; 1976, AVRDC.

Observed fruit-setting	Screening		Total	Proportion
	previous	1976[a]		
	-----(no. of cultivars)-----			(%)
None	3058	134	3192	79
Light	548	74	622	15
Moderate	163	35	198	5
Heavy	30	8	38	1
Totals	3799	251	4050	100

[a]Planted in 6 sets from Jul 8 to 15; 4-m^2 plots; 2 replicates.

These 8 bring to 38 the total number of accessions with heat tolerance potential identified by AVRDC after screening 4050 cultivars from

79 countries over the past three years. One of the new additions, PI 341155, is of special interest because it bears much larger fruit than any of the heat tolerant plants found previously.

Several of our selections from 1975 were planted on a series of different dates to check their yield performances throughout the year. Each trial had 50 entries, including 46 breeding lines and 2 each of fresh market and processing cultivars as checks. Each entry occupied a two-row plot, spaced 1.5 m between rows and 0.4 m between plants.

Just before forming the beds 40 kg N, 152 kg P_2O_5, and 60 kg K_2O per ha were incorporated in the soil as a basal dressing. One to two weeks after transplanting, the tomato plants were side dressed with 40 kg N/ha. A final application of 40 kg N and 60 kg K per ha was applied four to five weeks after transplanting, just before hilling up.

Table 3. Yield of the best entries in monthly plantings of fresh market and processing tomato breeding lines; 1976, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Date of trials: Feb-May	Mar-Jun	Apr-Jul	Average yield
	Fresh market tomato:	(t/ha)			
143-0-48-1-0	VC 48-1/Tamu Chico III	20	26	12	19
143-0-6-9-0	VC 48-1/Tamu Chico III	17	24	9	17
9d-0-3-6-0	VC 11-1-2-1B/Saturn	15	19	11	15
11d-0-2-2-0	VC 9-1-2-9B/Venus	17	18	11	15
(388)	(Green Skin)[b]	12	7	7	9
LSD 5%		6	6	4	
	Processing tomato				
143-0-48-1-0	VC 48-1/Tamu Chico III	24	26	12	21
143-0-10-3-0	VC 48-1/Tamu Chico III	23	21	15	20
7-0-5-1-0	VC 11-1-2-1B/Florida MH-1	23	24	11	19
11d-0-1-2-0	VC 9-1-2-9B/Venus	17	20	13	17
(124)	(TK 70)[b]	18	21	9	16
LSD 5%		7	ns	3	

[a]All values are means of 3 replications. [b]Check cultivars.

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Monthly plantings of both fresh market and processing tomato selections showed a clear trend toward lower yields as night temperatures and rainfall began to increase (see Table 3 and temperature chart, page 44). The new breeding lines included selections from late blight crosses which are not heat tolerant, so yields, as expected, were not high. However, some of our selections in the April planting produced respectable yields of about 15 t/ha at a time when tomatoes were becoming scarce in the local markets. In all trials, some of the AVRDC selections had higher yields than the check.

Winter Yield Trials

In winter yield trials at 2 locations in Taiwan, 9 processing tomato breeding lines had average yields that were more than double that of the local check TK 3 (Table 4).

High yields were demonstrated by a number of cultivars and AVRDC selections when grown as early as October in our experimental fields (Table 5). Chico III was particularly remarkable because it yielded 100 t/ha but its fruit size was small. It may not be accepted in Taiwan

Table 4. Yields and other horticultural traits of the 9 best processing tomato breeding lines planted at two locations in the fall; 1976, AVRDC.

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Marketable yield average	Y. Mei[a]	AVRDC[b]	Fruit size[c]	Days to flower[c]
		(t/ha)	(t/ha)	(t/ha)	(g)	(no.)
32d-0-1-10-0	VC 9-1-2-3/Venus	66	50	83	67	31
33d-0-2-1-0	VC 9-1-2-3/Saturn	63	56	71	45	27
32d-0-1-25-0	VC 9-1-2-3/Venus	60	51	70	54	33
32d-0-1-13-0	VC 9-1-2-3/Venus	57	50	64	63	31
32d-0-1-7-0	VC 9-1-2-3/Venus	56	42	69	63	28
32d-0-1-2-0	VC 9-1-2-3/Venus	56	46	65	66	29
122-0-1-2-0	ah TM-2a/VC 11-1	56	46	65	41	26
179-0-1-4-0	VC 11-1/Tamu Chico III	55	45	66	30	26
32d-0-1-11-0	VC 9-1-2-3/Venus	54	43	66	62	30
(123)	(TK 3)	25	24	27	48	34
LSD 5%		13	14	13	13	5

[a]Planted at Yeong Mei in southern Taiwan Nov 16 (1975). [b]Planted at AVRDC Nov.(1975).
[c]Data from AVRDC planting.

Table 5. Yield and other traits of promising local selections compared to a commercial variety, 1975-76, AVRDC.[a]

AVRDC acc. no.	Pedigree or cultivar name	Marketable yield	Fruit size	Days to flowering	Total solid	Citric acid	pH
		t/ha	(g)		(Brix)	(mg/100g)	
3855	Chico III	101	17	23	4.2	367	4.4
3953	Niagara VF 317	93	100	27	3.7	365	4.3
124	TK 70-4[b]	92	86	24	4.6	460	4.2
3926	Niagara VF 315	92	86	25	3.9	353	4.3
123	TK 3-4[b]	90	44	23	4.5	450	4.2
319	VF 145-21-4	89	116	29	4.4	346	4.4
3978	TK T-2	89	73	24	4.3	292	4.4
124	TK 70-5[b]	88	79	24	4.7	448	4.3
124	TK 70-6[b]	88	88	22	4.3	416	4.3
115	Roma[c]	54	79	31	4.4	327	4.6
LSD 0.05		30	15	5	0.4	92	0.1
0.01		39	20	6	-	122	0.2
C.V. (%)		25	12	11	12.8	14	1.8

[a]Planted Oct 14 (1975); harvested in 7 pickings beginning Jan 6 and ending March 9, 1976; all values are means of 3 replications. [b]AVRDC selection from original cultivar. [c]Check cultivar.

because the farmers prefer to grow large fruited tomato for ease of harvesting. The processing qualities such as total solids, citric acid, and pH, however, were comparable with those of the check and in some cases even better.

August plantings were made to compare some of our selections to the local cultivars for early winter supply of market tomatoes. The performances of our August plantings are summarized in Tables 6 and 7. Among the fresh market selections, selection 9d-0-0-1-0 yielded the highest with fruit size comparable to that of the check, White Skin. Selection 114-5-5-0 on the other hand was comparable in yield to that of the check but it had bigger fruit (78 g/fruit). In the processing group, two selections, 7-0-5-1-0 and 123-2-4-0 out-yielded the commercial cultivar, TK 70. Again 114-5-5-0 had comparable yield to that of the check but with bigger fruit.

Table 6. Performances of <u>fresh market</u> tomato selections compared to a local cultivar.[a]

AVRDC selection (or acc.no.)		Marketable yield	Fruit size	Fruit-setting score[b] O	Fruit-setting score[b] T	Days to flowering
		(t/ha)	(g)			
9d-0-0-1-0	VC 11-1-2-1B/Saturn	80	58	2.00	1.58	25
32d-0-1-19-0	VC 9-1-2-3/Venus	70	57	2.33	1.68	28
8d-0-7-1-0-0	VC 11-1-2-1B/Venus	65	57	2.33	1.68	21
11d-0-2-2-0	VC 9-1-2-9B/Venus	60	43	3.00	1.84	23
32-0-1-1-0	VC 9-1-2-3/Venus	58	65	2.33	1.68	24
9d-0-1-6-0	VC 11-1-2-1B/Saturn	48	65	2.33	1.68	25
11d-0-2-4-0	VC 9-1-2-9B/Venus	48	59	2.67	1.77	23
123-2-3-0-0	ah TM-2a/VC 8-1-2-1	44	54	3.00	1.84	23
114-5-5-0	TK 3/VC 8-1-2-1	44	78	2.67	1.77	24
(387)	White Skin[c]	52	54	2.33	1.68	22
	LSD 0.05	21	12		0.2	3
	0.01	29	15		0.3	4
	C.V. (%)	27	13		7	8

[a]Planted Aug 30; harvested in 7 pickings beginning Nov. 8 and ending Dec. 27; all values are means of 3 replications. [b]Original data (O) were transformed (T) to $\sqrt{x + 0.5}$ prior to analysis of variance. [c]Check cultivar.

Table 7. Performance of processing tomato selections compared to a local cultivar.[a]

AVRDC selection (or acc.no.)		Marketable yield	Fruit size	Fruit setting score 0	Fruit setting score T	Days to flowering
		(t/ha)	(g)			
7-0-5-1-0	VC 11-1-2-1B/Florida MH-1	60	49	2.67	1.68	28
123-2-4-0	ah TM-2a/VC 8-1-2-1	56	57	3.33	1.95	26
122-0-1-15-0	ah TM-2a/VC 11-1	54	30	4.33	2.03	24
143-0-4B-1-0	VC 48-1/Tamu Chico III	53	40	4.00	2.12	28
119-1-2	TK 70/Florida MH-1	52	42	3.00	1.87	20
143-0-6-9-0	VC 48-1/Tamu Chico III	43	17	4.00	2.12	18
32d-0-1-10-0	VC 9-1-2-3/Venus	41	67	2.67	1.68	25
11d-0-2-4-0	VC 9-1-2-9B/Venus	41	59	3.33	1.95	24
103-0-5-2-0	Roma/VC 48-1	40	39	3.00	1.87	26
114-5-5-0	TK 3/VC 8-1-2-1	37	86	3.00	1.87	27
(124)	TK 70[c]	34	64	2.00	1.58	21
	LSD 0.05	16	8		0.17	4
	0.01	18	9		0.19	5
	C.V. (%)	24	11		5.6	10

[a]Planted Aug. 30; harvested in 7 pickings beginning Nov. 8 and ending Dec. 28; all values are means of 3 replications. [b]Data were transformed to $\sqrt{x + 0.5}$ prior to analysis of variance. [c]Check cultivar.

The first picking in these trials was made Nov 8, about a month before the first picking of cultivars now used by local farmers. Thus, some of our breeding lines can be grown in Taiwan to supply tomatoes in early winter. This is in line with our objective of lengthening the season that tomato can be grown in the lowland tropics.

Seed yield and quality of 9 breeding lines were supperior to Roma in a test comparing various horticultural traits of this popular cultivar with 13 AVRDC lines. Eight of the lines also produced higher marketable yields and matured earlier than Roma (Table 8).

Heat Tolerance Studies

We initiated a series of experiments to study the genetic stability of heat tolerance in tomato. Our observations suggest that the genes controlling heat tolerance are easily influenced by environmental factors and, therefore, our heat-tolerant selections should be tested in as many

Table 8. Marketable yield and other horticultural traits of 8 processing tomato selections compared to that of the commercial cultivar Roma; 1976, AVRDC.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Marketable yield	Fruit size	First flower	Total solid	pH	Citric acid
		(t/ha)	(g)	(days)	(°Brix)		(mg/100g)
123-1	Selection from TK 3	54	25	26	5.1	4.2	387
11d-0-1-2-0	VC 9-1-2-9B/Venus	52	42	24	5.9	4.2	418
122-0-5-3-0	ah TM-2a/VC 11-1	51	26	22	6.2	4.5	287
124-1	Selection from TK T-2	51	32	12	6.2	4.2	405
32d-0-19-0	VC 9-1-2-3/Venus	48	42	15	6.2	4.4	320
8d-0-7-1-0	VC 11-1-2-1B/Venus	48	30	26	5.3	4.3	350
143-0-4B-1-0	VC 48-1/Tamu Chico III	47	20	22	5.5	4.2	424
32d-0-1-25-0	VC 9-1-2-3/Venus	46	36	14	6.0	4.4	337
(115)	(Roma)	32	37	46	5.8	4.4	331
LSD 5%		13		7	0.1	0.1	101

[a]Planted Nov. 3 (1975); harvested in 7 pickings beginning March 24 and ending May 11; all values are means of 3 replications. Total of 13 AVRDC entries in the trial.

locations and seasons as possible to define the exact nature of their heat tolerance. The results of another AVRDC experiment confirmed that both heat and cold tolerance might be controlled by the same gene(s).

Selection for Intensive Cropping Systems

Research workers in the Philippines selected from AVRDC breeding materials several lines that produced good yields when partially shaded (Table 9) or grown in an untilled paddy field following rice (Table 10). These attributes are particularly useful in developing tomato for intercropping with taller crops or inclusion in intensive cropping systems.

Table 9. Average percent fruit setting rate of the best tomato varieties grown in the open and under shade.[a]

Entry[b]	Location open	Location shade	Average
	-------------------	(%)	-------------------
AVRDC selections			
122-0-1-3-1	28	33	30
103-0-5-3	30	29	30
30-0-4-18-1	51	39	45
32d-0-1-13-1	29	30	30
30-4-1-1	33	26	30
Local cultivars			
VC 9-2-4	34	33	34
VC 8-1-2-4 GS	25	26	26
VC 8-1-2-7	40	35	38
UPCA 2029	34	34	34
UPCA 1169	40	51	46
All centries	34	25	30

[a]All values were transformed to arcsine before tests of significance were made. [b]No significant differences were found for these varieties between growing them in the open and in the shade, indicating suitability for intercropping.

Table 10. Fruit size and yield of tomato breeding lines in uncultivated paddy soil; 1976, IPB, Philippines.[a]

AVRDC selection (or acc.) no.	Pedigree (or cultivar name)	Fruit size	Marketable yield
		(g)	t/ha
554 F_4-62	VC 8-1-2-1/Venus// Kewalo	65	26
554 F_4-34	VC 8-1-2-1/Venus// Kewalo	44	28
554 F_4-30	VC 8-1-2-1/Venus// Kewalo	41	28
32d-0-1-13-1	VC 9-1-2-3/Venus	37	28
(9)	(VC 9-1)	34	26
(21)	(VC 11-1)	31	28
30-4-1-1	VC 9-1-1/Saturn	29	26
(232)	(Nagcarlan)	14	29

[a]Data supplied by Dr. L. T. Empig, Institute of Plant Breeding (IPB), Los Banos, Philippines. Tomato seed dibbled near a rice stubble.

Fig. 1. Pollen collector developed by tomato breeders at AVRDC.

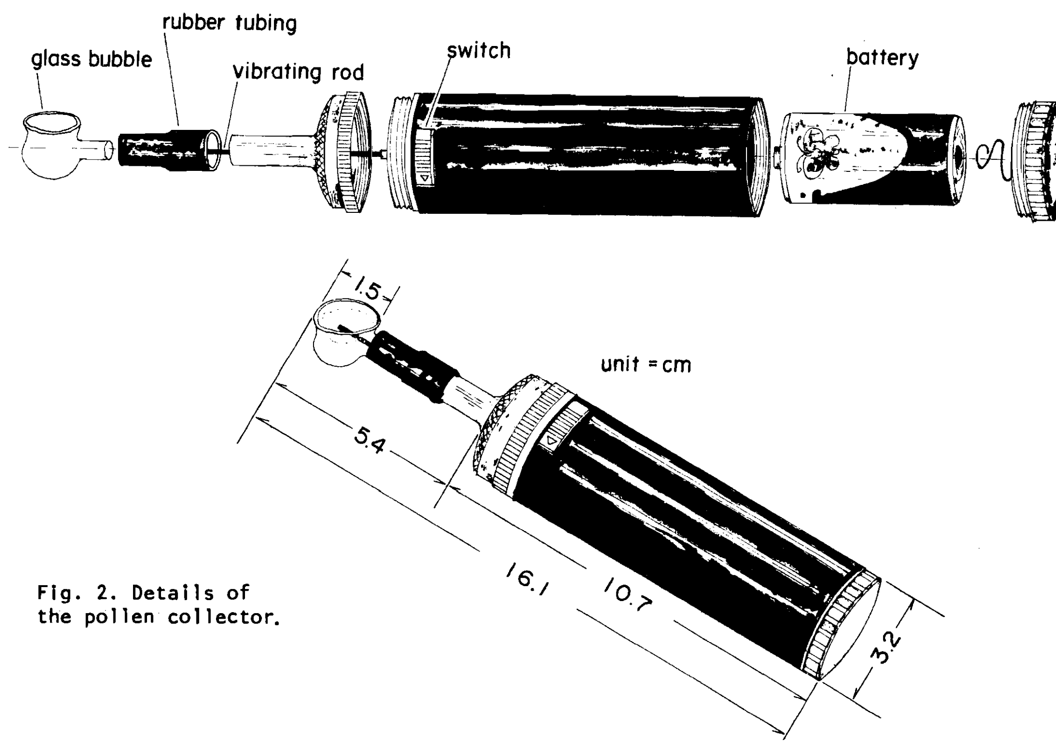
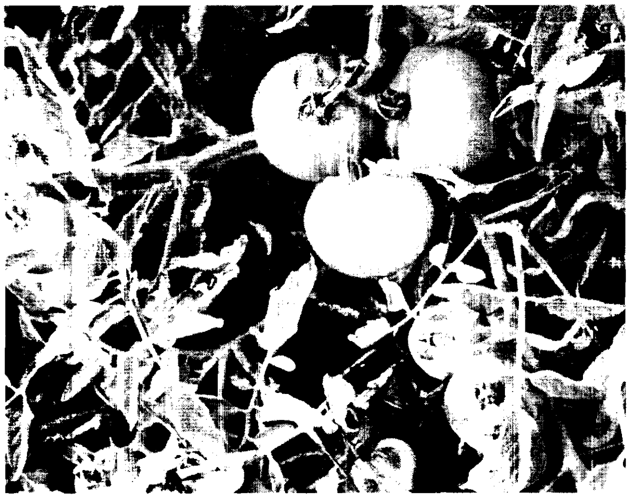


Fig. 2. Details of the pollen collector.

Pollen Collector Developed to Aid Crossing

We developed a handy, light (150 g), and compact pollen collector (Figs. 1 and 2), which facilitates hybridization of tomato and other flowers of similar size or larger. Plans of this modified pollen collector are available from AVRDC upon request.



Late blight infects leaves, stems, and fruit.

Bacterial wilt is another major tomato disease in the tropics.

Pathology

Late Blight

Accession 1197 was the only one out of 73 accessions and 89 crosses that proved to be resistant to late blight. Twenty-nine crosses indicated they may have resistance but they have to be re-evaluated. Too many plants were lost due to other causes to permit a significant check. Plants were inoculated with homogenized fungal suspension of *Phytophthora infestans*.

Powdery Mildew

Out of nine accessions tested, only one, AVRDC accession number 30 (pedigree VC 9-1-2-3) was confirmed as resistant to powdery mildew. Accessions 17 (VC 8-121) and 40 (TR/VC 40-1), which were resistant in 1974 and 1975, showed only moderate resistance in 1976.

Tomato Bacterial Wilt, Leaf Mold, and Gray Leaf Spot

One hundred eighty-nine F_2 populations were inoculated in flats with these three pathogens. More than 200 seedlings of each entry were inoculated with each pathogen. Only selection 618-1 was rated resistant to all three diseases.

Double Streak Virus and Tobacco Mosaic

One out of 25 breeding lines screened for double streak and 25 out of 79 tested for tobacco mosaic virus showed resistance.

Root-Knot Nematode

In spring test plots located on the Taiwan Fiber Crops Experiment Station, Tainan, 7 out of 98 entries supplied by AVRDC showed resistance (Table 11).

At the same station in the fall a heavily infested field was planted to jute (*Corchorus capsularis* L.) which serves as a trap crop. Infested jute roots were collected and homoginized in a blender, then plowed into the field. Forty-four lines of tomato seedlings were transplanted in this field in the fall of 1976. Six lines showed resistance (Table 11).

Table 11. AVRDC plants showing resistance to root-knot nematode, spring and fall, 1976 at Taiwan Fiber Crop Experiment Station, Tainan.

AVRDC acc. no.	Variety or pedigree name	Source
272	Anahu	Hawaii
313	Atkinson	California
274	Kewalo	Hawaii
383	Kalohi	Hawaii
275	Hawaii 7795	Hawaii
3889[a]	72 T 14	Hawaii
3893	BWN-18 F_1	Hawaii

[a]Accession no. 3889 was tested in spring only.

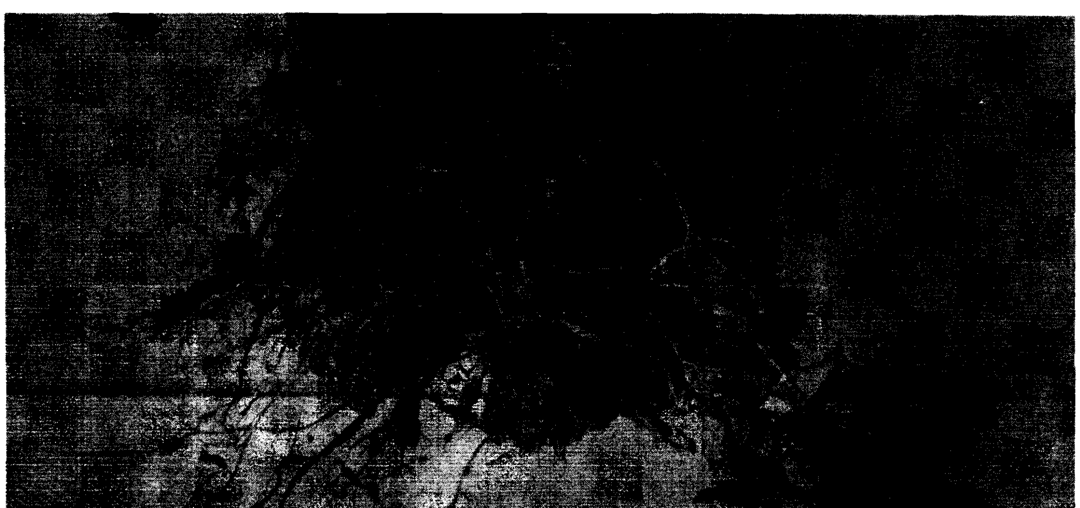


Fig. 3. Roots infected with root-knot nematode.

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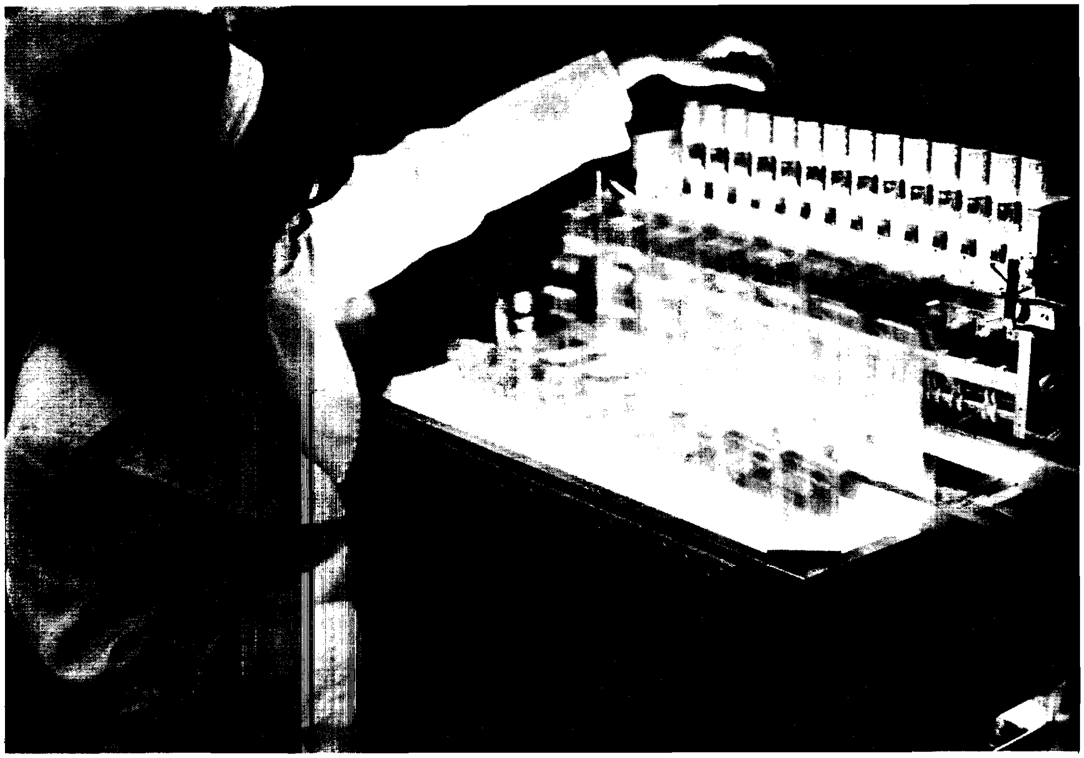

Physiology

A major objective of physiological studies was to determine the basis of moisture tolerance and identify means of preventing waterlogging damage. Waterlogging causes much damage to tomatoes in rainy seasons in the tropics.

Lack of oxygen in the root zone is thought to be the primary cause of flooding damage. Electron transport would be slowed by shortage of oxygen. Inhibition of the related metabolic pathway would result, which would also affect the rate of anaerobic activity, increasing fermentation.

Waterlogging may also reduce the amount of hormones translocated to the shoots of tomato plants. Application of gibberellin partially overcomes the reduced shoot growth of waterlogged tomato plants and decreases the levels of cytokinins in sap transported to their shoots.

BA Reduced Waterlog Damage

Effects of benzyladenine (BA) on the growth of waterlogged and non-waterlogged heat sensitive or heat tolerant tomato plants were studied (Fig. 4). The results imply a physiological basis of moisture tolerance and considerable promise for the practical application of BA for reduction of waterlogging damage (Table 12).

Fig. 4. From left to right, typical plants from non-waterlogged, no BA treatment group; non-waterlogged group that received BA sprayings; waterlogged group that received BA sprayings; and waterlogged group that was not sprayed with BA. Little effect is shown in the non-waterlogged plants but the BA sprayings helped survival of waterlogged plants (second from right).

Table 12. Survival rate (%) of waterlogged and non-waterlogged tomato plants with or without BA[a] treatment.

AVRDC acc. no.	Waterlogged				Non-waterlogged	
	-BA	+BA			-BA	+BA
		BW[b]	BDW[c]	DW[d]		
Heat sensitive						
123	0	80	0	0	100	100
124	0	60	60	40	100	100
Heat tolerant						
1	20	100	80	60	100	100
245	20	40	60	40	100	100

[a]Survival rate was taken on the 5th day of waterlogging. [b]BW : BA applied before waterlogging. [c]BDW : BA applied before and during waterlogging. [d]DW : BA applied during waterlogging.

Two heat sensitive and two heat tolerant cultivars were tested in a greenhouse experiment with BA application. Waterlogged plants of each cultivar receiving no BA treatment were compared with plants that were sprayed with BA on five consecutive days before waterlogging and plants sprayed on five consecutive days after waterlogging. The BA was applied to aerial parts of plants at a concentration of 50 mg/l containing 0.01% Tween 80. Another group of non-waterlogged plants of each cultivar was given the same BA spray treatment for comparison.

Table 12 shows that waterlogging caused tomato plants to wilt and die rapidly. Stem growth was retarded in all cultivars but heat tolerant cultivars seemed to be more resistant to waterlogging. However, BA tended to retard the plant stem growth on heat tolerant cultivars (Table 13). The BA treated plants definitely had better survival rate than nontreated plants after waterlogging.

Adventitious roots could be observed on the third day of waterlogging but fewer adventitious roots appeared in heat tolerant cultivars than in heat sensitive ones (Table 14). These distinctive morphological adaptations are used as an indication of damage to the main root system. BA treatment reduced the number of adventitious roots, which may also imply that BA treated plants stand a better chance of maintaining good root systems under waterlogging.

In another experiment in October and November, tomato plants did not wilt and die under lower temperature (day temperature about 30°C and night temperature about 20°C). However, the waterlogged plants showed chlorosis in the lower parts of leaves (Table 15). All plants survived after five days of waterlogging. Plant height was significantly retarded, which can be attributable to the chlorosis as well as lower photosynthetic

Table 13. Stem height of waterlogged and non-waterlogged tomato plants treated with or without BA[a].

AVRDC acc. no.	Waterlogged				Non-waterlogged	
	-BA	+BA			-BA	+BA
		BW[b]	BDW[c]	DW[d]		
	cm					
Heat sensitive						
123	45	49	50	46	87	82
124	42	49	43	44	80	77
Heat tolerant						
1	55	47	41	48	88	68
245	66	57	62	59	108	88

[a]Measure was taken one week after 5-day waterlogging. [b]BW : BA applied before waterlogging. [c]BDW : BA applied before and during waterlogging. [d]DW : BA applied during waterlogging.

Table 14. Adventitious root formation in waterlogged and non-waterlogged tomato plants treated with or without BA[a].

AVRDC acc. no.	Waterlogged				Non-waterlogged	
	-BA	+BA			-BA	+BA
		BW[b]	BDW[c]	DW[d]		
Heat sensitive						
123	++++[e]	+	++	+++	-	-
124	++++	+	++	+++	-	-
Heat tolerant						
1	+++	+	+	++	-	-
245	+++	+	+	++	-	-

[a]Adventitious roots observed on the 3rd day of waterlogging. [b]BW : BA applied before waterlogging. [c]BDW: BA applied before and during waterlogging. [d]DW: BA applied during waterlogging. [e]Each + indicates intensity of about 10 adventitious roots formed.

Table 15. Effect of waterlogging on chlorophyll content, photosynthesis and shoot growth of heat tolerant and heat sensitive cultivars.

Type of cultivars	Treatment	Chlorophyll content[a]	Net photosynthesis[b]	Shoot growth
		(mg/g leaf)	(mg $CO_2/dm^2/hr$)	(Δ cm/day)
Heat tolerant	Waterlogging	1.2	17.9	0.9
	Control	1.4	22.8	1.9
Heat sensitive	Waterlogging	0.6	21.4	0.6
	Control	1.5	24.0	1.5
LSD 0.05		0.7		0.39

Transplanted: Oct. 7, 1976. Grown in greenhouse under 22°C average temperature condition.
Measurement taken 65 days after transplanting.
[a]Third leaf from the bottom. [b]Third leaf from top.

rate. These results seem to suggest that the wilt and death of plants under waterlogging and high temperature conditions may be mainly due to oxygen deficit leading to inhibition of transport of the water required to meet the higher demand of transpiration rate at high temperature. Waterlogging under lower temperature leads to chlorosis and dwarfing of plants by the lack of oxygen.

Fruit Quality

Numerous fruit characteristics have been employed by investigators as indices of quality. Among those most frequently used are pH, titratable acidity, reducing sugar, pectic substance, color, soluble solids, and ascorbic acid. Each of these characteristics contributes to the total quality. However, the importance of some of these indices is dependent on the uses for which the tomatoes are intended. Color, for instance, is extremely important in tomatoes that are to be processed, but of less importance in fruits for fresh use. People in different places also have different preferences. Therefore we are not trying to develop a particular fruit type. Intended means of consumption and potential market have to be defined before we are able to evaluate lines for quality aspects. This preliminary evaluation project was carried out to judge the effect of time of harvest on processing quality.

Tomato selection 11d-0-1-2-2-0-0 was harvested through the entire summer season of 1976. Fruit samples were analyzed weekly in the laboratory. Fig. 5 shows results of tests for vitamin C content, soluble solids, and titratatable acidity.

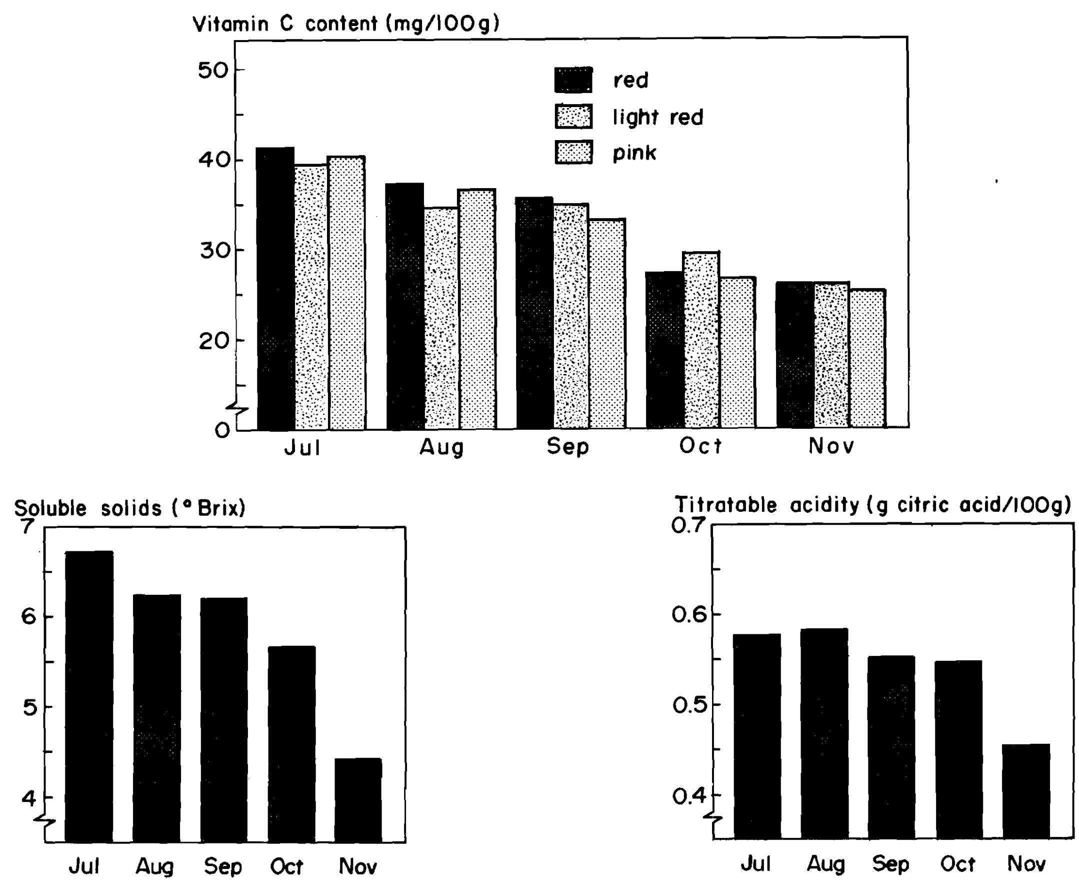

Fig. 5. Effects of time of harvest on three quality characteristics of tomato selection 11d-0-1-2-2-0-0 in the summer of 1976. Fruit samples were analyzed weekly. The quality of summer fruit is better than that of winter fruit. Several factors may affect the quality of tomato fruit. For the three quality characteristics mentioned here, the seasonal variations may be mainly due to the fruit yield differences at different seasons.

Crop and Soil Management

Tomato plants wilt in the hot, wet season in the tropics and few recover to produce acceptable yields. AVRDC soil scientists and crop management specialists jointly conducted a series of experiments with management methods designed to improve vegetative growth during this summer period.

Maintenance of Soil Aeration

Application of compost under the center of raised beds reduced plant wilting after heavy and prolonged rains, and tended to increase tomato yields (Tables 16, 17). Root development and penetration were improved by adding compost at the rate of 20 t/ha under the center of the bed and mulching the bed surface with rice straw (see photos).

The improved size and growth of roots shown in Figure 6 suggests that a considerably higher level of soil aeration existed in plots where compost and rice straw mulch were applied. Short fibrous roots developed on plants in the untreated control plots, Figure 7.

Table 18 shows results of a comparison of different types of mulching materials in summer and fall tests, 1976. Rice straw gave best results. Mulching resulted in formation of a less impervious soil crust on the bed surface and reduced soil temperatures 3°C. Subsoiling to a depth of 40 cm failed to increase tomato yields.

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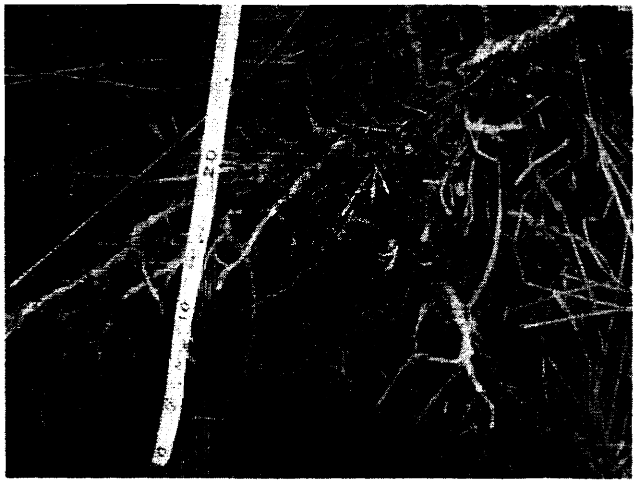


Fig. 6. Tomato root development and penetration was near normal in spite of waterlogged conditions when compost was placed under the center of the bed and the surface mulched with rice straw.

Fig. 7. Short, fibrous roots developed on plants that weren't given the mulch.

Table 16. Rice straw mulching and soil management treatment means for tomato plants during hot/wet summer season,[a] AVRDC, 1976.

Soil management	Rice straw mulch	Plants wilted[b]	Yield ripe fruit
		(%)	(kg/10 m^2)
No compost check	No	51	3.6
No compost	Yes	33	5.8
Compost (20 t/ha)	Yes	4	8.6
Compost (40 t/ha)	Yes	26	6.9
Rice straw under bed[c]	Yes	39	5.9

[a]Selection 11d-0-1-2-0 transplanted April 23 in 2 m by 10 m raised beds prepared mechanically, ripe fruit harvested 9 times at weekly intervals beginning July 17. [b]Counted July 8 after 5 consective days of heavy (393 mm) rainfall. [c]Rice straw was compressed into a furrow and 80 kg N/ha was applied in addition to the basal fertilizer to decompose the rice straw before forming a bed over the straw.

Table 17. Mean yields in relation to amount and type of organic material and nitrogen applied to tomato in a cropping system involving four crops per year; tomato growing during AVRDC season, 1976.[a]

Organic amendment and (amount)	Number of applications per year	Total yield: no nitrogen	Total yield: nitrogen	Soil amendment means
		(kg/10 m²)		
No amendment check	-	3.9	3.8	3.8
Green manure	1	3.9	7.7	5.8
Compost (20 t/ha)	1	6.5	9.3	7.9
Compost (60 t/ha)	3	9.3	10.0	9.6
Compost in furrow (60 t/ha)	3	6.8	9.7	8.2
Rice hull[b] and compost (10 t/ha)	1	6.6	8.4	7.5
Rice hull[b] and compost (30 t/ha)	3	4.6	10.0	7.3
Nitrogen means		5.9	8.4	

LSD 5% between two nitrogen means = 0.8 kg/10 m²

between two soil amendment means = 2.4 kg/10 m²

between two nitrogen means at the same level of soil amendment = 2.1 kg/10 m²

between two soil amendment means at the same level of nitrogen = 3.1 kg/10 m²

[a]Selection 11d-0-1-2-0 transplanted June 1 in raised beds prepared with a buffalo and plow; ripe fruit harvested at weekly intervals beginning Sept 7 and green fruit harvested Sept 20 and totalled with ripe fruit. [b]A volume of rice hulls equal to the volume of 10 t/ha compost was mixed together and incorporated into the soil before forming beds.

Table 18. Tomato yields for AVRDC selection 11d-0-1-2-0 as influenced by mulching materials, AVRDC, 1976.[a]

Mulching treatments	Yield: summer[a]	Yield: fall[b]
	(kg/10 m²)	
No mulch check	1.2	3.6
Rice straw (RS)	4.6	6.9
Clear plastic	0.4	0.3
Black plastic	1.6	1.9
LDS 5%	2.0	1.6

[a]Transplanted June 20 (wet season) and harvested between Sept 16 and Oct 30. [b]Transplanted Aug 31 and harvested Nov 9 and Dec 28.

Fig. 8. Wire trellising and table systems of supporting determinate-type tomato plants were compared with straw mulching alone during the wet season of 1976. Little difference was noted in four out of five experiments so the cheapest method, mulching, is recommended.

Fertilizer Trial on Calcareous Soil

A very high yield, more than 120 t/ha, was obtained this year from Walter tomatoes in calcareous soil at AVRDC by applying large amounts of fertilizer and compost (see Table 19). Note that (1) the February harvest was significantly higher, (2) compost increased yields by 20% and (3) the Walter variety gave a superior performance.

Weed Control

We integrated 1975 weed control results into a weed management system for trial in 1976. We knew that rice straw mulch usually controlled more than 50% of the weeds, but required hand removal of weeds that grew through the mulch. Thus, we applied a preemergence herbicide (alachlor at 2 kg a.i./ha) to the soil surface before transplanting the tomatoes. A post-emergence treatment of contact-type herbicide (paraquat at 0.5 kg a.i./ha) was applied between the rows and on the edge of the bed. With the use of these weed control methods, only one or two hand weedings were necessary, within the rows, even during the wet season. In check plots manual cultivations only partially controlled the weed growth and the soil structure was further destroyed.

Mulching, Staking, Trellising

To maintain or improve fruit quality by reducing fruit contact with the moist soil, we compared several staking or trellising systems with the rice straw mulch treatment (Fig. 8). Yields in four out of five experiments were similar for mulching, staking, or trellising. Rice straw mulching was superior to plastic mulching. Thus we recommend the straw mulching method to reduce costs when growing AVRDC's determinate selections. A second layer of rice straw (approximately 7 t/ha) should be applied before the foliage covers 50% of the bed surface.

Table 19. Tomato response to fertilizer application[a] on calcareous soils at AVRDC; with and without compost.[b]

Cultivar[d]	Applications and amounts harvested in:[c]			
	January	February	March	total harvest
	---------	t/ha	---------	
Walter				
with compost	14.97	89.94	15.88	120.8
without compost	12.07	59.72	13.72	85.6
Manalucie				
with compost	-	39.47	24.36	63.8
without compost	-	26.56	13.57	40.2
Magniflotente				
with compost	-	32.02	24.25	56.3
without compost	-	28.96	18.25	46.6

[a]Basal application 60 kg N, 80 kg P_2O_5, and 150 kg K_2O per ha. Top dressings: five top dressings of 50 kg ammonium sulfate per ha each and a final dressing of 40 kg/ha. Three foliar applications of boron were made at 10 kg boron/ha. [b]Twenty tons rice straw per ha plowed into soil before transplanting. Ten t/ha applied as mulch. Prior to these experiments 30 t/ha had been applied to field. [c]Tomato seedlings transplanted Oct 23. [d]Walter tomatoes were harvested January 14 and 27; February 3, 9, 16, 2b, and 26; and March 5 and 11. Manolucie and Magniflotente were harvested February 9, 16, 20, and 26 and March 5 and 11.

Plant Spacing Within the Row

To limit yield losses associated with reduced plant populations, we compared a 20 cm spacing to the commonly used 40 cm spacing. We found that yields were not increased by the closer plant spacing. Also, disease and insect control were more difficult due to the increased amount of foliage.

Branch Pruning and Fruit Size

As expected, tomato yields in three experiments were reduced as additional branches were pruned from the plant. Pruning increased fruit size during the cool-dry season, whereas fruit size remained unchanged during the hot-wet season or the transition period.

Seasonal Variation in Production

Tomato yields ranged from 1 to 10 t/ha during the hot-wet season, 18 to 35 t/ha during the fall transition period, and 50 to 85 t/ha during the cool-dry period. Fruit size was 20% smaller for the hot-wet season than for the cool-dry season. About 40% of the hot-wet season fruit was culled due to rot, cracking, or other physical defects compared to 5% culled during the cool-dry period. We also noted that the number of culled fruit could be reduced if appropriate soil management techniques were implemented during the wet season and if the fruit were harvested in the green manure stage before some of the problems associated with fruit quality develop.

Harvest Duration

We noted that 2 to 3 months were required after transplanting before the first fruit were harvested, and that an additional month was required to complete the harvest of 75 to 85% of the fruit load. Consequently, a 3 to 4 month growing period would be required if a farmer decided to adjust his cropping system to include the production of these determinate tomato lines.

Soil Treatment Test with Two Cultivars

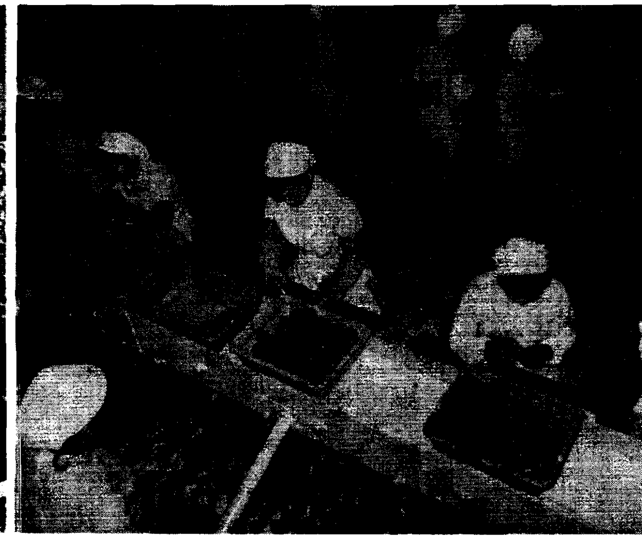
Seedlings of cultivars 11d-0-2-2-0-0 and 11d-0-2-0-0 were transplanted to fields for fertility tests September 17. Neither yields nor nutrient contents of leaves, stems, or roots of these two processing tomato cultivars were affected much by compost application in the fall season (Table 20).

The amount of nitrogen application, however, has a significant effect on the N, P_2O_5 and K_2O found in leaves and stems of both cultivars. This was true for nitrogen application tests both with and without the addition of rice straw compost.

Table 20. Tomato yields of two cultivars in fall[a] season as influenced by nitrogen rate and compost addition.

Nitrogen application (kg/ha)	11d-0-2-2-0-0				11d-0-1-2-0-0			
	with straw		without straw		with straw		without straw	
	total	marketable	total	marketable	total	marketable	total	marketable
50	38	31	36	27	49	36	50	40
125	45	35	40	31	52	38	51	42
170	50	38	55	38	49	38	58	45
200	57	42	59	43	55	45	57	43

[a]Transplanted September 17, 1976.

Fresh and Processing Tomato Marketing Studies

AVRDC's agricultural economists interviewed 20 producers of fresh market tomatoes in central and southern Taiwan during late 1975 and early 1976. They obtained information on the farmers' costs, labor requirements, and returns in producing fresh market tomatoes. Then they compared these data with interviews last year with producers of processing tomatoes. Seventeen farmers who produced the processing tomatoes as a single crop and 17 who produced them as an intercrop were interviewed last year.

Special varieties have been bred for the two uses. The fresh market tomatoes, called indeterminate varieties, set fruit over a period of 2 to 3 months and are relatively sensitive to environmental conditions. The "determinate" varieties grown for processing are short plants having less vine. They ripen more uniformly in a shorter period of time -- 1½ to 2 months. The fruit are generally smaller but plants are more tolerant to varied environmental conditions.

The indeterminate varieties involve more labor because they require more staking, pruning, and tying to obtain large, high quality fruit. Some advantages and disadvantages of the two types of tomatoes are given in Table 21. Tables 22 and 23 give cost and labor comparisons for the two types of production.

Table 21. Crop characteristics identified in surveys of fresh market[a] and processing[b] tomato producers in Taiwan, 1976.

Crop characteristics	Fresh market tomato (N=20)	Processing tomato (N=34)
Fruit type	Medium to large size	Small to medium size.
Harvest:		
Color	Mostly green with some redness	Uniformly red.
Period	2 to 3 months	1 to 2 months
Frequency	Every one or two days, e.g. 35-45 times	Every 7 to 15 days, e.g. 3-10 times.
Crop field duration	5 to 7 months	4 to 6 months
Additional practices	Staking, pruning, and training; sometimes remove excess flowers and give hormone treatment.	Sometimes mulch with rice straw.
Labor use	Skilled and persistent management; almost entirely family labor.	Moderate level management; combined family and hired labor.
Advantages	High return per unit of land; uses surplus family labor; continuous cash income for several months; adaptable to very small farm size near urban areas or markets.	Guaranteed price and buyer; convenient input supplies and technical assistance; adaptable to areas relatively far from vegetable markets; adaptable to rotation systems with rice or upland crops.
Disadvantage	Price fluctuations; considerable production skill required; large capital investment; location only near a market or population center; excessive labor.	Weak price and grade bargaining position; limitation of factory contracted area.

[a]Indeterminate. [b]Determinate varieties.

Table 22. Production factors and costs for fresh market[a] and processing[b] tomato, Tainan and Kaohsiung Counties.

Production factors	Fresh market tomato N=20		Processing tomato monoculture (N=17)		Processing tomato intercrop (N=17)	
	average	(range)	average	(range)	average	(range)
Farm size (ha)	0.87	(0.22-2.3)	1.3	(0.35-2.8)	2.52	(0.30-9.0)
Field size[c] (ha)	0.19	(0.07-0.5)	0.53	(0.17-1.1)	0.69	(0.30-1.5)
Yield (kg/0.1 ha)	4,430	(2.056-8,429)	6,680	(3,570-9,460)	6,215	(3,500-9,200)
Labor:						
Harvest (hrs)	219		98		125	
Total (hrs)	529		175		196	
Self	493		86		65	
Hired	36		89		131	
Est. total cost (US$)	210		64		69	
	------------------Income and Expenses: US$/0.1 ha ------------------					
Gross returns	339		186		172	
Net returns	- 5		40		28	
Farm income	207		109		95	
Total costs	344		146		144	
Cash costs	132		76		78	
Non-cash costs	212		70		66	
Price/kg: Actual	0.076		0.028		0.028	
Breakeven	0.078		0.022		0.023	

[a]Fresh market tomato survey of the 1975/1976 crop in Tainan and Kaohsiung Counties included 20 farmers. [b]Processing tomato survey of the 1974/75 crop in Tainan County included 17 producers planting monoculture and 17 intercropped stands. [c]The average field size of 51 fresh market tomato producers was 0.2 ha with fields in Central Taiwan tending to be smaller and those in South Taiwan being slightly larger. The average field size of 558 processing tomato farmers in 1975/76 crop year (both intercrop and monoculture) was 0.34 ha; substantially lower than average.

Location of the producers usually was related to sales outlets -- market agents or factories. However, some concentrated areas of production were found far from their sales outlets. They thrived due to collective sales to local shippers or a truck pickup place. Good transportation and cooperative pooling, processing, and shipping can greatly extend the radius of markets available.

Recently, a sharp reduction in demand for tomatoes by factories resulted in a large influx of the small red tomatoes in the fresh market system. Some advantages in flexibility were found for growing these varieties for fresh market. They proved to have a dual market potential (manufacturing or fresh market); they fit more environmental conditions (highland sandy soils or lowland clay soils; increasing distance from population centers). They are adaptable to intercropping with sugar cane and orchard trees. Labor requirements are decidedly lower (see Tables 23 and 24).

Conclusions

Fresh market varieties appeared most suitable for producers who lived near large population centers and had a large family labor supply. The fresh market varieties gave them more and larger tomatoes over a longer period of time. They offered a steady cash income over a longer period.

Processing tomatoes seemed better adapted to the integrated farmer-factory approach, to marketing over greater distances, and to offering flexibility of choice between fresh or canning markets. They had disadvantages of weak bargaining position and limitation of land area which can be contracted by factories.

The farmer-factory contracts held advantages, especially for beginners, by guaranteeing price, and providing such inputs as fertilizer and training on better production methods. A processing tomato crop's impact on a community is proportionate to the number, capacity, and locations of the processing factories. Extra employment opportunities in the factories, improved farm financing (through the factories), and improvement in varieties usually result.

Addition of tomatoes to other cannery specialties, such as pineapple, mushroom, and asparagus, enables year-around factory operation. Twelve-month operation is not possible in many western countries. It is an advantage that has not been fully exploited in Asia. The Republic of China, the Philippines and other tropical countries have not expanded fresh fruit and vegetable markets in densely populated countries like Japan, Hong Kong, and Singapore as much as they could. However, there has been great progress in expanding exports of processed tomato products (see Table 25).

One stumbling block to further expansion is the trade restrictions some of the temperate countries use to protect their greenhouse growers. If these intra-regional restrictions could be eliminated the large seasonal price fluctuations in the region could be eliminated to the benefit of producers, consumers, and processors of tomatoes and other vegetables.

The addition of another processing line for the canned food industry and increasing the value of foreign exchange are only some of the national benefits. A crop linked to rural industrialization (with processing plants in the countryside), helps provide alternative employment for farm family members who will thereby be able to stay in the rural areas.

Table 23. Production cost and returns per 0.1 ha for fresh market[a] and processing tomato[b], Tainan and Kaohsiung Counties.

Item	Fresh market (N=20)	Processing Mono (N=17)	Processing Intercrop (N=17)
Yield (kg)	4,430	6,680	6,215
Revenue	$ 339	$ 186	$ 172
Expense	344	146	143
Material (Subtotal)	115	52	43
Seedlings	14	4	4
Fertilizer: Organic	12	6	7
Inorganic	27	12	10
Pesticides	30	20	15
Power source: Animal	1	5	2
Machine	6	4	4
Misc.	24	1	1
Labor (Subtotal)	202	64	69
Land prep. & bed formation	2	2	2
Transplanting	8	5	4
Fertilization	8	2	2
Irrigation	6	1	1
Pesticide spraying	23	14	11
Intertillage & weeding	20	6	6
Harvesting	62	34	43
Transportation & sale	17		
Additional practices	56		
Others (Subtotal)	27	30	31
Irrigation water fee	3	2	2
Land tax	5	4	5
Interest: on capital	4	4	4
on land	15	20	20
Cash cost	132	76	77
Farm income[c]	207	110	95
Non-cash cost	212	70	66
Net profit[d]	- 5	40	29

[a]Survey of fresh market producers, 1975/76 season in Tainan and Kaohsiung Counties. [b]Survey of processing tomato producers, 1974/75 season in Tainan Country. [c]Farm income is total revenue minus cash costs. [d]Net profit equals farm income minus non-cash costs.

Table 24. Frequency range with which various field operations were performed according to type of tomato produced, Taiwan 1974-1976.

Field operation	Fresh market tomato[a]	Processing tomato[b] monoculture	Processing tomato[b] intercrop
	(N=20)	(N=17)	(N=17)
Pesticide spraying			
Ave. number	9.6	9.8	10.5
Range	(4 - 15)	(2 - 15)	(3 - 20)
Fertilizer applications			
Ave. number	5.0	1.9	1.8
Range	(2 - 12)	(1 - 3)	(1 - 2)
Irrigations			
Ave. number	7.1	1.6	1.8
Range	(0 - 18)	(1 - 3)	(1 - 4)
Weeding & intertillage			
Ave. number	4.3	2.7	2.4
Range	(1 - 7)	(1 - 5)	(1 - 8)

[a]Survey of fresh market tomato producers, 1975/76 season, in Kaohsiung and Tainan Counties. [b]Survey of processing tomato producers, 1974/75 season, in Tainan County.

Table 25. Value of exported fresh market tomato and processed tomato products, Taiwan, 1967-75.

Year	Processed tomato products		Fresh market tomato	
	value (US$1,000)	no. of countries	value (US$1,000)	no. of countries
1967			440	2
1968	n.a.	n.a.	332	2
1969	128	4	285	2
1970	235	6	340	2
1971	142	7	305	2
1972	329	12	322	2
1973	2,872	15	322	3
1974	9,214	21	116	1
1975	12,316	35	258	2

Source: 1) Export & Import Yearbook by Customs, Ministry of Finance, ROC (Fresh Market Value 1967-75 and Processing Products Value 1969- 72).

2) Taiwan Exports of Canned Food, 1973, 1974, 1975, Taiwan Canners Association (Processing Products Value, 1973-75).

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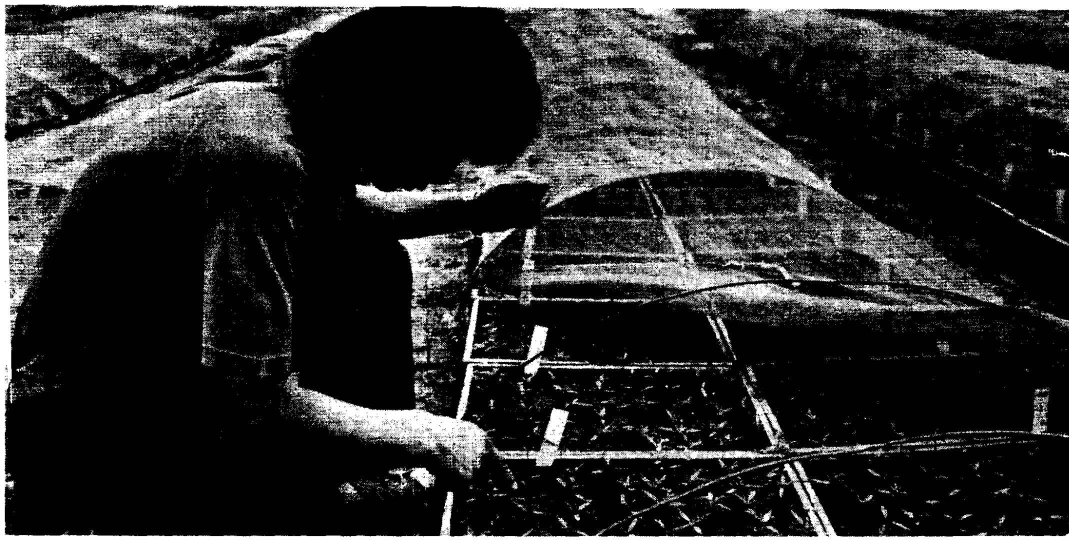


Training

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 tomato research included:

Hemant S. Bedekar, India - reaction of varieties to wilts and evaluation of seed yields.

Seung Jin Kim, Korea - screening F_1 hybrids for virus resistance.

Jaime B. Rebigan, Philippines - tomato reaction to excessive moisture.

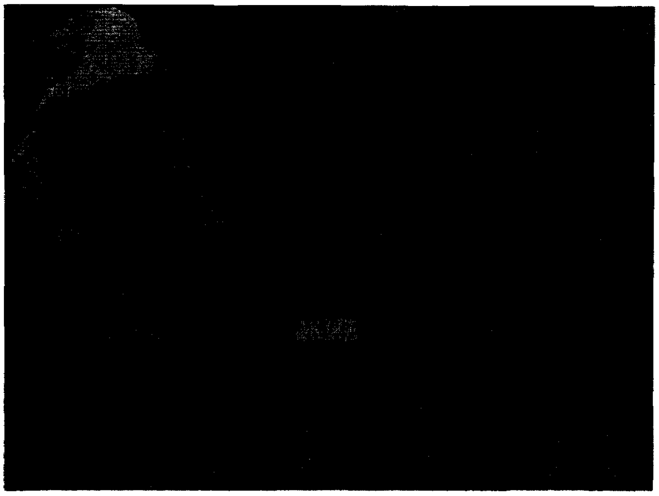
Chin-Chi Wang, R.O.C. - reaction to bacterial wilt and serological studies on the tomato strain of potato virus.

Augusto P. Lansigan, Philippines, and Ying-Ren Chen, R.O.C. - performance of tomato with and without irrigation, and tomato yield trial.
Marius E. Olf, Surinam - multiple cropping.

Chia-Chie Chen, R.O.C. - effect of waterlogging and N-benzyladenine on growth of tomato.

Rodolfo G. Flores, Demetrio V. Oria, and Amador B. Raqasa, Philippines - effects of compost and fertilizers on tomato yields.

A training brochure which describes the training opportunities at AVRDC in greater detail is available by writing to the Training Officer.



Melor Rejab, assistant to Dr. Thean Soo Tee of MARDI, Selangor, West Malaysia, exhibits one of 7 lines they selected from 50 AVRDC genotypes of SSD line 555 (F_5) for outstanding performance.

B. Khail, specialist of the Horticultural Research Institute of Indonesia, showing resistant AVRDC line. Wilt infested check variety (Bonset) is shown in the foreground.

International Cooperators

Sarawak, East Malaysia: Don D. Cobb, Methodist Rural Life Center, obtained yields of 5 to 16 t/ha from 10 AVRDC lines he tested during the rainy season. This performance was impressive because no other cultivars could be grown successfully due to bacterial wilt and heavy rains (580 mm during the cropping season).

Selangor, West Malaysia: Dr. Thean Soo Tee of MARDI had good results with AVRDC lines in tests of bacterial wilt resistance in a peat soil at the Jalan Kebun Experiment Station. Dr. Tee and assistant, Miss Melor Rejab tested 50 genotypes of SSD line 555 (F_5), which is a triple cross of VC 8-1-2-1/Saturn//Kewalo, and selected 7 outstanding lines on the basis of bacterial wilt resistance, heat tolerance, and fruit size for large scale evaluation. They consider the resistant genotypes a breakthrough and plan to pick one or two top performers for multiplication and distribution to farmers. Tomatoes have had to be grafted to wilt resistant eggplant root stock in the past. (Table 26).

Singapore - Forty tomato lines were sent to the Sembawang Field Experiment Station of the Primary Production Department for testing. The performance of the best five of these lines is presented (Table 27). Obviously, these lines have great potential under Singapore conditions since no tomatoes can be grown in Singapore unless grafted to a wilt-resistant rootstock. Wilt-susceptible materials when grown in the same field were completely wiped out by bacterial wilt. Fruit size was considered within acceptable range for the Singapore market.

Indonesia: Sujoko Sahat, Horticultural Research Institute, reported 70 to 90% survival of AVRDC breeding lines under wilt infection conditions. Saturn had 50 to 60% survival and Bonset, the check variety was 100% infected.

Table 26. The best yielding VC 8-1-2-1/Saturn//Kewalo lines in preliminary trial; 1976, West Malaysia.[a]

SSD no.	Yield per plant	Yield per ha[b]	Fruit size	Days to flowering	Survival[c] rate
	(g)	(t/ha)	(g)		(%)
12	728	36	26	25	98
47	496	24	27	29	98
16	484	24	27	23	95
18	478	24	45	30	100
29	376	19	41	34	98
39	333	16	36	29	100
45	318	16	38	29	95

[a]Planted July 12; data are means of 40 to 60 plants. [b]Plant population was 49,383 plants/ha. [c]Under natural epiphytotic of *Pseudomonas solanacearum*; check cultivar was completely wiped out by the disease. (First successful use of SSD method for rapid generation advance involving 3 resistant sources to *P. solanacearum*.

Table 27. Important horticultural traits of five tomato lines from AVRDC (Evaluated in Singapore)[a].

AVRDC selection (or acc. no.)	Pedigree (or cultivar name)	Survival[b] rate	Fruit[c] weight	Fruit setting rate
		(%)	(g)	(%)
32d-0-13-0	VC 9-1-2-3/Venus	96	60	80
122-0-1-18-0	ah TM-2a/VC 11-1	98	70	79
(11)	VC 11-3-4	95	45	81
(9)	VC 49-1-3	98	45	95
(64)	(TR/VC 48-1)-17-2-2	90	110	61

[a]Adapted from Jourl. of Primary Industries 5(1); yield range for the lines was 25 to 40 t/ha. [b]Under natural epiphytotic of bacterial wilt; means of 240 plants. [c]Average weight of 50 randomly picked fruits.

Japan: Dr. Sadao Nishi, plant breeder of the Vegetable and Ornamental Crops Research Station reports that 2 AVRDC breeding lines, 32d-0-1-4-0 and 246-0-4b-2-0, showed excellent resistance to bacterial strains he used. They were more resistant than any of 31 lines tested.

Dr. Osamau Takahashi, plant breeder for the Takii Seed Co., found variable resistance to wilt strains at different locations for some AVRDC accessions. Accession 39; 8; and 4045, for example, were resistant in the Philippines; 274 was resistant in Hawaii. Most lines were resistant to *Fusarium*, which was surprising since, with the exception of 274 and 4045, the lines had not been tested against *Fusarium*.

Philippines: Materials tested in Guam and Sri Lanka were also tested in Davao, Philippines (Table 28). Sri Lanka had the highest yields and Guam, the lowest. Guam and Davao reported bacterial wilt. KL 1, which is wilt susceptible in Taiwan and Davao, was not affected by the wilt strains at Guam. Guam farmers who cooperated in an islandwide trial of the most promising lines were satisfied by the performance except for the size of fruit, which ranged from small to medium. In Davao, two lines were used in semi-commerical scale by the Davao Fruit Corp.

Research workers in the Philippines selected from AVRDC breeding materials several lines that produced good yields when partially shaded

Table 28. Marketable yield performance of AVRDC breeding lines at 3 locations compared to local cultivars.[a]

AVRDC selection (or acc. no.)		Location: Guam	Davao	Sri Lanka	Average
		--------(kg/plot)		-------	(t/ha)
123-4-3-0	ah TM-2a/VC 8-1-2-1	7 (7)	34 (1)	30 (7)	29
32d-0-1-2-0	VC 9-1-2-3/Venus	2(17)	29 (2)	32 (4)	26
30-0-4-18-0	VC 9-1-1/Saturn	4(12)	27 (5)	29 (8)	25
32d-0-1-7-0	VC 9-1-2-3/Venus	3(15)	26 (6)	31 (6)	25
32d-0-1-10-0	VC 9-1-2-3/Venus	1(19)	23 (8)	36 (1)	25
32d-0-1-15-0	VC 9-1-2-3/Venus	3(14)	27 (4)	24(11)	22
(1)	VC 48-1[c]	4(13)	28 (3)	18(17)	21
32d-0-1-13-0	VC 9-1-2-3/Venus	2(16)	24 (7)	25(10)	21
(245)	KL 1[d]	9 (6)	3(17)	33(3)	19
	LSD 0.05	0.7	3	12	
	C.V. (%)	7	26	29	

[a]All values are means of 3 replications; combined analysis of variance was not conducted because variance were heterogenous. [b]Numbers in parentheses refer to ranking within location; yield range in Guam was 1 to 14 kg/plot, 6 to 29 kg/plot in Davao and 15 to 36 kg/plot in Sri Lanka. [c]Common resistant check to bacterial wilt. [d]Common susceptible check.

or grown in an untilled paddy field following rice (see Tables 9 and 10). These attributes are particularly useful in developing tomato materials for intensive cropping systems.

We were also encouraged by a report from researchers at the Philippine Sugar Research Institute (PHILSUGIN) that 8 of our breeding lines did very well during the hot, wet season when intercropped with sugar cane (Table 29). Cane and sugar yields were generally not affected by the intercrop except in one case which was due to a low percentage of cane replants and harvest of the cane at 10 months (before full maturity).

Advantage of a tomato crop that can be grown between sugarcane rows in the rainy season would be to give farmers additional income while waiting for the sugar crop to be harvested. Prices for tomatoes during the rainy season are as much as 10 times higher than normal in La Carlota City and neighboring areas.

The U. P. Research and Training Station at La Carlota City also screened 124 SSD lines of CL 554 and 179 lines of CL 549 from AVRDC for heat tolerance and bacterial wilt resistance. Both populations were of the F_4 generations. S. R. Gumasing and R. M. Payson also evaluated the performance of 148 breeding lines from AVRDC. Best performing lines are presented in Table 30.

In addition to conducting 4 tomato studies at the Bureau of Plant Industry's Economic Garden Experiment Station, the staff of the AVRDC Philippine Outreach Program distributed 32 sets of tomato seeds for

Table 29. Marketable yields of tomato, cane, and sugar for two tomato/sugarcane intercropping experiments; 1975-76, PHILSUGIN, Philippines.[a]

	Trial I				Trial II		
AVRDC selection no.	tomato yield	cane yield	sugar yield	AVRDC selection no.	tomato yield	cane yield	sugar yield
	t/ha	TC/ha	PS/ha		t/ha	TC/ha	PS/ha[c]
435	11	78	160	434	11	57	143
432	7	41	85[b]	764	10	64	132
547	6	50	103	433	9	73	152
431	5	54	113	502	7	57	120
Cane alone	0	60	125	Cane alone	0	61	126
LSD 5%	3	14	28		4	ns	ns

[a]Sugarcane planted May 12, 1975 (onset of rainy season) at 30,000 cuttings/ha 1-month tomato seedlings were immediately transplanted between 1-m rows of cane. Tomato harvesting began 65 days after transplanting and lasted for 23 days. Cane was harvested Apr 1, 1976. [b]The lower cane yield resulted from early harvest. [c]PS/ha = picul sugar per hectare.

Table 30. The ten best performing lines in an observational trial; 1975-76, University of Philippines Research and Training Station, La Carlota City, Negros Occ., Philippines.[a]

AVRDC selection no.	Pedigree	Yield		Fruit size
		per plant	ha	
		(kg)	(t/ha)	(g)
8d-0-7-1-0-1	VC 11-1-2-1/Venus	0.86	29	51
122-0-3-5-0-2	ah TM-2a/VC 11-1	0.84	28	60
141-0-2-5-0-2	VC 48-1/KL 2	0.75	25	50
11d-0-1-1-0-2	VC 9-1-2-9/Venus	0.73	24	41
8d-0-7-1-0-2	VC 11-1-2-1/Venus	0.70	23	58
9d-0-6-1-0-1	VC 11-1-2-1/Saturn	0.67	22	56
122-0-5-3-0-2	ah Tm 2a/VC 11-1	0.62	21	39
7-0-9-2-0-2	VC 11-1-2-1/Florida MH-1	0.62	21	62
9d-0-3-9-0-2	VC 11-1-2-1/Saturn	0.55	18	79
141-0-1-6-0-2	VC 48-1/KL 2	0.54	18	78

[a]Planted in December, 1975.

trials by various research institutions throughout the Philippines. In these nation-wide trials, AVRDC lines produced yields significantly higher than varieties locally available. Results of selected trials shown in Table 31 illustrate the magnitude of the increases in yield.

AVRDC tomato selection 32d-0-1-15-0 grown at the Economic Garden in Los Baños has yielded 28 to 75% higher than the local varieties--Improved Pope and VC 13. At Mindanao Institute of Technology in Cotabato, the yield of a sister line 32d-0-1-4-0 was 2.8 times the yield of the local variety, VC 11. At Central Luzon State University in Nueva Ecija another AVRDC tomato line, 11d-0-1-2-0, selected at the Center in Taiwan where the crosses were performed, produced a yield 1.5 times that of the tomato variety UPCA 2029, grown locally in Nueva Ecija (Table 31).

The present information from such limited trials indicates two facts of major importance: (1) that from a massive breeding program based on a world-wide germplasm collection, significant increases in yields are possible; and (2) the different responses of breeding lines to different locations show that national trials need to be continued before the best lines for each location can be determined. The Philippine Seed Board, as a result of these trials, recommended 15 AVRDC lines to be included in the 1977 all-Philippine Tomato Trials.

Table 31. Mean yields of marketable fruit for 2 highest yielding entries in each of 3 selected AVRDC Philippine Outreach Program trials performed at 3 locations.

Trial location	Name of entry	Rank of entry within trial	Yield t/ha	% of location check
Los Baños[a]	CL32d-0-1-15-0[d]	1	45	128
	CL32d-0-2-4-0	2	44	128
	Improved Pope (local check)	13	35	100
	VC 13-2-1 (local check)	21	26	73
Mean of 30 entries			32	
LSD 5%			11	
North Cotabato[b]	CL32d-0-1-4-0	1	41	278
	CL32d-0-1-15-0	2	21	141
	VC 11 (local check)	8	15	100
	VC 8-1-2 (local check)	21	4	27
Mean of 30 entries			10	
LSD 5%			7	
Nueva Ecija[c]	CL11d-0-1-2-0[e]	1	39	145
	CL143-0-4B-1-0[f]		36	132
	UPCA 2029(local check)	8	27.2	100
Mean of 21 entries			26	
LSD 5%			8	

[a]Philippine Outreach Center, BPI, Economic Garden, Los Baños. [b]Mindanao Institute of Teachnology, Dr. R. T. Gloria, cooperator. [c]Central Luzon State University, Dr. F. F. Campos, cooperator. [d]CL32 lines are from a cross between VC 9-1-2-3 and Venus. [e]CL11 lines are from a cross between VC 11-1-2-9 and Venus. [f]CL143 lines are from a cross between VC 48-1 and Tamu Chico III.

S. R. Gumasing and N. Cabrillos inspect one of 148 AVRDC breeding lines they evaluated in 1976 at the University of the Philippines Research and Training Station. See Table 30 for performance of best lines.

In contrast to the resistant AVRDC line 33d-0-2-1-0 behind Dr. A. J. Quimio, pathologist, University of the Philippines at Los Baños, the check variety shows severe bacterial wilt infestation.

The single seed descent (SSD) method of selecting material for various locations (described in the 1974 AVRDC Annual Report) seems well adapted to the outreach concept. At AVRDC crosses were made from selected tomato material. The lines were advanced four generations without selection. Then the material was distributed in the Philippines for selection under local conditions. During the wet season of 1975, 134 SSD lines of cross CL 554 F_4 (VC 8-1-2-1/Venus) and 180 SSD lines from cross CL 549 F_4 (VC 48-1/Saturn) were planted in a field with *P. Solanacearum*. Out of the 314 lines, 17 survived. Seeds from the surviving plants were planted during the wet season of 1976 in a poorly drained field highly infested with *P. solanacearum*. All of the 17 lines survived (Table 32). Survival rate (No. plants surviving/total No. planted) increased from 1.2% in 1975 to 16.2% in 1976. A 47 percent survival rate was the maximum observed. Seeds were saved for planting in the 1977 wet season.

Table 32. Plant-survival performance of SSD tomato trial of 1976 contrasted with 1975 trial to show improvement in bacterial-wilt resistance through selection.[a] Tomato lines grown in poorly drained fields heavily infested with *P. solanacearum*. (Philippines Outreach Program trials performed at Economic Garden, Los Baños.)

Year	Mean % of No. plants surviving	Mean % of No. lines surviving
1975	1.3	5
1976	16.2	100
% improvement	1146.0	1900

[a]Seeds from survivals in 1975 trial saved for planting in 1976 trial.

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).

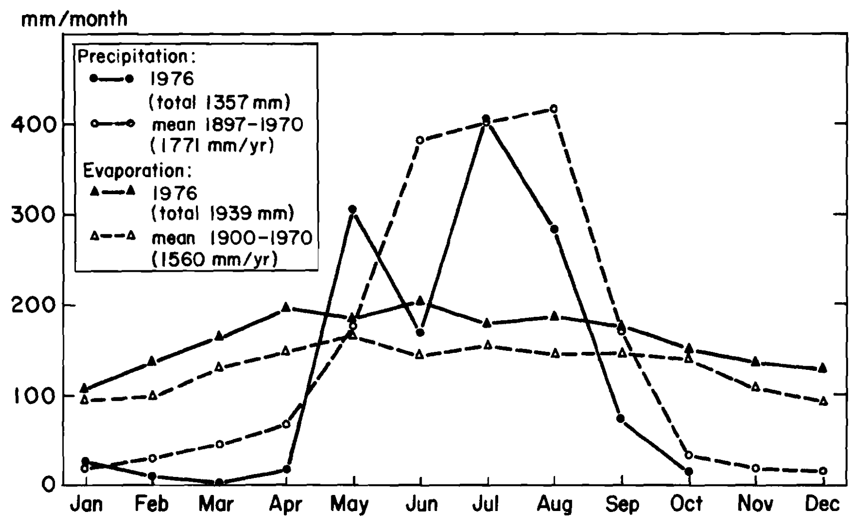


Fig. 1. Monthly precipitation and evaporation data for 1976 at AVRDC compared with means from 1897 to 1970 and from 1900 to 1970, respectively, for Tainan City. (Reference: Central Weather Bureau, 1974, Summary to meteorological data -- Taiwan. Vol III).

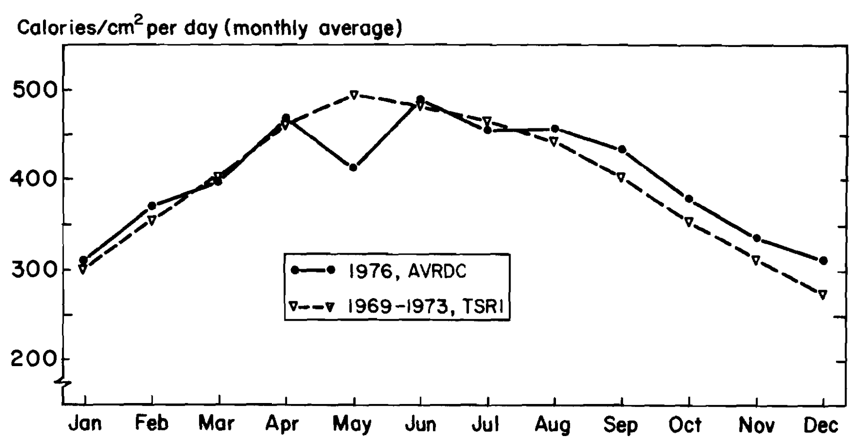


Fig. 2. Solar radiation during 1976 at AVRDC compared with 5-year average at Tainan City.

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[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.

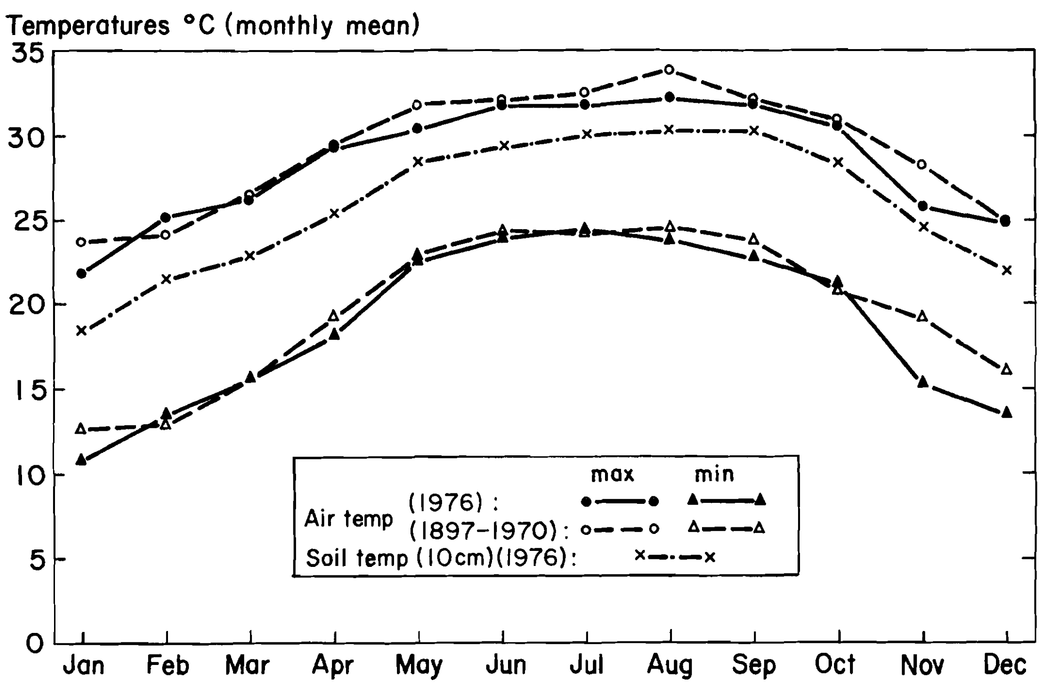

Fig. 3. Temperature ranges for 1976 compared with the means for Tainan City (1897-1970). Soil temperatures (10 cm depth) for 1976 are also included.

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++ 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.

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