AVRDC Report 2000

Asian Vegetable Research and Development Center

AVRDC Report 2000

Asian Vegetable Research and Development Center

AVRDC

Asian Vegetable Research and Development Center (AVRDC)
PO Box 42 Shanhua, Tainan, Taiwan 741, ROC
Tel: +886 6 583 7801
Fax: +886 6 5830009
Email:avrdcbox@netra.avrdc.org.tw

AVRDC publication 01-520
ISSN 0258-3089

Editors: George Kuo, David Abbass, and Thomas Kalb

Desktop publishing: Ronald Mangubat and David Abbass
Additional typesetting: Meng Shih-jung and Liou Yung-chi

Cover photograph: Chen Ming-che

Suggested citation

AVRDC. 2001. *AVRDC Report 2000*. Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan. vii + 152 pp.

Contents

Foreword

Dear Readers,

As we head into a new century, there are emerging challenges that our global community faces. Populations in developing countries continue to rise; malnutrition and poverty remain as key issues. Concerns over the safety of food are greater than ever.

AVRDC, the only international research center working exclusively on vegetable crops, continues its efforts to make sure that nutritious vegetables can be accessible to the poor in the developing world through its scientific endeavors. In 2000, progress was made in all 12 projects that are identified and prioritized in our action plan. Our scientists were very active in the improvement of genetic materials, developing new production technologies, and then transferring these technologies to farmers. This was a team effort in the fullest sense, including AVRDC staff at regional programs in Africa and Asia, and our partners who work in regional networks across the globe.

You will notice that this year's annual report includes some special features. There is a comprehensive summary of our activities during the past decade in Bangladesh. Socioeconomic studies proved that technologies adopted benefited both farmers and consumers. You will also notice AVRDC's new initiatives that focus on indigenous vegetables. We are convinced that these activities will generate new opportunities for farmers in the tropics for better nutrition and higher incomes in the future.

We have also decided to include most of our scientific outputs of last year in this annual progress report because we know that this information is valuable to our partners. The full text of this report is also available at our web site. We invite you to visit our web site and learn more about our research activities. We hope that by working together as partners we can meet the emerging challenges that are ahead of us.

Sincerely,

Samson C.S. Tsou
Director General

Board members

[a] Left during 2000
[b] Assumed office during 2000

Program I

Vegetables in cereal-based systems

Program I works to increase the efficiency of cereal-based vegetable production systems through the development of improved cultivars. The goal is sustainable cereal–vegetable cropping systems that enhance returns to land, labor, and capital, and at the same time protect the environment.

The mechanism involves the application of strategic research to develop improved technologies and innovative research methodologies that are applicable to national agricultural research systems. Improved technologies include improved breeding materials or production techniques. Methodologies might include practical means to screen plant populations for disease and insect resistance or nutrient content. The major shift in the approach is to look not only at the production system but also at the marketing and consumption systems. The key is integration of available and new technologies following a systems approach.

The objectives of Program I are to:

- increase production per unit of land area through intensified cropping
- help ensure cropping system sustainability through crop rotation, recycling of unused plant parts, and reduction in the use of agrochemicals
- make available more safe vegetables for human consumption, especially in off seasons
- diversify incomes, regularize cash flow, and reduce risk
- make more efficient use of labor and other resources
- serve as a catalyst for infrastructure development and growth of local service industries

Project 1. Off-season tomato, pepper, and eggplant

Project 1 encompasses most of AVRDC's research on solanaceous vegetables. It has two main purposes:

- to increase tomato and sweet pepper yields in hot-wet and hot-dry environments, and
- to increase and stabilize chili and eggplant yields.

In the hot-wet season, high temperature, flooding, and numerous disease and insect problems drastically reduce tomato yield. Improved tomato lines with heat tolerance and multiple disease resistance, coupled with effective and economical management practices, must be developed to overcome these constraints and extend tomato production into the hot-wet season. Management of bacterial wilt (BW) of tomato has received considerable research attention at AVRDC because of the importance of this disease in the hot-wet season. In hot-dry environments, production of tomato is limited by tomato yellow leaf curl virus, and production of sweet pepper is constrained by high temperatures.

In contrast to tomato and sweet pepper, chili and eggplant are extensively grown in the off-season, even in hot-wet and hot-dry conditions, but pests and diseases often make yields low and unstable. For eggplant, a long-term project output is identification of lines/accessions resistant to major insect pests (particularly eggplant fruit and shoot borer) and BW. For chili, AVRDC plans to increase yield and yield stability by developing improved chili lines and management practices designed to overcome numerous disease problems, especially cucumber mosaic virus, chili veinal mottle virus, tobamoviruses, phytophthora blight, and anthracnose.

ToLCV tolerant tomato lines

Tomato leaf curl virus (ToLCV), a heterogeneous complex of whitefly-vectored geminivirus, is a serious production constraint of tomato worldwide but particularly in warm-dry environments. One preliminary yield trial of 9 F_7 ToLCV tolerant determinate tomato lines and three check varieties was conducted at AVRDC in 1999–2000 (Table 1). The trial was sown on 28 September 1999 and transplanted on 26 October 1999. Trial plots were

Table 1. *Yield and other horticultural characters of ToLCV tolerant tomato lines in a preliminary trial*

Entry	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g)	Solids (°Brix)	Color[1] (a/b)	BW resistance[2] (%)
CLN2116A	110	59	65	4.0	2.00	93
CLN2116B	103	48	64	4.2	2.08	92
CLN2116C	103	43	56	3.6	1.01	63
CLN2116D	101	56	72	3.7	1.98	83
CLN2116E	100	54	72	3.8	1.85	85
CLN2116F	99	55	66	3.8	1.90	98
CLN2114A	96	50	58	3.4	1.84	63
CLN2116G	95	57	62	3.6	1.98	85
CLN2116H	95	39	47	3.7	2.05	100
H24 res. ck	76	56	69	4.5	1.72	NT[3]
CLN2026D sus. ck	103	70	68	3.9	1.90	NT
CLN1621L sus. ck	90	33	47	4.1	1.98	NT
Mean	99	52	61	3.9	1.96	84
CV (%)	12	11	11	5.5	4.10	11
LSD (5%)	12	10	11	0.4	0.13	20

[1] Values for a and b were measured with a chromometer using a red standard surface. Immature green tomatoes have an a/b ratio less than 0. The a/b ratio increases to zero and above as the fruits ripen toward a dark red

[2] Percentage of healthy plants after drench inoculation with the bacterial wilt pathogen in a separate greenhouse trial.

[3] NT = not tested.

single 1.5-m beds with two 4.8-m-long rows per bed. Plants were staked and pruned. Entries were replicated three times and plots were arranged in a randomized complete block design (RCBD). Mean maximum/minimum temperatures during the trial were 24.5/15.9°C. A separate greenhouse trial was conducted to estimate bacterial wilt tolerance after drench inoculation with the bacterial wilt pathogen. All CLN2116-prefixed lines and H24 were confirmed tolerant to the Taiwan ToLCV strain after exposure to viruliferous whiteflies in an AVRDC plastic house. However, ToLCV pressure in the field was low during the flowering and fruit set periods and, consequently, the tolerant lines did not yield significantly more than susceptible check CLN2026D (Table 1). However, the AVRDC ToLCV tolerant lines significantly out-yielded ToLCV tolerant check H24 (inbred line from India) and generally showed better fruit quality than H24. The CLN2116 entries combine resistance to ToLCV and bacterial wilt, both of which are important problems in the tropics.

Contact: P Hanson

Heritability of high temperature fruit-set in tomato line CL5915

High temperature fruit-set (heat tolerance) is a critical character of tomato (*Lycopersicon esculentum* Mill.) varieties targeted for lowland wet season production in the tropics and subtropics. AVRDC tomato line CL5915-93D4-1-0-3 (CL5915) is a valuable source of heat tolerance genes for tomato genetic improvement. The gene action of heat tolerance in CL5915 was determined by evaluating the fruit-set characters of F_1, F_2, BCP_1 and BCP_2 of a cross between CL5915 and heat sensitive line UC204A in two wet season trials at AVRDC.

Parent-offspring regression of F_2-derived F_3 ($F_{2:3}$) family means on the F_2 plants from CL5915 × UC204A was used to estimate the heritability of F_2 single plant selection for heat tolerance. Mean percent fruit-set and fruit number per cluster of the F_1 and BCP_1 exceeded mid-parent values and were not significantly different from those of CL5915, indicating complete dominance for heat tolerance (Table 2). Generation mean analyses indicated that a

Table 2. *Generation means and gene effects estimates of CL5915 x UC204A evaluated for tomato fruit-set traits under high temperatures, AVRDC, Taiwan, 1995 and 1996*

	N[1]		Flower per cluster		Fruit per cluster		Fruit-set[2]	
	1995	1996	1995	1996	1995	1996	1995	1996
Generation								
CL5915 (P_1)	27	51	8.4 ± 0.3 a	9.3 ± 0.3 a	2.5 ± 0.2 a	2.4 ± 0.1 a	30.4 ± 2.1 a[3]	26.3 ± 1.5 a
UC204A (P_2)	30	40	4.4 ± 0.1 d	5.0 ± 0.1 c	0.1 ± 0.0 c	0.3 ± 0.0 c	1.0 ± 0.6 c	5.1 ± 0.9 b
F_1	29	50	7.1 ± 0.1 b	7.3 ± 0.2 b	2.3 ± 0.1 a	2.5 ± 0.1 a	33.2 ± 2.5 a	34.9 ± 1.7 a
F_2	122	132	6.8 ± 0.1 b	7.1 ± 0.1 b	1.7 ± 0.1 b	2.1 ± 0.1 ab	25.2 ± 1.6 ab	30.3 ± 1.3 a
BCP_1	53	59	8.7 ± 0.2 a	8.7 ± 0.2 a	2.7 ± 0.1 a	2.7 ± 0.1 a	31.8 ± 1.9 a	31.6 ± 1.2 a
BCP_2	56	40	5.6 ± 0.2 c	6.1 ± 0.2 bc	1.2 ± 0.1 b	1.5 ± 0.2 b	20.5 ± 2.2 b	24.2 ± 3.5 a
Effect[4]								
[m]			6.5 ± 0.2**	7.2 ± 0.1**	1.3 ± 0.1**	1.4 ± 0.01**	15.6 ± 0.8**	25.2 ± 2.4**
[d]			2.1 ± 0.2**	2.2 ± 0.1**	1.3 ± 0.1**	1.1 ± 0.01**	14.5 ± 0.8**	10.2 ± 0.7**
[h]			0.7 ± 0.4 NS	0.1 ± 0.3 NS	1.0 ± 0.2*	1.2 ± 0.12**	19.0 ± 1.8**	9.3 ± 3.4 NS
[i]			-	-	-	-	-	- 9.7 ± 2.5 NS
[j]			1.5 ± 0.9 NS	-	-	-	-	-
[l]			-	-	-	-	-	-
c^2			5.80 NS	2.78 NS	3.03 NS	3.75 NS	1.93 NS	1.22 NS

[1] No. of plants.
[2] Total number of fruit set in clusters 2–6 divided by total flower number in clusters 2–6.
[w] Mean ± standard error of the mean.
[3] Means followed by the same letter in the same column are not significantly different at P = 0.05, according to the least significant difference.
[4] m = mean effect, d = additive gene effect, h = dominance gene effect, i = additive × additive gene effect, j = additive × dominance gene effect, l = dominance × dominance gene effect.
NS *, ** Nonsignificant or significant at P£ 0.05, P£ 0.01, respectively.

model including simple additive and dominance effects adequately explained the inheritance of mean fruit number per cluster both years. For mean percent fruit-set, a model including simple additive-dominance effects produced an adequately fitting model in the 1996 season, but the best-fitting model included an epistatic component in the 1997 season. Heritabilities estimated for fruit-set characters in 1996 and 1997, respectively, were 0.31 and 0.21 for percent fruit-set; 0.28 and 0.14 for mean fruit number per cluster; and 0.53 and 0.15 for flower number per cluster (Table 3). The low heritabilities for percent fruit-set and mean fruit number per cluster under high temperatures imply that single plant selection in the F_2 for heat tolerance from crosses involving CL5915 is not effective and suggests that selection should be based on replicated family testing in the F_3 and later generations.

Table 3. *Heritability estimates for CL5915 x UC204A based on parent-offspring regression for fruit-set characters at AVRDC, Taiwan*

Trait	Generation parent–progeny	n	Heritability ± s.e.
Flowers/cluster	F_2-$F_{2:3}$ (1996)	48	0.53 ± 0.12**
	F_2-$F_{2:3}$ (1997)	37	0.15 ± 0.09NS
Fruit number/cluster	F_2-$F_{2:3}$ (1996)	48	0.28 ± 0.05**
	F_2-$F_{2:3}$ (1997)	37	0.14 ± 0.10NS
Fruit-set (%)	F_2-$F_{2:3}$ (1996)	48	0.31 ± 0.05**
	F_2-$F_{2:3}$ (1997)	37	0.21 ± 0.07NS

n = number of parent–offspring pairs.
NS, ** = Nonsignificant or significant at P£0.01, respectively.

Contact: P Hanson

Genetic diversity of whitefly-transmitted geminiviruses in South and Southeast Asia

Knowledge of the genetic diversity of geminiviruses affecting solanaceous crops and common weeds in Asia is important for implementation of effective integrated pest management (IPM) programs.

Leaf samples from plants showing symptoms of geminivirus infection, such as vein clearing, yellowing, curling, blistering of the leaves, upright terminal shoots, and general plant stunting, were squashed on nylon membranes and tested by nucleic acid hybridization (NAH) using various digoxigenin labelled probes including: ToLCV-Ban 1, ToLCV-Ban 2, ToLCV-Ban 3, and ToLCV-LK (for India, Pakistan, and Nepal samples), ToLCV-BD1 (for Bangladesh samples), ToLCV-PH (for Philippines samples), and ToLCV-TW (for Taiwan samples), TYLCV-TH (for Thailand samples), and TYLCV-IL/EG and TYLCV-TZ (for Mauritius and Tanzania samples). Selected samples were processed by polymerase chain reaction (PCR) using the general degenerate primer pair PAL1v1978/PAR1c715, which amplifies the top part of geminivirus DNA-A (approx. 1.5 kb, including the IR, PreCP, and part of the C1 and CP regions) followed by cloning and sequencing (as described in *AVRDC Report 1998*), and, lastly, a blast analysis with DNA-A sequences of all geminiviruses available in the GENBANK database of the National Center for Biotechnology Information.

Results show that the tomato and pepper crops in most Asian countries are infected by geminiviruses (Table 4). Many weeds, particularly *Ageratum* sp. and *Croton* sp., but also other weeds, such as *Raphanus* sp., *Parthenium* sp., *Mimosa* sp., and *Euphorbia* sp., also harbor geminiviruses.

Table 5 lists the geminiviruses cloned and sequenced at AVRDC in 2000. Based on DNA sequence blast analysis, the tomato geminiviruses from Malaysia, Sri Lanka, and the Philippines are distinct because their sequences have less than 90% homology with any other geminiviruses. The tomato geminivirus from the Kolar region, Karnataka State, India, was found to be a closely related strain of ToLCV Ban-2, common in the Bangalore area (sequence homology 94%). There is strong evidence that the tomato geminiviruses from Taiwan are strains of the same virus. However, the geminivirus infecting *Ageratum* sp., found at the edge of a tomato field with a high percentage of ToLCV-infected tomato plants, was not ToLCV, but possibly a strain of ageratum yellow vein virus, originally described in Singapore. The geminivirus that infects chili in Bangladesh is a distinct virus, not related to the geminiviruses infecting tomato in that country. Similarly, the geminivirus infecting chili in Pakistan is a distinct geminivirus. The above findings confirm the high genetic diversity of geminiviruses infecting the tomato crop in Asia. Furthermore, geminiviruses infecting peppers seem to be different from those infecting tomato.

Table 4. *Geminivirus survey of major solanaceous crops and weeds in Asia and other regions using NAH and/or PCR, 2000*

Country	Plant[1]	No. samples tested	No. (%) samples positive	
Bangladesh	To	56	30	(54)
	Pe	38	2	(5)
	W [2]	9	2	(22)
India	To	201	89	(44)
	Pe	67	23	(34)
	W [3]	123	31	(25)
Indonesia	To	21	1	(5)
	Pe	8	2	(25)
Malaysia	To	1	1	(100)
	Pe	2	2	(100)
	W [4]	3	3	(100)
Mauritius	To	17	1	(6)
Nepal	To	56	23	(41)
	Pe	2	1	(50)
Philippines	To	5	3	(60)
Taiwan	To	54	35	(65)
	Pe	67	0	
	W [5]	28	10	(36)
Tanzania	To	182	72	(40)
	W [6]	23	0	
Thailand	To	7	6	(86)
	Pe	1	1	(100)
Total		971	338	(35)

[1] Pe = pepper; To = Tomato; W = weeds. Weeds found to contain geminiviruses after nucleic acid hybridization (NAH) or polymerase chain reaction (PCR) tests are listed in bold below.

[2] Including *Heliotropium indicum*, *Croton sparsiflorus*, *Raphanus raphanistrum*, *Eclipta prostrata, Euphorbia hirta.*

[3] Including *Amaranthus spinosus, Zinnia elegans, Borhaavia diffusa, Parthenium histerophorus*, *Acalypha sp*, *Ageratum conyzoides*, *Acanthospermum hispidum, Phyllanthus niruri, Leptadenia reticulata, Vernonia anthelmintica, Croton bonplondianum, Corchorus aestuans, Sida acuta, Martynia annua*, *Euphorbia geniculata.*

[4] *Ageratum houstonianum*, *Mimosa invisa.*

[5] *Ageratum* sp., *Petunia.*

[6] including *Datura* sp., *Ageratum* sp., *Nicandra* sp., *Solanum* sp., *Amaranthus* sp., *Aeschynomene aspera, Oxalis latifolia, Galinsoga* sp.

Nineteen tomato lines, identified by cooperators in Costa Rica as tolerant/resistant to ToLCV in 1999 (AVRDC Accessions L131, L157, L167, L170, L432, L456, L464, L623, L647, L712, L837, L851, L982, L1014, L1504, L1830, L1958, L2094, and L2288) were found susceptible (100% infection with strong curling and yellowing symptoms) to the Taiwan tomato leaf curl virus at 63 days after exposure (DAE) to viruliferous whiteflies. However, in three accessions (L157, L464, and L2094) infection ranged from 27% to 37% at 47 DAE when infection in the other lines ranged from 50% to 83%. Plants of the susceptible check TK-70 showed 100% infection at 40 DAE.

Contact: SK Green

Pyramiding of TYLCV resistant genes into tomato by marker-assisted selection

Pyramiding resistant resources into a single variety is necessary in order to provide more durable resistance for plant diseases. However, disease screening provides information solely based on the disease reaction of an individual plant. Molecular analysis of resistant plants can determine how many and which types of resistant genes are involved. Molecular markers are thus useful to reveal genetic inheritance of individual plants and accordingly assist selection in the breeding program.

Ty-1 gene and the resistant gene from *L. hirsutum* are two identified sources for tomato TYLCV resistance, of which RFLP-type markers are available. Previously marker-assisted selection was employed in three doublecross breeding programs using two donor and three elite breeding lines to incorporate two resistant sources into three recurrent parents. This year, selection was followed up to the $DCBC_1\ F_1$ generation. Seventy-two plants from each population were exposed to viruliferous whiteflies for virus protection. Consequently, 11, 13, and 18 healthy plants were selected from three populations (derived from backcrossing with CLN399, CH154, and CLN2026, respectively) for confirmation of carrying two resistant genes. Three RFLP markers each for *Ty*-1 and the *L. hirsutum* resistant gene were evaluated. The introgression from *L. hirsutum* is regarded as resistant while *Ty*-1 was regarded as tolerant gene for TYLCV disease. Previous test for doublecross generation indicated that more than 90% of the symptom-free plants carried the resistant introgression from *L. hirsutum*, while only less than half of the plants carried *Ty*-1 gene. The results for DC_1BC_1 generation, however, deviated from the previous DC offspring (Table 6). Only one to two-third of the healthy plants carried the *L. hirsutum* gene, though the ration for *Ty*-1 gene is not much biased against the previous test. Different ratio of plants shown in three populations could be due to artificial selection for favorable fruit traits along with resistance to TYLCV. Almost all healthy plants carried either resistance or tolerance to introgression

Table 5. *DNA sequence blast analyses of begomoviruses of solanaceous crops and weeds cloned and sequenced in 2000*

Country	Crop	Clone used for comparison[1]	Sequence similarity (%)	Virus with highest sequence similarity	Genebank accession
Bangladesh	Pepper	BC1	86	Papaya leaf curl virus	Y15934
India (Kolar)	Tomato	IndM	94	Tomato leaf curl virus India (ToLCV-Ban 2)	Z48182
Malaysia	Tomato	MT1-5	88	Tomato leaf curl virus (Laos)	AF195782
Pakistan	Pepper	PP4 (12)	86	Tomato leaf curl virus Bangladesh (BD-2)	AF188481
Philippines	Tomato	PH9	80	Ageratum yellow vein virus (Singapore)	X74516
Sri Lanka	Tomato	SL14	83	Tomato leaf curl virus India (Ban 2)	Z48182
Taiwan Central	Tomato	Ch1	98	Tomato leaf curl virus (Taiwan-South)	U88692
Taiwan East	Tomato	KD	96	Tomato leaf curl virus (Taiwan-South)	U88692
Taiwan South	Ageratum	Agskg	91	Ageratum yellow vein virus (Singapore)	X74516

[1] Full length DNA-A

Table 6. *The genetic status of TYLCV-related introgression among symptomless plants of three backcross populations*

Line	No. of tested plants	R gene from *L. hirsutum*		Ty-1 gene		Plants with both genes	Plants without TYLCV gene
		Full length	Partial	Full length	Partial		
$CLN2513DC_1BC_1$	11	8	0	4	1	2	1
$CLN2514DC_1BC_1$	13	3	2	9	0	2	2
$CLN2515DC_1BC_1$	18	9	5	7	3	4	0

from donor parents. The results confirmed the protection function of these two genes against TYLCV. It is surprising that in $CLN2514DC_1BC_1$ (with CH154 as recurrent parent), only three out of 13 healthy plants carried resistance gene while nine plants carried tolerance genes. It is possible that when the virus infection strength was not severe, the tolerance gene could provide sufficient protection. The results of this study indicate that the incorporation of various resistant resources can provide better resistance against specific disease.

Contact: G Kuo

Heat tolerant tropical tomato lines

AVRDC tomato line CL5915-93D4-1-0-3 is an excellent source of genes for high temperature fruit-set and earlier we reported on the heritability of early generation selection for heat tolerance in this line. From this study we identified heat tolerant lines from CL5915 × UC204A (= CLN2001) with good fruit qualities, and during summer 2000 we conducted a preliminary yield trial (PYT) of 10 F_6 determinate tomato lines and five checks to identify potential lines for international distribution. The PYT was sown 13 July 2000 and transplanted on 15 August 2000. Trial plots were two 1.5-m-wide beds with one 4.8-m-long row per bed. Plants were staked and pruned. Entries were arranged in RCBD with three replications. Mean maximum/minimum temperatures during fruit-set were 31.3/23.2ºC and mean relative humidity was 73.5%. Yield and horticultural characteristics of entries are shown in Table 7. CLN2001F1, the hybrid of CL5915 × UC204A, produced larger fruit and yielded 45% more than heat tolerant parent CL5915-93D4-1-0-3. Heterosis for heat tolerance in tomato has been observed and indicates the potential benefits of heat tolerant hybrids for summer production. One inbred line, CLN2001(1604)-127-4-0-2, yielded significantly more than CL5915. Fruit size means of most entries tended to be closer to that of smaller parent CL5915, demonstrating the problematic association between high temperature fruit-set and small fruit size. Internal fruit color (a/b) of most entries exceeded 2.00, and some might have potential as processing tomato varieties.

Table 7. *Yield and other horticultural characters of tropical tomato lines in a preliminary trial, AVRDC, 2000*

Entry	Marketable yield (t/ha)	Fruit-set (%)	Fruit size (g)	Fruit shape	pH	Solids (ºBrix)	Color[1] (a/b)	Vine cover
CLN2001(1604)-127-2-0-6	26.5	31.0	31.7	plum	4.00	4.47	2.04	fair
CLN2001(1604)-27-3-0-1	29.1	27.4	38.4	oblong	3.97	4.87	2.25	poor
CLN2001(1604)-127-40-5	28.0	28.3	37.6	oblong	3.97	4.90	2.07	fair
CLN2001(1604)-127-4-0-2	34.8	29.6	39.5	oblong	3.94	4.53	2.11	fair
CLN2001(1604)-27-3-0-2	31.6	29.2	39.6	oblong	3.92	4.87	1.85	good
CLN2001(1604)-127-4-0-6	29.2	31.1	33.0	deep globe	4.03	4.70	2.17	good
CLN2001(1604)-5-1-0-2	18.5	23.9	38.4	deep globe	4.31	4.73	1.85	good
CLN2001(1604)-27-3-0-5	21.5	32.4	38.0	oblong	3.97	4.97	2.19	poor
CLN2001(1604)-127-40-2	34.8	27.9	34.2	square	3.95	4.90	2.06	poor
CLN2001(1604)-126-3A-0-4	23.2	34.6	39.4	square	4.09	4.67	2.11	good
CLN2001F1	40.0	34.7	47.6	globe	4.07	4.67	2.04	good
CL5915-93D4-1-0-3 (parent)	27.5	23.6	35.3	plum	4.07	4.77	1.91	good
UC204A (parent)	5.4	2.9	54.8	deep globe	4.33	4.87	2.10	excellent
CLN2026D	28.9	48.6	52.4	oblong	4.04	4.10	1.76	fair
CLN1621L	26.4	32.2	34.1	plum	4.15	4.80	1.92	good
Mean	26.2	29.2	39.6		4.05	4.72	2.03	
CV (%)	21.5	22.0	8.8		1.5	4.0	7.7	
LSD (0.05)	9.4	10.7	5.9		0.10	0.32	0.26	

[1] Values for a and b were measured with a chromometer using a red standard surface. Immature green tomatoes have an a/b ratio less than 0. The a/b ratio increases to zero and above as the fruits ripen toward a dark red.

A second PYT of mostly of indeterminate tomato inbred lines was carried out at AVRDC in order to identify lines adapted to the late hot-wet season. Entries and checks were sown on 6 July and transplanted on 23 August 2000. Entries were arranged in RCBD with two replications. Plots included single 1.6-m-wide beds with two 4.8-m-long rows per bed. Spacing was 0.6 m and 0.4 m between and within rows, respectively. Plants were staked and pruned. Harvesting took place between 7 November and 5 December 2000. Yields and horticultural characteristics of the best entries are shown in Table 8. Entry CLN2418-161DC2-1-4-22-6 yielded significantly more than FMTT22, and several entries produced significantly higher yields than checks FMTT33 and FMTT553. Despite high temperatures during fruit-set, average fruit sizes of seven entries were 90 g or greater. Most entries demonstrated greater than 80% survival after bacterial wilt inoculation in a glasshouse trial.

Contact: P Hanson

Bacterial wilt tolerant processing tomato lines

Processing tomato varieties often serve a dual purpose—they are used to make products, such as paste and ketchup, or sold in the fresh market. Bacterial wilt is a major in constraint of tomato production in the tropics and subtropics, and few processing varieties tolerant to this disease are available. A preliminary yield trial (PYT) of processing tomato inbred lines was conducted at the AVRDC during the dry season to identify superior entries for international distribution. The trial was sown on 18 September and transplanted on 18 October 2000. Trial plots were two 1.5-m-wide beds with one 4.8-m-long row per bed. Plants were staked and pruned. Entries were replicated twice and plots were arranged in a randomized complete block design. Due to favorable growing conditions, marketable yields were high, ranging from 77.0 to 120.2 t/ha, with check line NCEBR-6 yielding the highest (Table 9). (NCEBR-6 contains the og^c gene, which gives the fruit a deep red color valued by the processing industry.) Most entries demonstrated excellent color values but solid contents were low due to rain just prior to harvest. Some entries, such as CLN2123E, produced high contents of beta-carotene, lycopene, and vitamin C. In addition to BW tolerance, entries with the CLN2123 prefix also carry resistance to tomato leaf curl virus. Entries CLN2231C, CLN2243B, CLN2123C, CLN2123E, and CLN2123F will be made available for international distribution.

Table 8. *Yield and horticultural characteristics of fresh market tomato lines tested in preliminary yield trial, late summer, 2000*

Entry	Marketable yield (t/ha)	Growth habit[1]	Days to maturity	Fruit set (%)	Fruit size (g)	Solids (ºBrix)	Acid[2] (%)	Color (a/b)	Fruit shoulder color[3]	Fruit shape[4]	Cracking[5]	Firmness	BW resistance[6] (%)
CLN2418-161DC2-1-4-22-6	50.9	ID	93	39.7	81	4.40	0.26	1.76	LGS	DG	SVC	firm	66.9
CLN2418-161DC2-1-4-22-4	47.5	ID	93	41.0	85	4.20	0.21	1.73	LGS	DG	MR/SVC	firm	92.2
CLN2418-161DC2-1-4-19-12	46.7	D	91	37.8	68	4.60	0.25	1.92	LGS	DG	SVR/C	firm	80.0
CLN2413-194DC2-1-5-12	44.1	ID	93	32.4	93	5.00	0.25	1.78	GS	DG	N	firm	91.2
CLN2418-161DC2-1-4-19-11	43.6	D	92	36.6	65	4.40	0.24	1.88	LGS	DG	SVC	firm	80.0
CLN2413-124DC2-1-1-12	41.9	SD	94	32.6	112	5.30	0.29	1.64	LGS	DG	MC	firm	97.1
CLN2413-194DC2-1-3-13	41.4	ID	94	30.6	82	4.80	0.22	1.71	LGS	DG	MC	mod. firm	96.2
CLN2424-227DC2-2-7-23-23	38.7	ID	91	39.7	65	4.90	0.29	1.07	LGS	DG	MC/R	mod. firm	78.1
CLN2424-227DC2-2-7-23-24	38.4	ID	91	31.6	72	4.90	0.27	2.04	LGS	DG	MC	firm	87.1
CLN2424-227DC2-2-5-19-2	37.5	ID	91	35.5	59	4.95	0.29	2.09	LGS	DG	SVC/R	mod. firm	81.0
CLN2413-194DC2-1-4-12	33.9	ID	94	26.7	108	4.90	0.28	1.58	GS	DG	MC/R	firm	87.9
CLN2413-195DC2-2-8-0-2	33.6	ID	92	38.5	98	4.95	0.27	1.95	DGS	EL	MC	firm	73.1
CLN2424-227DC2-2-7-20-8	32.9	ID	92	28.4	76	5.05	0.31	2.06	LGS	DG	MC/R	mod. firm	60.4
CLN2413-194DC2-1-5-1	32.1	ID	93	28.9	90	4.80	0.25	1.72	GS	DG	N	firm	89.4
CLN2413-194DC2-1-4-12	31.8	ID	94	27.5	92	4.75	0.27	1.42	GS	DG	N	firm	87.9
CLN2413-195DC2-2-8-0-4	27.9	ID	92	36.9	92	5.05	0.29	1.74	DGS	DG	VSLR	firm	75.8
FMTT22 ck	35.4	ID	95	22.8	106	5.15	0.32	1.73	LGS	DG	VSLR	mod. firm	
FMTT33 ck	29.7	ID	101	19.5	92	4.85	0.26	1.69	LGS	DG	VSLR	firm	
FMTT553 ck	27.3	ID	95	20.3	97	6.50	0.33	1.89	DGS	DG	R	very firm	
Mean of all entries	37.2	74	93	31	87	4.93	0.27	1.76					79.9
CV (%)	17.2	3.4	1.8	20.2	76	8.1	7.8	9.9					16.6
LSD (0.05)	13.4	5.3	4	13.3	13.9	0.83	0.04	0.15					26.5

[1] ID = indeterminate, D = determinate, SD = semideterminate.
[2] Equivalent of citric acid.
[3] GS = green shoulder, LGS = light green shoulder, DGS = dark green shoulder.
[4] DG = deep globe, EL = elongated.
[5] N = none, C = concentric, MC = moderate concentric, SVC = severe concentric, R = radial, VSLR = very slight radial, MR = moderate radial.
[6] Percentage of healthy plants after drench inoculation with the bacterial wilt pathogen in a separate greenhouse trial.

Table 9. *Yield data and horticultural characteristics of processing tomato lines*

	Marketable yield (t/ha)	Fruit set (%)	Fruit size (g)	Days to maturity	Solids (°Brix)	pH	Acid[1] (%)	Color[2] (a/b)	Beta-carotene (mg/100 g)	Lycopene (mg/100 g)	Vit C (mg/100 g)	BW[3] (% survival)	Disease[4] resistance
CLN2231C	92.4	68.2	54.3	86.5	4.0	4.31	0.28	2.04	1.09	3.64	34.3	82.9	ToMV, F-1
CLN2243B	84.4	59.4	56.6	86.5	3.3	4.17	0.33	2.12	0.47	3.54	19.4	77.8	ToMV, F-1, F-2
CLN2231-157-25	104.7	75.9	50.7	88.5	3.7	4.16	0.30	1.94	0.78	2.85	21.1	76.7	ToMV, F-1, F-2
CLN2237-35-14	103.0	88.2	56.2	89.5	3.6	4.22	0.26	1.65	1.22	3.32	20.4	56.5	ToMV, F-1, F-2
CLN2237A	95.8	69.1	40.7	88.5	3.8	4.28	0.26	1.86	0.79	2.93	19.4	76.7	ToMV, F-1, F-2
CLN2237B	87.8	68.3	61.3	105.5	3.6	4.23	0.25	1.50	0.67	1.77	20.1	73.3	ToMV, F-1
CLN2237-35-14-5	88.8	76.9	61.7	95.5	3.7	4.25	0.30	1.82	1.00	3.69	28.3	60.8	ToMV, F-1
CLN2026M	88.1	63.4	66.7	71.0	4.0	4.30	0.26	2.01	0.75	4.30	36.3	85.0	ToMV, F-1,F-2, GLS
CLN2026N	90.7	67.5	65.1	73.5	4.0	4.27	0.25	2.02	0.93	4.71	27.3	85.3	ToMV, F-1,F-2, GLS
CLN2123-111-16-17-16	84.1	60.5	60.2	83.5	3.7	4.30	0.27	2.13	0.91	4.85	21.3	70.0	ToMV, F-1
CLN2123C	97.7	58.6	52.7	79.5	3.8	4.37	0.26	2.17	1.23	5.29	31.8	90.0	ToMV, F-1, GLS
CLN2123D	92.9	64.2	45.6	71.0	3.7	4.29	0.26	2.03	0.94	4.89	28.5	85.0	ToMV, F-1, GLS
CLN2123-111-2-12-11	103.6	65.0	56.3	78.0	3.9	4.44	0.25	2.09	0.97	5.54	30.4	78.9	ToMV, F-1, GLS
CLN2123E	88.7	71.4	51.7	82.0	3.8	4.46	0.24	2.16	1.07	5.93	41.7	73.7	ToMV, F-1, GLS
CLN2123F	98.8	68.6	58.0	75.5	3.7	4.24	0.29	1.98	1.10	4.51	18.2	52.6	ToMV, F-1
ASGROW Line A	95.8	54.0	87.2	74.5	3.7	4.39	0.22	1.98	0.45	3.40	18.2	47.4	
NCEBR-6 ck	120.2	54.3	72.8	100	3.7	4.35	0.27	2.16	0.35	2.85	17.0	15.0	
CLN2026D	77.0	55.3	85.6	70.0	3.6	4.16	0.30	1.99	0.62	3.14	20.0	70.0	ToMV, F-1,F-2, GLS
LSD (0.05)	23.7	15.5	1.1	13.5	0.6	0.11	0.03	0.16	-	-	-	-	
Mean of all entries	94.1	66.0	60.2	83.3	3.7	4.29	0.27	1.98	-	-	-	-	
CV (%)	11.9	11.1	8.4	7.7	7.1	1.2	6.0	3.9	-	-	-	-	

[1] Equivalent of citric acid.

[2] Values for a and b were measured with a chromometer using a red standard surface. Immature green tomatoes have an a/b ratio less than 0. The a/b ratio increases to zero and above as the fruits ripen toward a dark red.

[3] Percentage of healthy plants after drench inoculation with the bacterial wilt pathogen in a separate greenhouse trial.

[4] ToMV = tomato mosaic virus; F-1 and F-2 = resistance to races 1 and 2, respectively, of the fusarium wilt pathogen; GLS = gray leaf spot.

Contact: P Hanson

Variation of *Ralstonia solanacearum* strains isolated from tomato plants in Indonesia, Philippines, and Taiwan

Bacterial wilt (BW), caused by race 1 strains of *Ralstonia solanacearum*, is the most important disease of tomato in the tropics. Planting resistant varieties has been the main control strategy, as the pathogen is soil-borne and has a wide host range. The success of BW resistant tomato varieties has, however, been limited by the location-specific nature of the resistance to BW. This is due in part to large pathogen strain variation. Recent studies at AVRDC have shown that a population of *R. solanacearum* collected from tomato production fields in Taiwan is highly diverse both in genotype and aggressiveness. In order to extend our understanding of strain variation at the regional level, a collaborative effort was made to collect and assay strains from Indonesia, the Philippines, and Taiwan. Here we report on strain variation in genotype and aggressiveness among Southeast Asian populations and their possible population structure (differentiation among subpopulations at different hierarchical levels).

Forty-two strains from Indonesia (collected in 1990–1997), 48 strains from the Philippines (collected in 1975–1998), and 46 strains from Taiwan (collected in 1988–1997) were isolated from wilting tomato plants in production fields. The Indonesian strains were collected from west Java, mostly from the Parahyangan highlands, and the Philippine strains from Luzon and Mindanao. Biovar, genotype, and aggressiveness of each strain were determined. To evaluate aggressiveness, 3-week-old tomato seedlings of L390 (susceptible), L180-1 (moderately resistant), and Hawaii 7996 (H7996 resistant) were inoculated with each strain, by soil drenching method, and maintained at a mean temperature of 27.8°C. Pathotype, a group of strains showing similar aggressiveness, was defined based on final severity (final mean percent wilting) of each tomato line by cluster analysis using the average linkage method. Genotypic variation was examined using seven strain-specific primer pairs, developed by J. Timmis, Univ. of Adelaide, Australia: AU787B-11F/RR, AU7T151-1FF/RR, AU8Tm22-4F/RR, AU20T151-Tm22FF/RR, AU767/768, AU769/770, and AU11T151-10F/R. Haplotypic diversity (H; Nei's index) was calculated to indicate the degree of genetic diversity. The index of differentiation (G_{ST}) was calculated to determine differentiation at different hierarchical subdivisions.

Strains of biovars 2, N2, 3, and 4 were found over countries. However, biovars 2 and N2 were only present in Indonesia, which comprised 81% of the collection (21.4% of biovar 2 and 59.5% of N2). Predominance of biovars 2 and N2 could be due to potato production in the Parahyangan highlands; potato is a common host of biovars 2 and N2. Strain variation in the lowlands of Indonesia should be assessed in order to determine if other biovars predominate outside highland areas. Biovar 3, common in the lowland tropics, was the most frequent biovar in the Philippines and Taiwan. Aggressiveness data of Indonesian strains is not presented because of low severity and large variation among replications. Low severity or large variation might be due to the specific interaction between biovars 2 and N2 strains and tomato. Overall, the Philippine population was more aggressive than the Taiwan population (Table 10), and cluster analysis revealed five pathotypes over both populations. Strains from both countries clustered in each pathotype. However, the Philippine strains accounted for most of the strains in the higher aggressive pathotypes 1 and 2. Pathotypes 3 and 4 were the predominant groups, in which 72.5% of the strains from the two countries clustered. Interaction with tomato lines indicated that resistance sources, such as H7996, are effective against pathotypes 3 and 4, and effectively control the disease. Breeding for resistance against pathotypes 3 and 4 should be effective. On the other hand, it will be necessary to search for new resistance sources against pathotypes 1 and 2. Cultural practices to reduce pathogen survival should be incorporated into an integrated management strategy aiming for a sustainable and effective management of pathotypes 1 and 2. A total of 18 haplotypes were identified. Strains of biovars 2 and N2 were quite homogeneous and consisted of only 2–3 haplotypes. The Taiwan population consisted of 10 haplotypes, of which four contained only Taiwanese strains. The Philippine population consisted of 6 haplotypes, of which four contained only Philippine strains. The dissimilarity of all strains was 0.33, and the Taiwan population was more dissimilar and diverse than the other populations (Table 11). Strong differentiation at the country and biovar level was reflected by the high G_{ST} values. Differentiation at the biovar level was due to the presence of biovars 2 and N2 strains. Differentiation at the country level implies that the

Table 10. *Mean final percent wilting on tomato lines caused by Philippine and Taiwan strains of* Ralstonia solanacearum

Population	Strain no.[1]	L390	L180-1	H7996
Philippine	42	94.8 ± 7.6	44.3 ± 30.9	25.3 ± 26.6
Taiwan	38	80.8 ± 22.3	23.1 ± 22.4	7.1 ± 12.5
Pathotype 1	7 (1/ 6)	98.6 ± 4.0	93.1 ± 9.1	75.5 ± 17.4
Pathotype 2	7 (1/ 6)	96.8 ± 6.9	78.2 ± 23.5	43.1 ± 19.7
Pathotype 3	20 (7/13)	97.7 ± 4.2	44.9 ± 19.8	16.2 ± 15.3
Pathotype 4	38 (22/16)	89.1 ± 15.4	16.8 ± 16.9	4.8 ± 9.9
Pathotype 5	8 (7/1)	43.5 ± 21.8	2.6 ± 4.6	1.2 ± 3.6

[1] Number of strains in each pathotype. Numbers in parentheses are number of Taiwan strains/number of Philippine strains.

population structure and trends of pathogen evolution could be different from country to country and requires specific monitoring. The genetic structure of the Philippine population was examined. No differentiation was detected at the pathotype level; however, strong differentiation was found at the geographic origin level in comparing strains from Luzon and Mindanao islands (Table 11). No differentiation was detected at the pathotype and geographic origin level when the Taiwan population was examined.

In conclusion, large variation in genotype and aggressiveness were found in Southeast Asia. Characteristics of Indonesia lowland strains would need to be determined, as mostly highland strains were collected for this study. Although the Philippine population is more aggressive than the Taiwan population, the range of variation and predominant groups are similar. At present, control of tomato BW will require an integrated approach (use of both cultural practices and resistant varieties).

Table 11. *Genetic diversity and differentiation at country and biovar level, and geographic origin level of* Ralstonia solanacearum *in Southeast Asia*

	Strain no.	Haplotype no.	Dissimilarity		H	G_{ST}
			Within	Among		
Country						0.242
Philippines	48	6	0.10	0.42	0.59	
Taiwan	46	10	0.21	0.33	0.79	
Indonesia	42	9	0.15	0.52	0.55	
Biovar						0.394
2	9	2	0.08	0.50	0.56	
N2	25	3	0.01	0.49	0.16	
3	73	15	0.23	0.42	0.82	
4	25	4	0.14	0.30	0.52	
Island						0.35
Luzon	29	4	0.06	0.12	0.36	
Mindanao	15	3	0.07	0.12	0.36	

Contact: JF Wang

Characterization of tomato lines resistant to bacterial wilt—temperature and strain effect

Resistance to bacterial wilt (BW), caused by race 1 *Ralstonia solanacearum* in tomato, is location-specific. Variation in environment and pathogen strain is the main cause of this location specificity. Temperature is the most important environmental factor, as resistance in some BW resistant tomato lines can be reduced under high temperature. However, the response of many resistance sources to high temperature is not clear. Strain variation in aggressiveness has been reported in several race 1 populations; for example, six pathotypes have been identified in Taiwan. Information on the interaction between different pathotypes and BW resistant tomato lines is important for resistance breeding and overall disease management. Therefore, the objectives of this study were to examine the responses of BW resistant tomato lines over a range of temperatures and to determine their stability against different pathotypes.

BW resistant tomato lines bred or selected from different locations were used for this study. Hawaii 7996 (H7996) from Hawaii, BF-Okistu 101 (BF-Okistu) from Japan, L180-1 from AVRDC, CRA66 from Guadeloupe, Rodade from South Africa, Fla7421 from Florida, and GA219 from Georgia were used. L390, a susceptible tomato line, was used as a control. Tomato seedlings were inoculated with Pss4 strain (race 1, biovar 3) by soil drenching. Inoculated seedlings were kept in growth chambers at 16, 20, 24, 28, 32, and 36ºC. Maximum severity (% wilted plants) was usually observed 28 days after inoculation (W28), and these data were used for analysis. Twenty resistant tomato cultivars were selected for the strain effect study, including Hawaii 7996, Hawaii 7997, and Hawaii 7998; R-3034, Tml-46, Tml-114, and F7-80 from the Philippines; CRA66, CRA84, Caravel, and Caraibe from Guadeloupe; GA219, GA1405, and GA1565 from Georgia; BF-Okistu; Rodade from South Africa; and L180-1, L285, CLN1466, and CLN1463 from AVRDC. One strain each from seven different pathotypes defined by Jaunet and Wang (1999) were inoculated on each tomato line by soil drenching, and maintained at 28ºC. Pss4 strain, used at AVRDC for routine screening, was included for comparison. Maximum severity was recorded, which usually was observed 21 days after inoculation (W21). Cluster analysis using average linkage method was conducted for grouping the resistant lines using W21 data.

Generally, BW severity increased at higher temperatures. But maximum disease severity occurred at different temperatures for different cultivars: 24°C for L390; 28°C for BF-Okistu 101, CRA66, Rodade, and Fla7421; and 32°C for L180 and GA219. Five of the seven tested cultivars, including L390, had a lower W28 at 36°C than at 32°C, which indicates that 36°C might reduce multiplication of the pathogen in tomato. Similar trends in temperature responses were observed for all cultivars when plotting W28 over temperature, and ranking of severity among tested lines was similar over temperatures, except 36°C (Figure 1). H7996 had not reached 100% severity even at 36°C. Thus, the durability of resistance in H7996 under high temperature might contribute to its stable resistance as observed in multilocation trials. Ranking of the seven strains according to aggressiveness was similar to that noted by Januet and Wang (1999). Pss190 (the most aggressive pathotype) caused 88.3% wilting (mean final), while Pss81 (the least aggressive pathotype) caused 5.2% wilt. Cluster analysis using W21 data revealed 3 clusters (Figure 2). The mean final percent wilting over lines in clusters 1, 2, and 3 were 62.9%, 27.1%, and 43.4%, respectively. Cluster 1 consisted of lines from diverse sources. All lines from the Philippines were grouped together with H7996 in cluster 2. Among them, H7996, Tml-114, and F7-80 showed the lowest severity from Pss190. Resistance of lines in cluster 2 was stable in multilocation field trials. Thus, they are the best resistance sources for breeding programs. AVRDC breeding lines CLN1463 and CLN1466 were grouped in cluster 3 with CRA84, one of the parents of these lines. This would indicate that the selection procedure used to develop CLN1463 and CLN1466 was suitable in transferring resistance genes from CRA84. Resistant lines selected or bred in different locations might carry different sets of BW resistance genes due to diversity in strains and other factors. It might be possible to increase stability of BW resistance by pyramiding genes from various resistance sources. Use of relatively stable sources, such as H7996, should be given priority in breeding programs.

Contact: JF Wang

Risk assessment of escape of cucumber mosaic virus coat protein gene from transgenic tomato to wild relatives and eggplant

Crops and related wild or weedy plants can exchange genes through pollen transfer if provided the opportunity. Plant breeders have been exploiting this fact by using controlled introgression between crops and their relatives to enhance germplasm resources for breeding purposes. Hybridization between crops

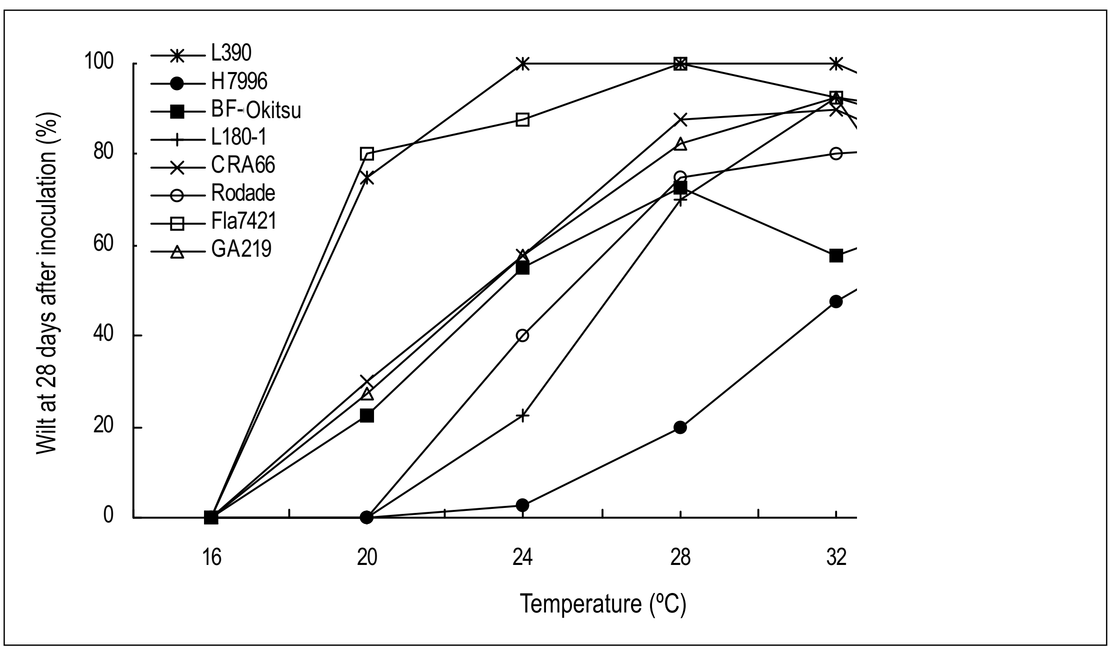

Figure 1. *Interaction of strain Pss4 and seven tomato lines under different temperatures.*

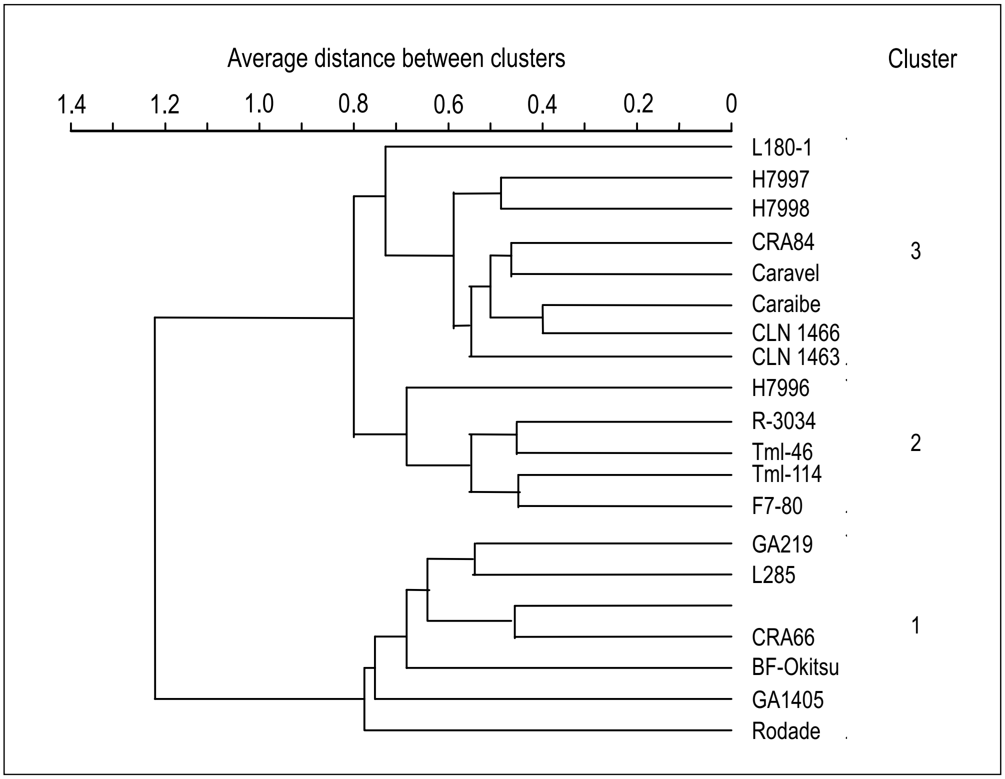

Figure 2. *Dendrogram derived by the average linkage method showing responses (final percent wilting) of tomato lines to seven strains of* R. solanacearum*. The seven strains represent the six pathotypes varied in aggressiveness identified from a Taiwanese population.*

and weeds has also been an area of concern, owing to the potential for cultigen contamination from the influx of wild pollen to breeding plots. However, there has traditionally been little interest in pollen flow from the crop to the weed relatives. In fact, there has been little consensus on the ecological or evolutionary significance of such crop-to-weed mating events. The gap in our understanding has lead to much speculation on the risks associated with the commercial release of transgenic cultivars, and the potential escape of engineered genes from the modified crop to wild or weedy relatives growing near sites of cultivation. The main concern is that a transgene might confer an adaptive advantage to the weeds. The purpose of this study was to evaluate the probability of escape of transgenes from transgenic tomatoes to their wild relatives and eggplant found around AVRDC.

Eggplant (*Solanum melongena*) (accession number S00271) seeds were planted in early September 2000. Mature plants of strawberry tomato (*Physalis pruinosa*), Chinese matrimony vine (*Lycium chinense*.), and night shade (*Solanum nigrum*), in the family Solanaceae, were collected and transferred to a greenhouse in late October 2000. Pollen of transgenic tomatoes with the cucumber mosaic virus coat protein gene (confirmed by Southern blot analysis) was collected one day before hand pollination and stored in a desiccator at 4°C. Stamens were removed one day before flowers opened. They were pollinated the next day—between 30 November and 15 December. Seed was harvested from mature fruits and germinated in the soil. DNA of putative hybrid plants was extracted from young leaves (according to a standard DNA extraction protocol). Two primers, CMV-CP5,5'-CTCTAGAGTTTCGTCTACTTATCT and CP3, 5' CGAGCTCTGGTCTCCTTTGAGAGACCCCATT-3' were used for polymerase chain reaction (PCR). PCR was performed in 25 ml of 5 ng genomic DNA, 0.5 mM primer, 0.05M Tris-HCl (pH 8.3), 0.4 M KCl, 0.25 mM $MgCl_2$, 100 mM each of dATP, dCTP, dGTP, and dTTP, and 0.2 unit Tag DNA polymerase. Amplification was carried out by using an Eppendorf thermocycler set for 40 cycles of 1 min at 94°C, 1 min at 50°C, and 2 min at 72°C. Amplified DNA products were electrophoresed in 1.8% agarose gels and stained with ethidium bromide. The images were then recorded using an AlphaImager 2000 (Alpha Innotech).

Only strawberry tomato × transgenic tomato produced mature fruit; however, the morphology of putative hybrid plants was very similar to strawberry tomato and the cucumber mosaic virus coat protein gene was not detected in these plants (Table 12). The fruits were probably due to self-pollination. Even though hand pollination was made to force introgression of the cucumber mosaic virus coat protein gene, the results from this study indicate that the probability of escape of a transgene from transgenic tomato to these four relatives is very small. Nevertheless, AVRDC will continue to exercise caution in its work with transgenic materials to minimize the chance of escape of transgenes. It has been strongly recommended that transgenic crops be surrounded by wide isolation barriers. This should be coupled with active and aggressive weed management, both in and around fields, to minimize the risk of negative ecological and economic effects.

Contact: CA Liu

Table 12. *Evaluation of transgene transfer from transgenic tomatoes to eggplant, strawberry tomato, Chinese matrimony vine, and night shade*

Plant pollinated with transgene	No.				
	Plants	Flowers pollinated	Mature fruit	Seeds	Hybrid plants with transgene
Eggplant	2	100	0	0	0
Strawberry tomato	3	400	4	168	0
Chinese matrimony vine	3	250	0	0	0
Night shade	3	500	0	0	0

R_6 transgenic tomatoes with cucumber mosaic virus coat protein gene

Cucumber mosaic virus (CMV) is a serious constraint to tomato production. Attempts to breed CMV resistant tomato varieties have been unsuccessful for lack of stable resistance sources, so researchers have turned to genetic engineering.

Several methods have been successfully employed, including ones that followed Sanford and Johnson's hypothesis regarding pathogen derived resistance (PDA). Expression of CMV satellite RNA, replicase gene, and coat protein gene have shown promising results toward the development of CMV resistant lines. Transgenic tomato lines with CMV coat protein gene were generated through Agrobacterium-mediated transformation and have been advanced to R_6 generation. Transgenic lines showing good levels of CMV resistance have been advanced and selected from individual transgenic tomato plants that showed reduced multiplication of CMV, confirmed by enzyme-linked immunosorbent assay (ELISA), and no or minor disease symptoms in the field (isolated for evaluation of transgenic plants). This study was undertaken to confirm the transmission of transgene into the R_6 transgenic tomatoes, and to evaluate the degree of CMV resistance.Twenty-nine R_6 transgenic tomato lines selected from individual ELISA-negative plants showing high levels of CMV resistance and good horticultural traits from the previous field testing of the R_5 generation were used for this study. R_6 seedlings with four expanded leaves were inoculated with CMV and inoculated again one month later, in the greenhouse. Plants were then transferred to the field. Young leaves were harvested from inoculated seedlings and plants in the field for ELISA to determine the degree of CMV multiplication. Reagent and antibody was purchased from DSMZ (Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH). Plant genomic DNA isolation followed the standard CTAB (hexadecyltrimethyl ammonium bromide) method. Genomic DNA was digested with restriction enzyme XbaI/SacI and subject to electrophoresis in 1% agarose gel. Probe was prepared by random labeling method of Prime-a-kit provided by Stratagene with primers CP5 (5'-CTCTAGAGTTTCGTCTACTTATCT-3'0 and CP3 (3'TTACCCCAGAGAGAGTTTTCCTCTGGTCTCGAGC 5') Southern analysis. Polymerase chain reaction with primers CP5 and CP3 was also carried out to confirm the presence of transgene in R_6 plants. Plant DNA was treated in 94°C for 1 min before 2.5 units of Taq polymerase was added. The reaction was performed under the following conditions: 40 cycles of 1 min at 94°C, 1 min at 50°C, 2 min at 72°C, followed by 10 min at 72°C.

The level of CMV multiplication varied from one R_6 transgenic line to another (Table 13). As detected in previous examinations, most transgenic plants' ELISA values were higher than background (ELISA-positive), but were much less than those of non-transgenic control L4783, the variety used for transformation, and of TK70, the indicator. It was obvious that there was still a portion of transgenic progeny that was ELISA-positive, even though they were derived from ELISA-negative individuals with no CMV symptoms. Table 14 shows the results of PCR and Southern blot analysis of CMV coat protein gene, and disease symptoms and ELISA evaluation of CMV in CMV-inoculated R_6 transgenic tomato plants. A few selected transgenic plants in the field were sampled for PCR and Southern analyses to confirm the transmission of transgene. Even though six plants could not be confirmed by Southern analysis (the bands were not clear), they were all positive in PCR analysis. Most selected transgenic plants showing ELISA-negative during seedling stage remained ELISA-negative, and all transgenic tomato plants that demonstrated CMV symptoms were ELISA-positive. Thus, ELISA can be used to examine and screen CMV disease development, and, subsequently, it can be used to identify CMV resistant/tolerant transgenic plants. Seeds from confirmed transgenic plants (ELISA-negative and showing no CMV symptoms) were harvested for further evaluation and generation advance. Based on the above data and previous studies in disease resistance evaluation of transgenic tomatoes, transformation of tomato with CMV coat protein gene could reduce greatly the multiplication of CMV in transgenic tomatoes and provide stable tolerance in most transformed plants. However, it is also obvious that the transformation of coat protein gene does not make transgenic plants immune to CMV infection. Losses due to CMV infection in tomatoes transformed with coat protein gene could be significantly reduced, but the degree of tolerance is still affected by the development and health of plants, the cultural environment, and the CMV strains present, their pathogenicity and biological characteristics.

Contact: CA Liu

Evaluation of heat tolerant sweet pepper

Sweet pepper production in the tropics and subtropics is limited due primarily to the lack of adapted varieties. The availability of heat tolerant, disease resistant sweet pepper varieties would increase the possibilities for expanded sweet pepper production in the tropics. Varieties adapted to both cool-dry and hot-dry environments are desirable.

The 2nd International Sweet Pepper Nursery (ISPN) was evaluated at AVRDC (four replications in RCBD, 10 plants/plot, 30,000 plants/ha) for yield and fruit quality. The trial was sown 8 September, transplanted 16 October, and harvested four times beginning 29 December 2000. Disease reactions of entries were tested in separate greenhouse screening trials conducted by the plant pathology units. Data for yield and horticultural characteristics are shown in Table 15. None of the inbred line entries yielded significantly more than hybrid checks Blue Star and Andalus; however, entries PBC 271 and PBC 843 yielded more than 1000 g per plant and achieved

Table 13. *ELISA examination of R_6 transgenic tomato seedlings with four expanded leaves after inoculation with cucumber mosaic virus in the greenhouse**

Line	*$R_6$1*	*$R_6$2*	*$R_6$3*	*$R_6$4*	*$R_6$5*	*$R_6$6*	*$R_6$7*	*$R_6$8*	*$R_6$9*	*$R_6$10*	*$R_6$11*
	16/24	2/23	3/24	8/24	22/24	8/24	3/13	5/24	3/24	7/24	16/24
Line	*$R_6$12*	*$R_6$13*	*$R_6$14*	*$R_6$15*	*$R_6$16*	*$R_6$17*	*$R_6$18*	*$R_6$19*	*$R_6$20*	*$R_6$21*	*$R_6$22*
	3/24	6/24	22/24	11/24	13/24	15/23	12/24	16/24	16/24	17/24	21/24
Line	*$R_6$23*	*$R_6$24*	*$R_6$25*	*$R_6$26*	*$R_6$27*	*$R_6$28*	*$R_6$29*	*TK70*	*L4783*		
	23/24	13/24	15/24	15/24	16/24	17/24	12/24	0/24	0/24		

* No. of ELISA-negative plants/no. of plants ELISA tested.

Table 14. *PCR and Southern blot analysis of cucumber mosaic virus (CMV) coat protein gene, and disease symptom and ELISA evaluation of CMV on selected CMV-inoculated R_6 transgenic tomato plants in the field*

Line	Plant	PCR	Southern blot	CMV symptom	ELISA examination
$R_6$1	1-1	+	+	-	-
	1-2	+	+	-	-
	1-6	+	+	-	-
	1-17	+	+	-	+
	1-21	+	+	-	-
	1-23	+	+	-	-
$R_6$2	2-1	+	+	-	-
$R_6$3	3-3	+	+	-	-
	3-4	+	+	+	+
	3-5	+	+	+	+
	3-20	+	nc	-	+
	3-23	+	nc	-	-
$R_6$4	4-6	+	nc	-	-
$R_6$5	5-1	+	+	-	-
	5-17	+	nc	-	-
	5-19	+	nc	-	-
$R_6$6	6-1	+	+	-	-
	6-2	+	+	+	+
	6-19	+	+	-	-
	6-21	+	+	-	+
$R_6$7	7-2	+	+	-	-
	7-19	+	+	+	+
$R_6$8	8-5	+	+	+	+
$R_6$9	9-1	+	+	-	-
$R_6$10	10-17	+	+	-	+
	10-21	+	+	-	-
$R_6$11	11-2	+	nc	-	-
$R_6$13	13-11	+	+	+	+
$R_6$15	15-2	+	+	+	+
$R_6$17	17-19	+	+	-	-
$R_6$18	18-24	+	+	+	+
$R_6$21	21-21	+	+	-	-
	21-24	+	+	-	-
$R_6$22	22-4	+	+	-	-
	22-22	+	+	-	-
	22-24	+	+	-	-
$R_6$23	23-13	+	+	+	+
	23-19	+	+	-	-
$R_6$24	24-17	+	+	-	-
$R_6$26	26-21	+	+	-	-
	26-24	+	+	-	-
$R_6$27	27-2	+	+	-	-
	27-9	+	+	-	-
	27-19	+	+	-	-
	27-20	+	+	-	+
$R_6$28	28-3	+	+	-	-
L4783		-	-	+	+

nc = Band of Southern blot analysis faint and/or not clear.

mean fruit sizes over 100 g. PBC 271 and PBC 845 were also potato virus Y resistant.

A preliminary yield trial of 46 entries, including inbred lines and checks, was conducted at AVRDC from 8 September 2000 through 16 January 2001. Plots included 10 plants at a population density of 30,000 plants/ha; entries were replicated twice and arranged in RCBD. Data from the best 10 entries (98 or 99 prefix) and checks are presented in Table 16. Entries 9852-174 and 9852-176 produced marketable yields significantly higher than check hybrid Andalus, and their average fruit sizes exceeded 100 g. These 10 lines will be tested in an advanced yield trial and considered for inclusion in future ISPN nurseries

Contact: P Hanson

RAPD analysis of F_2 progenies of interspecific pepper hybridization

Capsicum annuum L. is the most widespread and commercially important pepper species, popular as a vegetable and spice. Its solitary flowers and fruits, and its clear white corollas distinguish it from the other important pepper species—*C. baccatum, C. chinense, C. frutescens, and C. pubescens*. Interspecific hybridization is increasingly used in breeding *C. annuum*, particularly to introduce pest and disease resistance. *C. chinense* is closely related to *C. annuum* and *C. frutescens*, and is known to be a good donor for several desirable traits, such as resistance to tobacco mosaic virus and anthracnose, and multiple fruit per node (to reduce harvest cost). In a previous experiment, *C. annuum* was crossed with *C. chinense* to transfer anthracnose resistance (the F_1 hybrids were generated using embryo rescue). This study used random amplified polymorphic DNA (RAPD) analysis to reveal the genetic diversity of the segregating F_2 progenies and to determine the degree of gene introgression from related *Capsicum* sp. to cultivated *C. annuum*.

Three F_2 progenies of *C. annuum* and *C. chinense*, derived from F_1 hybrids ($F_1$168, $F_1$225, and $F_1$200) of PBC66 × PBC932, PBC534 × PBC932, and PBC972 × PBC932, were used for this study. Ninety-six pepper plants of each F_2 progeny, along with their respective original and F_1 parent, were analyzed. Standard protocol was employed for DNA extraction. Twenty 10-mer RAPD primers each from Operon primer kit AN and AE were used. Polymerase chain reaction (PCR) was performed in a 25 ml volume

Table 15. *Yield, plant and fruit traits, and disease reaction of the 2nd International Sweet Pepper Nursery, AVRDC 2000*

Code	Maturity date DAT[1]	Total yield (g/plant)	Biomass[2] (g/plant)	Fruit				PVY[3]	ToMV	ChiVMV	BW	BS[4] race1	BS race 2	BS race 3
				Length (cm)	Width (cm)	Weight (g)	No. per plant							
9955-25	108	822	390	9.9	4.3	52	16	100	75	58	55	5.9	4.9	5.9
9955-27	113	923	499	8.0	6.0	89	11	0	64	0	2	6.5	6.3	6.1
9955-29	113	851	432	8.4	5.5	79	11	83	0	92	4	6.0	4.5	5.2
9955-36	114	943	358	7.6	5.1	57	17	25	0	0	0	7.1	7.0	6.6
PBC 197	111	772	398	8.0	6.5	106	7	0	27	0	0	6.7	6.5	6.3
PBC 271	109	1154	391	8.9	6.9	110	11	100	64	0	21	7.1	6.4	6.9
PBC 344	117	727	517	11.9	4.8	67	11	0	0	0	28	NT	NT	NT
PBC 577	115	786	439	7.6	6.4	91	9	0	0	0	4	6.8	6.8	6.6
PBC 843	111	1102	405	9.5	6.6	130	9	100	0	0	0	6.5	6.5	6.3
PBC 845	110	962	458	8.8	7.1	124	8	17	0	0	0	6.3	6.9	6.8
F1 Blue Star	107	1013	419	10.2	6.5	111	9	NT	NT	NT	NT	NT	NT	NT
F1 Andalus	111	923	408	14.9	5.5	108	9	NT	NT	NT	NT	NT	NT	NT
Mean	111	915	426	9.5	5.9	94	11							
LSD (0.05)	4	237	150	0.8	0.4	20	4							
CV %	2	15	21	5.2	4.2	13	22							

[1] DAT = days after transplanting.
[2] Plant fresh weight after all fruits removed.
[3] PVY = potato virus Y; ToMV = tomato mosaic virus; ChiMV = chili veinal mottle virus; BW = bacterial wilt; numbers are the percent resistant plants after inoculation.
[4] BS = bacterial spot. Scores are diseased leaf area according to the Barrett-Horsfall scale and range from 0 (healthy) to 11 (100% diseased). PBC137 was the resistant check and showed scores for races 1, 2, 3 of 2.9, 2.4, and 2.0, respectively.
NT = not tested.

Table 16. *Yield, plant and fruit traits of selected entries from a sweet pepper preliminary trial, AVRDC 2000*

Entry	Marketable yield (g/plant)	Biomass[1] (g/plant)	Fruit				Maturity (DAT)[2]
			Length (cm)	Width (cm)	Weight (g)	No. per plant	
9847-4668	569	401	5.0	5.0	40	13	110
9852-131	990	418	10.4	4.2	56	18	112
9852-174	1076	436	9.6	7.0	149	7	109
9852-176	1144	439	8.2	7.1	128	9	112
9852-190	866	360	14.6	4.4	71	13	113
9852-191	800	363	12.9	4.7	68	12	115
9946-2168	911	349	8.2	5.9	74	12	113
9946-2192	983	253	7.3	8.1	152	6	112
9950-5336	820	267	7.8	6.2	86	10	113
9950-5661	938	321	10.0	6.8	139	7	110
Early Cal Wonder (PBC 275)	753	324	5.8	7.0	111	7	120
B18 (PBC843)	807	298	8.4	6.8	125	6	117
Andalus F1	625	284	13.2	5.3	90	7	118
Blue Star	835	379	10.5	7.2	139	6	118
Mean	778	325	8.7	5.9	89	10	113
LSD (0.05)	375	105	1.1	0.8	27	5	
CV (%)	23	16	6.1	6.5	15	25	

[1] Plant fresh weight after all fruits removed.
[2] Days after transplanting.

consisting of 5 ng of genomic DNA, 0.5 mM primer, 0.05M Tris-HCl (pH 8.3), 0.4 M KCl, 0.25 mM $MgCl_2$, 100 mM each of dATP, dCTP, dGTP, and dTTP, and 0.2 unit Tag DNA polymerase. Amplification was carried out by Eppendorf thermocycler set for two cycles of 1 min at 94°C, 1 min at 40°C, and 2 min at 72°C, then 39 cycles each at 94°C for 30 sec, 40°C for 30 sec, 72°C for 1 min, followed by one cycle of 10 min at 72°C and 2 hours at 4°C. Amplified DNA products were electrophoresed in 1.8% agarose gels and stained with ethidium bromide. The images were then recorded by use of the AlphaImager 2000 (Alpha Innotech). Only clear and bright bands were used for this study. The data matrix was read by NTSYS-ps (Version 2.0) and analyzed using the method SIMQUAL (Similarity for Qualitative Data) with Jaccard's similarity coefficients. The dendrograms were constructed employing UPGMA with the SAHN routine. Because the overall tree topology suggested a rather weak grouping association, the distance matrix was then converted to two-dimensional coordinates using the MDS (multidimensional scaling) procedure of NTSYS in order to visualize the relationships among those progenies.

Among the 40 primers used in this study, 37 (except AN02, AN04, and AN13) were able to generate clear and bright bands for the analysis of genetic diversity. The number of amplification products (bands) generated with the 37 primers of F_1 hybrids, F_2 progenies, and their respective parents are listed in Table 17. Most of the amplification products belonged to 'common band', which were detected in both parents. The unique bands, present in only the female (*C. annuum*) or male (*C. chinense*), were useful in confirmation of F_1 hybrids. F_1 unique band means bands only present on F_1 hybrids but not their respective parents. The genetic diversity relationship among F_1 hybrids, F_2 progenies, and their respective parents revealed by RAPD is shown in Figures 3, 4, and 5. From the genetic diversity data of the F_2 progeny, $F_1$168, and their respective parents (PBC66 and PBC932), it was revealed that most of the F_2 progeny were close to their *C. chinense* parent. The difference between the similarity coefficient of PBC66 and PBC932, and PBC66 and $F_1$168 was 0.42 and 0.23, respectively. Most of the similarity coefficient difference between F_2 progeny and PBC66 was located between 0.22 and 0.30. The distribution of F_2 progeny, $F_1$168, PBC66, and PBC932 on the MDS plot is displayed in Figure 3 and it shows that the distribution is skewed toward their *C. chinense* parent, PBC932. Similar distribution was observed in the other two populations (Figures 4 and 5). This study showed that analysis of genetic distance between F_2 individuals and their respective parents can be used to identify F_2 individuals genetically similar to their parents. The above data then can be employed to select F_2 plants close to their recurrent parent to reduce the time needed in a backcross scheme to reach homozygosity.

Contact: CA Liu

Table 17. *Number of amplification products of F_2 progeny, F_1 hybrids and their respective parents*

	Total number of bands	Common bands	Female unique bands	Male unique bands	F_1 unique bands
$F_1$168	137	83	23	29	2
$F_1$225	146	85	34	26	1
$F_1$200	149	93	31	23	2

Evaluation of the 10th International Chili Pepper Nursery

Chili peppers are widely grown in the subtropics and tropics. However, yields of chili peppers are unstable due to diseases and insect pests. AVRDC is developing improved chili pepper inbred lines with multiple disease and insect resistance for the hot and humid tropics in order to improve the yield stability of chili peppers and decrease production costs.

The AVRDC International Chili Pepper Nursery (ICPN) usually includes 22 entries with 20 inbred lines and one or two local checks, which may be inbred lines or hybrids. Inbred lines are either new AVRDC breeding lines or previous outstanding ICPN entries. The long-term check was PBC142. The 10th ICPN was sown at AVRDC on 1 February 2000, transplanted on 21 March, and harvested a total of five times beginning 7 June. The experimental design was RCBD with four replications. Checks were two commercial hybrids, HyHot and Golden Heat. Data for the entries are shown in Table 18. Seventeen lines achieved significantly higher yields than PBC 142, and three lines, 9852-17, 9852-91 and 9852-173, out-yielded Golden Heat. 9852-173, resistant to PVY and bacterial wilt, was an outstanding entry in ICPN 9

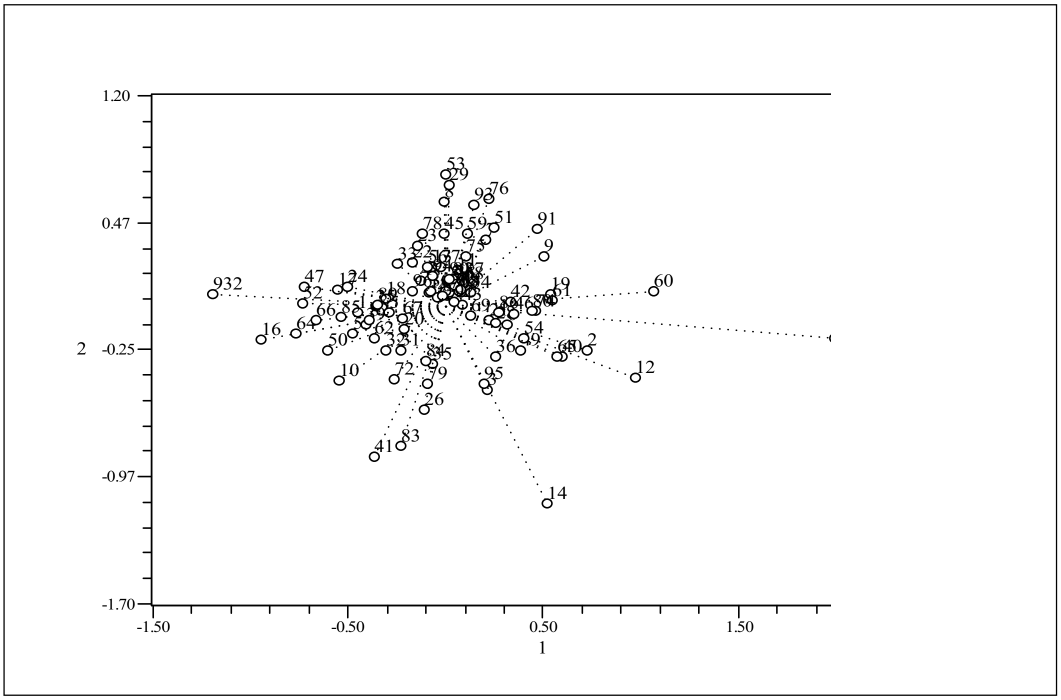

Figure 3. *Multiple dimensional scaling plot of PBC66, PBC932, $F_1$168 and their F_2 progeny.*

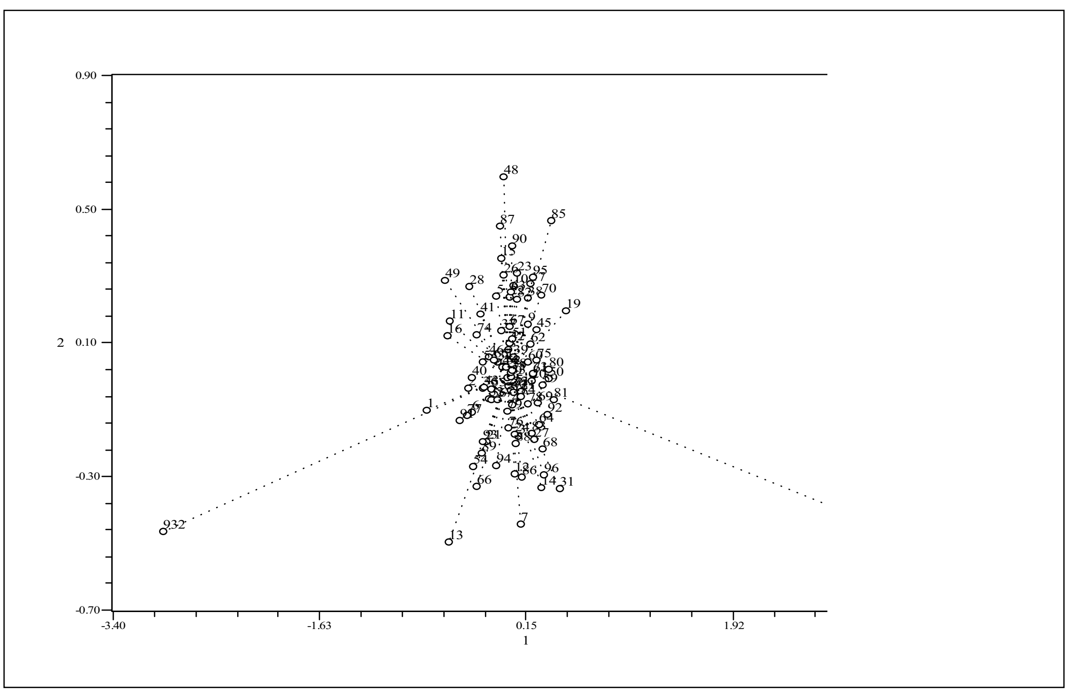

Figure 4. *Multiple dimensional scaling plot of PBC534, PBC932, $F_1$225 and their F_2 progeny.*

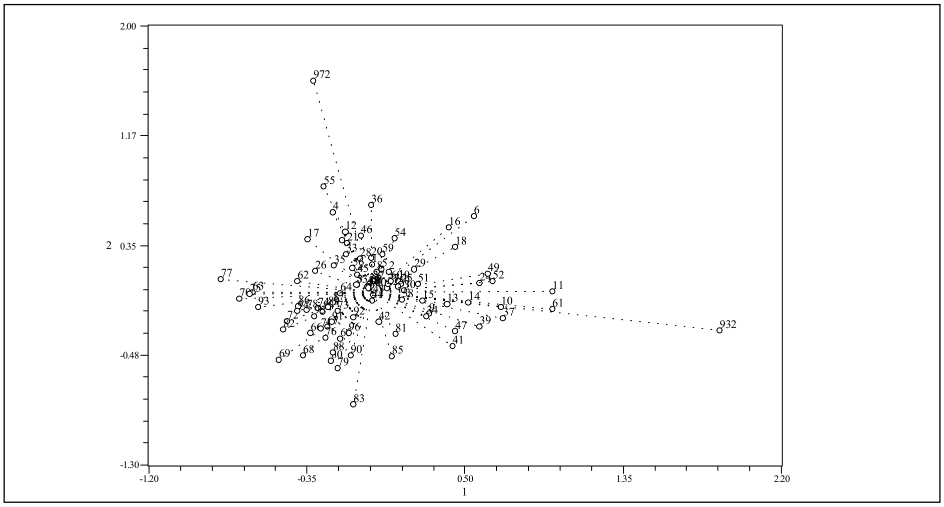

Figure 5. *Multiple dimensional scaling plot of PBC972, PBC932, $F_1$200 and their F_2 progeny.*

Table 18. *Yield, plant and fruit traits of the 10th International Chili Pepper Nursery, AVRDC, 2000*

Code	Total yield (g/plant)	Biomass[1] (g/plant)	Fruit Length (cm)	Fruit Width (cm)	Fruit Weight (g)	Fruit No. per plant	Capsaicin (SHU)[2] ('000)	PVY[3]	ToMV	CMV	ChiVMV	BW	PB Race 3 (root)	PB Race3 (foliar)
97-7126	614	421	12.1	1.7	11	57	0.6	0	0	0	17	0	79	83
97-7623	677	546	10.2	2.1	14	50	1.0	33	0	8	0	18	0	0
9852- 17	1031	427	12.4	1.7	13	86	18.6	0	0	0	0	23	0	0
9852- 19	798	476	10.7	1.7	10	83	5.0	100	0	0	8	4	0	8
9852- 90	776	645	11.8	2.2	21	37	13.8	100	0	9	0	27	13	0
9852- 91	1018	609	12.1	2.0	20	52	11.8	8	0	8	0	13	4	0
9852-100	717	531	7.8	1.5	6	133	3.7	0	0	17	100	53	92	8
9852-110	541	831	6.8	1.3	4	136	151.4	100	0	50	0	14	0	0
9852-115	866	474	15.7	2.1	20	43	23.8	10	0	0	0	0	0	0
9852-121	872	624	12.1	1.9	16	54	21.0	100	58	17	100	33	0	0
9852-149	845	839	10.3	1.6	8	104	2.7	100	0	0	0	63	0	0
9852-170	793	933	9.5	1.4	8	108	68.6	8	0	0	100	73	0	0
9852-171	831	484	10.8	1.7	13	67	2.6	100	0	0	0	37	4	0
9852-173	1115	568	10.1	1.8	12	93	1.4	100	0	0	0	87	0	0
9852-249	528	676	14.5	2.0	15	37	21.8	100	0	0	0	0	0	0
9852-327	752	610	12.3	2.1	14	52	19.2	17	0	8	0	0	0	0
9955-15	895	800	15.1	2.3	30	30	25.9	100	0	58	0	8	0	0
PBC 142	520	858	7.3	1.0	4	153	77.3	0	0	0	0	3	25	0
PBC 375	680	499	10.6	1.6	10	68	23.2	0	0	0	0	98	13	4
PBC 535	598	512	14.5	1.8	15	41	1.8	83	0	0	0	95	92	42
F1 Golden Heat	912	525	12.9	1.4	10	92	13.3	NT	NT	NT	NT	NT	NT	NT
F1 HyHot 3	855	810	15.1	1.5	15	58	8.0	NT	NT	NT	NT	NT	NT	NT
Mean	783	622	11.6	1.7	13	74	23.5							
CV (%)	9	16	8	5	10	12	24.7							
LSD (0.05)	98	145	1.3	0.1	2	12	23.5							

[1] Plant fresh weight after all fruits removed.

[2] Scoville Heat Units.

[3] Disease screening was carried out in separate glasshouse trials using Taiwan pathogen strains. PVY = potato virus Y; ToMV = tomato mosaic virus; CMV = cucumber mosaic virus; ChiVMV = chilli veinal mottle virus; BW = bacterial wilt; PB = phytophthora blight. Numbers are the percent resistant plants after inoculation. NT = not tested.

and is among the group of entries from the first nine ICPN trials that yielded >400% more than PBC 142 over locations (*AVRDC Report 1999*). 9852-110, with a very high capsaicin content would be suitable for oleoresin production.

Contact: P Hanson

CMV/ChiVMV resistance identified and characterized

Chili veinal mottle virus (ChiVMV) and cucumber mosaic virus (CMV) are the two most important viruses affecting peppers in tropical and subtropical Asia. A few sources of resistance to the common strains have been identified in recent years.

As new strains of these viruses have been isolated, it has become necessary to retest resistance sources and search for additional sources of resistance. The screening and rating protocols for ChiVMV and CMV were described in *AVRDC Report 1999*. Resistance to the common ChiVMV strain (P1037) from Taiwan was confirmed in 35 entries, several of which were also resistant to some or all of the other three Taiwanese ChiVMV strains (P3389, P714, and 3488). CMV resistance was confirmed in 22 entries, which were immune (0% infection) or resistant (1–25% infection), when inoculated at the five-leaf stage with the common Taiwanese CMV isolate P522. Fourteen of these entries were also immune or resistant to the aggressive strain P-3613. Only a few entries were also resistant at the cotyledon stage. Lists of resistant entries are available upon request.

The effect of CMV infection on yield was studied in one sweet pepper (VC27) and six chili varieties. Virus strains P522 and P3613 were mechanically inoculated in 24 plants of each variety at the three-leaf stage (each plant received just one strain). The plants were transplanted to the AVRDC field under a 60-mesh net to prevent cross contamination by aphids. The experimental layout was RCBD with three replications. Both virus strains significantly reduced yield (except in line VC 228) (Figure 6).

The usefulness of horizontal resistance (high yield under high infection pressure) for CMV was also studied by comparing the yield of 16 inoculated (I) and non-inoculated (NI) pepper entries (germplasm accessions and breeding lines) in the field. The plants were sown in the greenhouse and the set I was mechanically inoculated at the 5-leaf stage with CMV isolate P3613. The I and NI sets were transplanted to the same AVRDC field at 100 m distance from each other to prevent natural virus transmission by aphids from the NI set to the I set. Each set was laid out in RCBD with three replications. Experimental units consisted of three beds (1.5 m)/line and 10 plants/bed. Plants were spaced 45 cm apart and beds were 75 cm apart. All entries, except VC246, were susceptible (100% infection) to CMV P3613. Yield of seven inoculated entries was not significantly less than that of the non-inoculated checks (Figure 7). These entries should be further evaluated.

Identification of the different strains of these two viruses (particularly CMV) by biological means has so far been unreliable. Molecular differentiation of

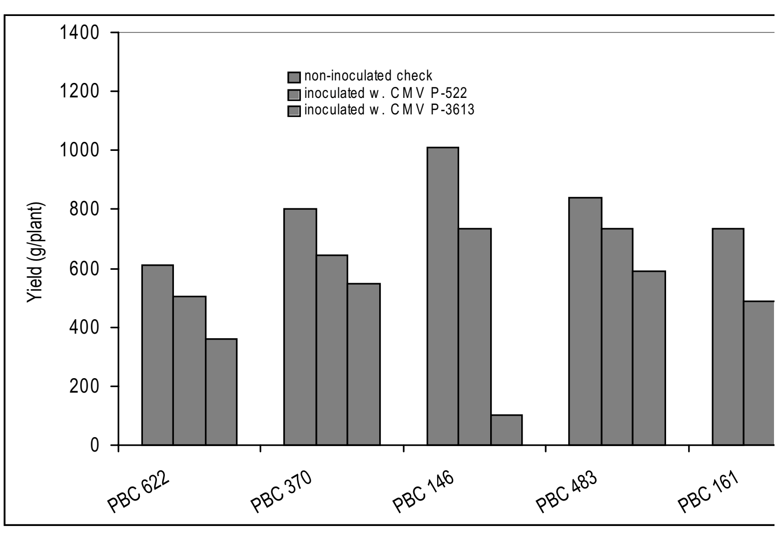

Figure 6. *Effect of CMV infection on yield of chili and sweet pepper (VC27).*

the two Taiwan pepper CMV strains (P522 and P3613) was therefore attempted using a fragment of the RNA-2, which encodes the 2b protein RNA4a. These fragments were cloned and sequenced and sequences aligned with those of other known CMV isolates. This method readily differentiated the two strains (Figure 8).

Contact: SK Green

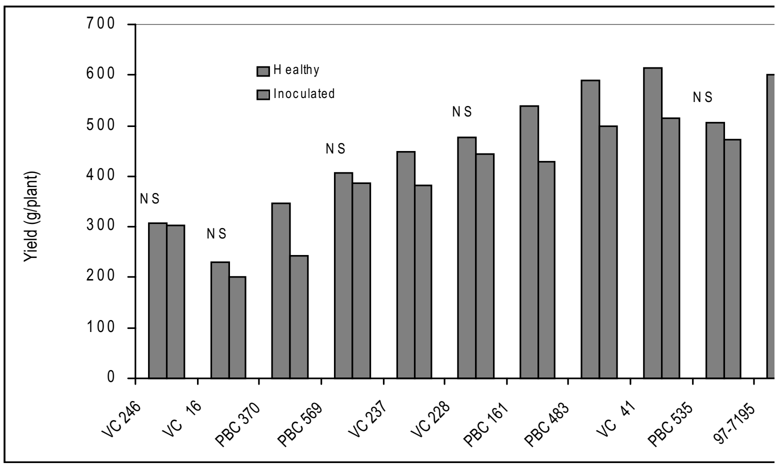

Figure 7. *Average yield of selected chili lines inoculated with CMV isolate P-3613.*

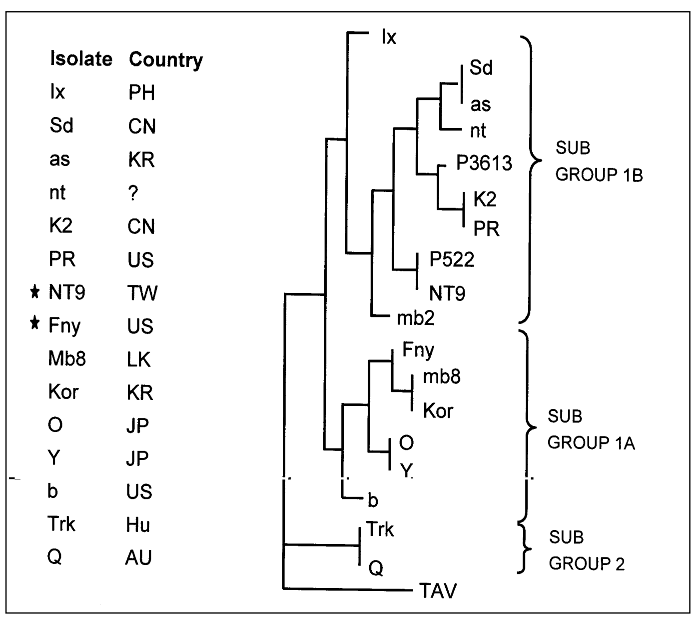

Figure 8. *Cluster alignment of CMV RNA 4a (encoding the 2b coat protein gene) of CMV isolates of different crops from different countries. Isolates marked with * are from tomato. Isolates P3613 and P522 are from Taiwan peppers. Tomato aspermy virus (TAV) is included as an out-group. Thephylogenetic tree was visualized with "PHYLIP" DNA analysis package.*

Project 2. Off-season onion and garlic

The influence of cultural practices on growth and yield of onion

The objective of this study was to assess the effects of mulching, plant spacing, planting method (direct seeding or transplanting), soil preparation (upland or puddled paddy field), and fertilization on yield of onion. Variety California 606, a variety widely used by farmers in Taiwan was used in all trials.

Effect of planting method and fertilization

The seedling survival rate is better in direct seeded crops compared to transplanted crops. In Taiwan, onion is transplanted and the plant-stand is poor in some years. Therefore, a split-plot trial with two replications was used to compare the performance of direct seeded and transplanted onion (main treatments) and four levels of fertilization (subplots): N-P_2O_5-K_2O, 75-120-180, 150-120-180, 250-120-180, and 288-300-300. In the direct seeded treatment, seeds were sown in the field on 30 September, while in the transplant treatment, seeds were sown in the greenhouse on 1 October and seedlings transplanted on 5 November 1998. The crop was harvested on 23 March 1999 for both treatments. Fertilizer was applied in six doses for the direct sown crop, and in four split doses for the transplanted crop.

The two planting methods produced similar total and marketable yield. However, the direct seeded crop produced significantly more extra-large and small size bulbs, but fewer large and medium size bulbs than the transplanted crop. The direct seeded crop also had more split-bulbs and uniformity was poorer than in the transplanted crop. Therefore, the transplanted crop produced higher marketable yield than the direct seeded crop.

Among fertilizer combinations, yields increased as nitrogen application increased, but only the lowest nitrogen level produced significantly lower yield than the others (Table 19). Treatment 150-120-180 kg/ha produced more large and medium size bulbs than the 250 kg N/ha and check treatments and seems to be the optimum treatment to obtain maximum marketable yield under AVRDC conditions in this season.

Table 19. *Effect of fertilization on the yield and bulb number of onion, autumn 1998-spring 1999*[1]

Treatment	Bulb yield (t/ha)						
	Extra-L (>10 cm)	Large (>8 cm)	Medium (>6.5 cm)	Small (<6.5 cm)	Split	Marketable[2]	Total
Subplot: Fertilization (N-P_2O_5-K_2O)[3]							
75-120-180	9.5 c[4]	39.8 b	21.3 a	4.4 a	2.4 a	70.6 b	79.9 b
150-120-180	15.8 abc	54.5 a	16.0 b	2.8 a	3.5 a	86.3 a	95.4 a
250-120-180	25.8 a	47.7 a	14.6 b	2.8 a	4.5 a	88.1 a	97.2 a
288-300-300	23.5 ab	48.6 a	13.4 b	3.4 a	7.6 a	85.4 ab	97.7 a
	Bulb no./m^2						
75-120-180	1.8 b	11.7 c	10.2 a	4.5 a	-	23.7 a	-
150-120-180	3.0 ab	15.3 a	7.5 b	2.3 a	-	25.8 a	-
250-120-180	4.8 a	13.5 b	7.1 b	2.8 a	-	25.4 a	-
288-300-300	4.2 a	13.7 b	6.4 b	3.5 a	-	24.3 a	-

[1] Seeds were sown on 1 Oct 1998; transplanted on 5 Nov 1998; and harvested on 23 March 1999.
[2] Marketable bulb yield includes extra large, large, and medium size bulbs.
[3] Fertilization was comprised of a basal application of 100-60-90 kg N-P_2O_5-K_2O/ha, and top dressing of 50-0-45, 50-60-45, and 50-0-0 kg N-P_2O_5-K_2O/ha at 3, 6, and 9 weeks after transplanting, respectively.
[4] Numbers followed by the same letter do not differ significantly at P<0.05 by Duncan's multiple range test.

Effect of bed mulching and spacing

The effect of mulching and spacing under the same fertilization level was evaluated using a split plot design with two replications. Main plot was mulching with polyethylene sheet (PE), rice straw, and no mulching (check). The subplot was four spacings: 15 cm × 3 rows (cm between plants, while rows refer to 1 m bed), 15 cm × 4 rows, 10 cm × 3 rows and 10 cm × 4 rows , for plant populations of 200,000, 266,000, 300,000, and 400,000 plants/ha, respectively.

Although PE mulch gave significantly higher total yield, nearly 47% of the bulbs were extra-large in size. The market prefers large and medium size bulbs. Rice straw mulch produced a significantly higher marketable yield if extra-large bulbs are included. If extra-large bulbs are excluded, then the difference is insignificant. However, in another experiment that compared PE mulch and rice straw mulch with a no-mulch check, the differences in marketable yield (bulb numbers) between treatments were insignificant, but bulb weight was significantly higher in PE mulch (Table 20). A 1-m-wide bed with four rows and 10 cm between seedlings produced the highest marketable yield, 108 t/ha (Table 21). Yield and number of extra-large bulbs decreased as population density increased, but the number of large and medium size bulbs increased. Among the four spacings, 10 cm × 4 rows gave the highest number of large, medium, and small bulbs.

Effect of soil preparation and transplanting method

Despite two typhoons, on 16 and 26 October 1998, high yields were obtained in the above two trials. At the same time, however, onions grown by farmers in southern Taiwan were almost destroyed. The main difference was cultural practices. Farmers transplanted their onions in puddled paddy fields. Farmers puddle the soil prior to transplanting seedlings in order to increase seedling survival and to save on labor. But puddling destroys soil structure and makes the soil too hard for proper root development. With poor root systems the plants could not withstand the typhoons, and suffered secondary infection. Farmers also applied excessive fertilizer (e.g., 560-340-180), which resulted in salt accumulation on the soil surface, further inhibiting root growth.

To confirm the effects of soil preparation and management at transplanting, a trial was conducted using random complete block design (RCBD) with eight replications in autumn 1999–spring 2000.

There were two treatments: farmer practice and AVRDC's recommended practice. The farmer-practice field was submerged and seedlings were transplanted in puddled plots—bed width 1.3 m, 6 rows per bed, and 16.9 cm between plants, for a population density of 266,279 plants/ha. Excessive fertilizer (6 t/ha chicken manure plus 420-282-436 kg N-P-K) was applied. The AVRDC-practice field was prepared when the soil was dry or at optimum

Table 20. *Effect of mulching material on the yield and bulb number of onion, autumn 1999-spring 2000*[1,2]

Treatment	Bulb yield (t/ha)						
	Extra-L (>10 cm)	Large (>8 cm)	Medium (>6.5 cm)	Small (<6.5 cm)	Rotten	Market-able[3]	Total
Check	0.4 a[4]	24.0 b	40.7 a	8.9 a	10.6 a	65.1 b	84.7 b
Rice straw mulch	0.5 a	36.5 ab	30.9 b	5.8 a	17.7 a	67.9 b	91.4 a
PE mulch	0.5 a	46.7 a	28.2 b	5.3 a	17.1 a	75.4 a	97.8 a
	Bulb no./m²						
Check	0.08 a	7.5 b	19.8 a	7.3 a	4.8 a	27.4 a	39.4 a
Rice straw mulch	0.11 a	12.0 ab	15.0 b	4.9 a	8.0 a	27.1 a	40.0 a
PE mulch	0.11 a	14.5 a	13.5 b	4.4 a	7.3 a	28.1 a	39.7 a

[1] Seeds sown 18 Nov 1999; seedlings transplanted on 29 Dec1999; and bulbs harvested 1 May 2000.
[2] Fertilization comprised a basal application of 100-60-90 kg N-P_2O_5-K_2O/ha, and top dressing of 50-0-45, 50-60-45, and 50-0-0 kg N-P_2O_5-K_2O/ha at 3, 6, and 9 weeks after transplanting, respectively.
[3] Marketable bulb yield includes extra large, large, and medium size bulbs.
[4] Numbers followed by the same letter do not differ significantly at P<0.05 by Duncan's multiple range test.

Table 21. Effect of spacing on the yield and bulb number of onion, autumn 1998- spring 1999[1,2]

Treatment	Bulb yield (t/ha)						
	Extra-L (>10 cm)	Large (>8 cm)	Medium (>6.5 cm)	Small (<6.5 cm)	Split	Marketable[3]	Total
Subplot: Spacing							
15 cm x 3 row	63.2 a[4]	23.4 d	1.7 c	0.6 b	10.7 a	88.3 b	99.6 c
15 cm x 4 row	50.2 b	43.1 c	7.6 b	0.9 b	7.5 ab	100.9 a	109.3 b
10 cm x 3 row	36.9 c	54.5 b	9.7 b	1.6 b	7.7 ab	101.1 a	110.4 b
10 cm x 4 row	22.8 d	61.4 a	23.5 a	4.3 a	6.4 b	107.7 a	118.3 a

1 Seeds were sown on 1 Oct 1998, transplanted on 6 Nov 1998, and harvested on 16 March 1999.
2 Fertilization comprised a basal application of 100-60-90 kg N-P_2O_5-K_2O/ha, and top dressing of 50-0-45, 50-60-45, and 50-0-0 kg N-P_2O_5-K_2O/ha at 3, 6, and 9 weeks after transplanting, respectively.
3 Marketable bulb yield includes extra large, large, and medium size bulbs.
4 Numbers followed by the same letter do not differ significantly at P<0.05 by Duncan's multiple range test.

moisture (field capacity). Seedlings were transplanted in 1-m-wide beds with 4 rows per bed and 15 cm between plants, for a population density of 266,666 plant/ha, to match the plant density in farmers' fields. AVRDC-practice included 150-120-180 kg/ha of N-P_2O_5-K_2O, 3 t/ha of chicken manure, rice straw mulch, and furrow irrigation.

A survey at 15 days after transplanting (DAT) showed that soil compactness in farmer-practice plots was significantly greater than in AVRDC plots (Table 22), and plant growth was stunted, with fewer leaves, and reduced dry weight. But the plants in the farmer-practice plots gradually caught up to the plants in the AVRDC-practice plots.

Total N uptake by plants in the farmer-practice plots was greater than in the AVRDC – practice plots at 113 DAT, since the total N applied by farmers was double that of AVRD practice. But there were no significant differences between treatments for total P and K uptake. AVRDC-practice produced higher marketable and total yields, which was mainly attributed to higher yield of extra-large bulbs (but with high moisture content) (Table 23).

Under the non-stress conditions of this trial, farmer practices compared well with AVRDC practice.

Contact: S Shanmugasundaram

Table 22. *Effect of transplanting method on the growth of onion, autumn 1999-spring 2000*

Treatment	At 15 DAT	At 55 DAT		At 72 DAT				
	Soil hardness (kg/cm^2)	Plant height (cm)	Leaf no. (/plant)	Plant height (cm)	Leaf dry wt. (g/plant)	Bulb dry wt. (g/plant)	Root dry wt. (g/plant)	Total dry wt. (g/plant)
Farmer	3.87 a	57.6 b	7.4 b	81.8 a	6.8 b	2.3 b	0.33 b	9.4 b
AVRDC	0.54 b	61.6 a	7.9 a	80.9 a	7.7 a	3.1 a	0.45 a	11.3 a
				At 113 DAT				
				Bulb DM (%)	Leaf dry wt. (g/plant)	Bulb dry wt. (g/plant)	Root dry wt. (g/plant)	Total dry wt. (g/plant)
Farmer				6.1 a	4.2 a	17.5 a	0.46 a	22.2 a
AVRDC				5.7 b	4.6 a	17.8 a	0.45 a	22.8 a

DAT = days after transplanting.
DM = dry matter.

Table 23. *Effect of transplanting method on yield and bulb number of onion, autumn 1999 –spring 2000*[1]

Treatment	Bulb yield (t/ha)						
	Extra-L (>10 cm)	Large (<10~8 cm)	Medium (<8~6.5 cm)	Small (<6.5 cm)	Split	Market-able[2]	Total
Farmer[3]	4.24 b[5]	59.06 a	14.01 a	0.66 a	0.00 a	77.31 b	77.97 b
AVRDC[4]	10.21 a	61.27 a	10.79 a	0.91 a	0.36 a	82.26 a	83.53 a
	Bulb no./m²						
Farmer	0.94 b	18.74 a	6.99 a	0.63 a	0.00 a	26.68 a	
AVRDC	2.20 a	18.34 a	5.17 b	0.85 a	0.11 a	25.71 b	

[1] Seeds were sown on 18 Nov, transplanted 29 Dec 1999; and harvested 19 Apr 2000.
[2] Marketable bulb yield includes extra large, large, and medium size bulbs.
[3] Farmer practice included a basal application of 6 t/ha of chicken manure, 120-60-90 N-P_2O_5-K_2O kg/ha (inorganic), and top dressing of 60-0-45, 60-60-45 and 60-0-0 N-P_2O_5-K_2O kg/ha at 2, 5 and 8 week after transplanting, respectively.
[4] In AVRDC practice, chicken manure and N fertilizer were half that of farmer practice.
[5] Numbers followed by the same letter do not differ significantly at P<0.05 by Duncan's multiple range test.

Effect of temperature on storage loss of onion

Twelve onion cultivars were placed in two storage rooms under ambient conditions. The temperature and relative humidity (RH); were recorded daily and the means for the rooms were: room 1 (SR1) 28.5±2.4ºC, 73.4±9% RH and room 2 (SR2) 27.7± 3.4ºC, 79.4±11.3% RH , and storage loss and disease incidence during storage were assessed. The trial began on 21 April and ended on 11 August, 2000. Forty selected bulbs were used for each replication, and cultivars were replicated three times. Percent marketable weight, total loss, rotten, and black mold and fusarium basal rot infected bulbs were different between rooms. Interaction between storage room and cultivar was significant for total loss, rotten, bacterial rot, and black mold. Cultivars Red Creole, TA386, and TA500 had the lowest losses after 15 weeks of storage (Table 24). Mean storage loss for the 12 cultivars was slightly lower in SR2 (51.5%) than in SR1 (57.9%). The correlation between storage loss and rotting was r = 0.998** and the correlation between storage loss and black mold infection was r = 0.94**. In general, cultivars with good storability have higher dry matter content, total soluble solids, pyruvic acid content, and firmer texture (Table 25).

Contact: S Shanmugasundaram

Storability of onion breeding lines

A total of 176 entries, including sib-mated, F_2, F_3, F_4, and back cross onion materials were planted in fall 1999 and stored in a room from 15 May 2000 under ambient high temperature (28.5±2.4ºC) and relative humidity 73.4ºC±9% for 3 months. Ten lines, including red and yellow bulb types, stored well, with less than 30% loss (Table 26). The check, Red Creole, suffered 41% storage loss. Most of the red onion lines had similar bulb size as the check. Local commercial variety CAL606, which produces large bulbs, suffered 96% storage loss (Table 26).

Evaluation of *A. cepa* × *A. fistulosum* for blight resistance, bulbing, and pollen fertility

Stemphylium leaf blight (SLB) is a major disease affecting onion in the tropics. Resistance to SLB in cultivated onion (*Allium cepa*) has proven unreliable. Durable resistance to SLB has been found, however, in *A. fistulosum*, green onion. Crosses were made between *A. cepa* and *A. fistulosum*, but the selfed inbreds from F_1 (70 combinations) and back crosses were invariably sterile and had very poor seed set. The objective is to combine SLB resistance from *A. fistulosum* with the good bulbing and seed set from *A. cepa*. A few segregants have been found that combine the three traits.

Selected progenies with good pollen viability from interspecific hybrids between *A. cepa* × *A. fistulosum* and *A. fistulosum* × *A. cepa* were crossed once or

Table 24. *Storage loss and disease incidence of 12 onion cultivars in ambient storage room 1 (SR1) and storage room 2 (SR2) after 15 weeks of storage*

Entry	Designation	Origin	Total loss (%)		Rotten (%)		Black mold (%)	
			SR1	SR2	SR1	SR2	SR1	SR2
R.Creole	Red Creole	Nepal	22.5 e[1]	15.8 de	22.5 e	14.2 ef	21.7 e	14.2 c
TA386	H675	Israel	27.5 e	18.3 d	28.3 de	18.3 d	21.7 e	12.5 c
TA500	PCSX1941	USA	32.5 de	6.6 e	31.7 de	6.7 e	27.5 de	5.0 d
TA1025	RC1102	USA	55.0 cd	31.7 d	55.0 cd	30.8 de	45.8 b-c	19.2 c
TA1026	RCS1103	USA	55.3 cd	56.6 bc	55.3 cd	56.6 bc	42.7 bc	41.0 b
AC731	Serrana	USA	55.8 cd	70.4 a-c	55.0 cd	70.4 a-c	36.7 c-e	48.3 ab
AC705	El Ad/ Nissan	Israel	56.7 cd	66.6 a-c	55.8 cd	66.6 a-c	48.3 a-d	45.6 ab
AC544	Sweet Success	USA	66.7 bc	53.4 c	66.7 bc	47.5 cd	62.5 ab	36.6 b
AC691	RCS1927	USA	67.5 bc	76.7 ab	67.5 bc	73.3 ab	60.0 ab	62.5 a
AC845	Orient F1	Netherlands	70.8 bc	67.9 a-c	70.7 bc	68.9 a-c	52.5 a-c	52.9 ab
AC715	PX292	USA	89.2 ab	81.6 a	87.5 ab	81.7 a	62.5 ab	46.8 ab
CAL606	California 606	USA	95.8 a	70.4 a-c	95.8 a	69.2 a-c	70.8 a	47.5 ab
Mean			57.9	51.5	57.6	50.2	46.1	36.0

[1] Means followed by the same letter within a column do not differ significantly at P<0.05 by Duncan's multiple range test.

Table 25. *Bulb dry matter content, total soluble solids, pyruvic acid, and firmness of 12 onion cultivars at harvest*

Entry	Dry matter (%)	Total soluble solids (ºBrix)	Pyruvic acid (µmole/g fwt)[1]	Firmness (Kgf)[2]
Red Creole	14.3 a[3]	12.9 a	6.9 a	6.3 ab
TA386	10.7 c	10.0 cd	6.6 a	6.6 a
TA500	12.4 b	10.9 bc	6.8 a	6.1 ab
TA1025	13.7 a	12.0 ab	6.4 ab	6.0 ab
TA1026	7.4 e	7.8 e	4.8 c	6.0 ab
AC731	9.2 d	9.6 d	6.4 ab	6.2 ab
AC705	6.5 ef	7.5 ef	6.0 a-c	5.2 c
AC544	6.9 ef	6.9 e-g	4.9 bc	5.6 bc
AC691	5.9 f	6.4 fg	4.9 c	4.4 d
AC845	11.0 c	10.3 cd	4.6 c	5.9 ab
AC715	5.9 f	6.1 g	4.5 c	4.1 d
CAL606	5.8 f	6.3 fg	5.1 bc	4.5 d
Mean	9.1	8.9	5.7	5.6
CV (%)	7.5	8.0	14.1	6.9

[1] fwt = fresh weight.
[2] Bulb firmness was measured using a rheometer (Fudoh, Japan): the higher the value, the firmer the bulb.
[3] Means followed by the same letter within a column do not differ significantly at P<0.05 by Duncan's multiple range test.

twice to *A. cepa* and the F_1 lines were evaluated for SLB reaction (scale of 1 to 6, highest to least resistance), bulbing, and pollen viability. The seeds were sown on 25 August 1999 and transplanted on 21 October 1999. When the plants produced umbels the pollen grains were examined for stainability using acetocarmine.

Ninety-two crosses from eight families and 27 crosses from six families were crossed with onion once and twice, respectively. For each family, the number of crosses made varied from 1 to 31, using 1 to 35 umbels. However, 0 to 2.41 g of seed was obtained in F_1. From all the seed (2.8 g) sown, a total of 66 lines with 164 plants were obtained.

Most of the resistant plants were non-bulbing, and therefore were rejected. Eleven plants with good resistance, bulbing, and seed set have been saved for further study. They are from families CF19(M),

Table 26. *Promising onion breeding lines with good storability*

Entry	*Pedigree*	*Generation*	*Storage loss (%)*[1]	*Average bulb weight (g)*	*Bulb Color*
SL9783	TA177-CST-N	Sib-mated	12.5	133	Red
SL3099	AC145-N	Sib-mated	15.3	134	Red
SL9507	AC319-C-N	Sib-mated	17.4	144	Red
SL9901	TA386(F)-CST-B-N	Sib-mated	18.3	127	Yellow
SL10002	Yellow Granex-C-D-N	Sib-mated	24.8	169	Yellow
SL9486	AC145-AST-C	Sib-mated	25.4	152	Red
SL9468	AC119-C-AST-C	Sib-mated	30.0	141	Red
SL9868	TA377-AA-N	Sib-mated	30.0	122	Yellow
SL10013	BC4ST-B	Back cross	22.2	62	Red
SL10072	ST3-0ST-A	F3	16.7	83	Red
Check1	CAL606		95.8	319	Yellow
Check2	Red Creole		40.9	144	Red
Mean of 176 entries			59.2	155	

[1] After 3 months storage under ambient conditions 28.5 ± 2.4ºC, 73.4 ± 9% relative humidity.

CF19, CF52, and CF16 (Table 27).

On 19 August 1999, 3472 seeds from 78 lines in F_3–F_5 were sown in the greenhouse. The seedlings were inoculated with Stemphylium spore suspension on 28 October 1999. The seedlings were rated on a scale of 1 to 6 for SLB reaction on 4 November 1999. The seedlings were transplanted in the field on 19 April 2000 in a 1.5 m bed with plastic mulch. The spacing between rows and plants was 20 cm, with three rows per bed.

Lines with good pollen viability selected from *A. fistulosum* × *A. cepa* (FC group) had low or no resistance to SLB. Average SLB reaction of CF5, CF16, and CF52 families were similar to that of *A. fistulosum*, the resistant parent. CF5 and CF19 produced better bulbs, higher resistance to SLB, and good pollen viability compared to the other families (Table 28). For CF16 and CF19, the viability could be improved by crossing with *A. cepa* (Table 27).

The seeds from plants with SLB ratings of 1–2 and plants crossed with *A. cepa* will be further evaluated for bulbing, seed set, and SLB reaction.

Contact: S Shanmugasundaram

Table 27. *Performance of selected interspecific families crossed with onion*

Cross	No. of lines	No. of plants	No. of plants: Bulbing	No. of plants: No bulbing	SLB reaction[2]: Resistant	SLB reaction[2]: Susceptible	Average pollen visibility (%)
Cross with *A. cepa* once (ACxAF) x AC	53	124					
CF16	10	23	4	19	19	4	64.6
CF16(M)[1]	14	24	8	16	17	7	13.4
CF19	17	53	44	9	16	37	63.4
CF19(M)[1]	3	15	15	0	8	7	27.2
CF52	8	8	1	7	8	0	27.8
CF52(M)[1]	1	1	1	0	1	0	86.9
Cross with *A. cepa* twice [(ACxAF)xAC] x AC	13	40					
CF16	9	30	21	9	24	6	86.3
CF19	3	9	9	0	3	6	94.9
CF52	1	1	1	0	0	1	

[1] Interspecific progenies used as male parent.
[2] Stemphylium leaf blight infected in field. Resistant: <25% infection, Susceptible: ^{3} 25% infection.
[3] % of pollen stained in acetocarmine observed under microscope.

Table 28. *Promising interspecific families of* A. cepa *and* A. fistulosum *for SLB resistance*

Cross	Parents	No. of		SLB reaction[1] (% plants)					Ave[1]. SLB rating	Resistant plants[2]	
		lines	plants	1	2	3	4	5		Viability[3] (%)	Bulbing[4]
CF1	AC4 × AF468	1	17	0	12	13	24	11	3.4	58.8	2
CF5	TA207 × AF468	22	576	21	35	40	3	0	2.3	75.6	1-4
CF16	AC15 × TA198	17	205	23	33	29	12	3	2.3	44.1	1-2
CF19	AC50 × TA198	19	503	0	4	39	49	9	3.6	65.0	1-4
CF52	AC49 × TA204	6	68	12	53	25	9	1	2.3	57.3	1-2
CF61	TA242 × TA204	4	54	0	33	26	35	6	3.0	51.7	1-2
FC27	AF468 × AC47	4	60	0	0	62	28	10	3.6		
FC42	TA198 × AC2	1	3	0	0	100	0	0	3.0		
FC45	TA198 × AC50	1	4	25	75	0	0	0	1.8		
FC66	TA204 × TA364	1	9	0	0	33	67	0	3.7		
AC47	*A. cepa*		16	0	0	50	44	6	3.6		
Granex 429	*A. cepa*		24	0	0	0	46	54	4.5		
TA198	*A. fistulosum*		9	11	45	33	11	0	2.4	92.6	1
TA204	*A. fistulosum*		29	31	42	24	3	0	2.0		

[1] Stemphylium leaf blight rating in controlled environment of green house with artificial inoculation: 1 = no symptoms, 2 < 2 5% infection; 3 = 6–25% infection; 4 = 26–50% infection; 5 ^{3} 50% infection.
[2] Plants show phenotype of interspecific crosses and SLB rating 1 or 2.
[3] % of pollen stained in acetocarmine observed under microscope.
[4] Bulbing performance of moderate resistant and resistant plants: 1 = no bulbing similar to *A. fistulosum*; 2 = slight bulbing tendency but thick neck like *A. fistulosum*; 3 = small bulb with thick neck; 4 = medium sized split bulb (similar to a shallot); 5 = single bulb.

Sustainable improved yield of virus-free clones of garlic

AVRDC routinely uses meristem culture to eliminate virus from garlic plant material. This study examines the sustainability of improved yield of meristem derived, virus-indexed garlic clones.

Two meristem derived, virus-indexed clones maintained in the nethouse, VFG176 and VFG180, the original-virus infected clone G176 and G180, and the virus-indexed clones grown in the open field for one (VFG176 P_1 and VFG180P_1) and two generations (VFG176P_2 and VFG180P_2) were planted in the open field on 6 October 1999 using an RCBD with two replications. The entries were planted in 0.75-m-long and 5-m-long beds with a population of 100 plants per replication. Five plants were sampled per replication at the maximum growth stage and average fresh plant weight, leaf number, plant height, pseudostem length, pseudostem diameter and leaf width were recorded on 17 February 2000. Bulb yield was determined after harvest. Enzyme-linked immunosorbent assay was used to detect the viruses in garlic leaves. Each entry had 20 plants. DMRT was used to separate the means between entries for all traits. Correlation between yield and other traits were calculated using Pearson correlation analysis.

VFG176 and VFG180 yielded 53.8% and 47.2% higher than the check G176 and G180, respectively (Table 29). Even after two generations in the open field, VFG176P_2 and VFG180P2 produced 28.8% and 38.8% higher yield than G176 and G180 respectively. Bulb yield was positively correlated with the average plant fresh weight (r = 0.89**), with leaf number (0.79**), with leaf width (r = 0.8**). Result indicates that plants with more vigorous vegetative growth yield more.

Data on virus reinfection following meristem culture showed that the reinfection rate for onion yellow dwarf virus (OYDV) and mite borne filamentous virus (MbFV) was higher in VFG176P_2 (Table 30). In VFG180P_2 reinfection of MbFV is absent. However, garlic common latent virus absent in the original clone is present in the meristem cultured clone via new infection FVG180P_2. In VFG180P_2, although the OYDV was lower than in VFG176P_2, the reinfection reached the same level as it was in the original clone G180 (Table 30).

After two generations of open field cultivation of

Table 29. *Yield and horticultural characters of virus free garlic in the open field, fall 1999.*

Entry	Bulb yield (t/ha)	Ave. plant FWT (g)	Leaf no.	Plant ht. (cm)	Pse.[1] length (cm)	Pse. Dia. (mm)	Leaf width (cm)
G176	5.2 h-n[2]	112 f-j	10.4 a-g	91.9 d-i	31.9 e-o	17.7 b-i	2.9 b-f
VFG176	8.0 c-f	167 b-e	11.1 a-e	105.3 a-d	39.8 a-g	20.6 a-d	3.1 a-d
VFG176P1	6.5 f-j	169 b-e	11.3 a-d	107.7 a-c	42.9 a-c	20.9 a-c	3.0 b-e
VFG176P2	6.7 f-j	148 c-f	10.2 a-g	102.1 a-e	38.9 a-h	21.4 a-c	2.8 b-e
G180	7.2 e-i	104 g-j	11.4 a-d	5.6 k-q	32.5 d-n	14.8 h-n	2.6 d-h
VFG180	10.6 ab	149 c-f	11.6 a-d	77.1 j-q	37.2 a-j	17.4 c-i	3.1 a-d
VFG180P1	10.4 a-c	171 b-e	11.4 a-d	81.0 h-o	42.1 a-d	18.6 n-h	2.9 b-f
VFG180P2	10.0 a-d	153 c-f	12.4 a	72.5 l-q	36.5 a-k	17.5 b-i	2.9 b-f

[1] Pseudostem
[2] Means with columns followed by the same letter do not differ significantly at P<0.05 by Duncan's multiple range test.

meristem derived virus indexed garlic clones, the improved yield can be sustained. The reinfection levels are lower than that of original virus clones.

Contact: S. Shanmugasundaram

Virus elimination and virus indexing of garlic

AVRDC conducts routine virus elimination and indexing to prevent introduction of viruses in exotic germplasm. Up to November 2000, 327 virus-indexed garlic lines had been produced.

The virus elimination protocol was improved in 2000 for more efficient elimination of allexiviruses, which were found in 32% of meristem-derived plants (*AVRDC Report 1999*). Treatment with heat and an antiviral chemical (Virazole®), in addition to meristem tip culture, were tried. The results confirmed that all viruses except allexiviruses can be readily eliminated by meristem tip culture alone (Table 31). To eliminate allexiviruses, bulbs or cloves are heat treated, then meristems are excised and placed on Virazole®-containing Murashige-Skoog (MSV medium).

Virus reinfection and bulb yield of two meristem-derived clones, cultivar Black Leaf, were measured for seven consecutive vegetative generations in the AVRDC field, with and without a 60-mesh net cage. Treatments consisted of 20 plants and RCBD with three replications was used. A summary of this experiment is shown in Table 32. Yields were highest in the third growth cycle, despite virus reinfection of more than 75%. Yields started to decline continuously thereafter. However, after seven growth cycles in the field, yields of meristem-derived plants were still higher than those of the same continuously field-propagated clone. Net protection and selecting virus-free material, rather than randomly chosen planting material generally leads to higher yields than field-grown plants of the same cultivar. Yield decline after the third growth cycle of meristem-derived garlic cloves was mainly due to two

Table 30. *The re-infection percentage of various viruses in garlic lines through ELISA 1999.*

Entry	SLV	GCLV	OYDV	LYSV	MbFV	SYSV
G176	100	30	100	80	50	0
VFG176	40	10	90	50	70	0
VFG176P1	30	10	90	10	80	0
VFG176P2	10	10	80	20	60	0
G180	20	0	50	20	20	0
VFG180	20	10	40	10	0	0
VFG180P1	20	10	60	10	0	0
VFG180P2	20	20	50	10	0	0

Table 31. *Effect of heat and Virazole ® treatment on virus in garlic*

Treatment[1]	% virus infection				
	SLV	OYDV	LYSV	GCLV	Allexivirus (GV-C)
H1	61/0/0[2]	59/0/0	0/0/0	1/0/0	41/5/2
V	33/0/0	49/0/0	8/0/0	0/0/0	79/0/2
H1+V	61/0/0	59/0/0	0/0/0	1/0/0	41/0/0
CK	33/0/0	49/0/0	8/0/0	0/0/0	79/0/4
H2	1/0/0	53/0/0	5/0/0	2/0/0	60/0/0
V	40/0/0	75/0/0	75/0/0	0/0/0	81/0/2
H2+V	1/0/0	53/0/0	5/0/0	2/0/0	60/0/0
CK	40/0/0	75/0/0	75/0/0	0/0/0	81/0/2

[1] Each treatment consisted of 10 meristems excised from each of five lines. H = heat treatment; V = Virazole® treatment. H1 heat treatment: 6 bulbs/line were subjected to 30ºC for one week, 36ºC for one week, and 38ºC for seven weeks, before excision of meristems, which were then placed on MS. H2 heat treatment: 60 cloves/line were subjected to 30ºC for one week, 36ºC for one week, and 40ºC for seven weeks, before excision of meristems. V treatment: excised meristems were placed on MSV medium (MS medium amended with 50 mg/liter of Virazole®). H1+V, H2+V treatments: bulbs (H1) or cloves (H2) were subjected to the respective heat treatments before meristem excision. CK = meristems excised from bulbs or cloves that had received no prior heat treatment and were placed on MS medium.

[2] Average virus infection before meristem excision/at the end of the first growth cycle/at the end of the second growth cycle.

SLV = shallot latent virus, OYDV = onion yellow dwarf virus, LYSV = leek yellow stripe virus, GCLV = garlic common latent virus, allexivirus (GV-C)

Table 32. *Yield and virus reinfection of meristem-derived garlic, cultivar Black Leaf*

Growth cycle[1]	Line[2]	Planting material[3]	% yield increase[4]		% virus infected plants[5]	
			with cage	without cage	with cage	without cage
1	M1	VF	11	NT	0	NT
	M2	VF	45	NT	0	NT
2	M1	VF	84	118	0	0
	M2	VF	141	161	0	0
3	M1	VF	429	302	76	86
	M2	VF	295	230	67	80
4	M1	VF	123	120	43	88
	M2	VF	67	51	0	97
5	M1	VF	74	88	30	64
	M1	R	60	61	57	98
	M2	VF	42	58	0	100
	M2	R	34	32	13	100
6	M1	VF	47	NT	8	NT
	M1	R	50	NT	35	NT
	M2	VF	20	NT	2	NT
	M2	R	11	NT	27	NT
7	M1	VF	63	24	62	97
	M1	R	22	21	92	95
	M2	VF	32	21	77	98
	M2	R	4	-2	93	93

[1] Cycle 1 planted in the highland (summer 1994); cycles 2–7 planted in the AVRDC field (fall).

[2] M1, M2 clones derived from meristem 1 and meristem 2 of cultivar Black Leaf, respectively.

[3] VF, R = planting material derived from virus-free or randomly chosen cloves, respectively, from the previous growth cycle.

[4] With respect to the continuously field-grown clone of the same cultivar.

[5] All viruses, including onion yellow dwarf virus, leek yellow stripe virus, shallot latent virus, and allexiviruses.

potyviruses, onion yellow dwarf virus and leek yellow stripe virus (Figure 9). The virus reinfection of meristem-derived lines was also tested in the field genebank maintained by AVRDC's Allium breeding unit. Virus reinfection cannot be avoided, even when the plants are protected by a 32 mesh net cover. Mite borne viruses are the major viruses. Open field planting results in a high percentage of virus reinfection with all common garlic viruses, except SYSV (Table 33).

Contact: SK Green

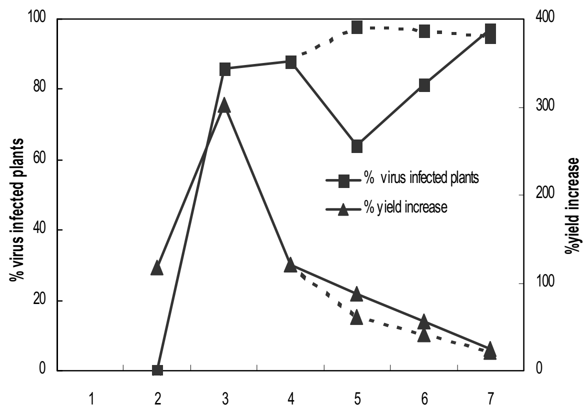

Figure 9. *Percent yield increase and total viruses infected plants of meristem-derived garlic plants (cv Black Leaf) grown for seven growth cycles in the field, (not protected by net). Dotted and solid lines planting material from randomly chosen clones and virus-free lines of the previous growing season respectively.*

Virus evaluation and characterization of garlic

To investigate the virus distribution and to characterize viruses occurring in Taiwan and Korea, leaves or bulbs of garlic were collected from each country and tested by enzyme-linked immunosorbent assay (ELISA) (Table 34). Samples collected from both countries were infected with onion yellow dwarf [poty]virus (OYDV), leek yellow stripe [poty]virus (LYSV), shallot latent [carla]virus (SLV), garlic common latent [carla]virus (GCLV), garlic virus A (GVA), garlic virus B (GVB), garlic virus C (GVC), and garlic virus D (GVD), but were free of shallot yellow stripe [poty]virus (SYSV) or shallot virus X (ShVX). More than 76% of the samples collected had OYDV, LYSV, GVA, and GVD. SLV infection was also severe (up to 86%) except in Korea 2.

Using four different OYDV antisera, different strains were detected. The OYDV infection percentages in Taiwan and Korea 3 were lower (by 12–17%) compared to Korea 1 and 2, because Korea 3 was tested by only OYDV 1 antisera. (However, OYDV 1 used monoclonal antibody and is applied by triple antibody sandwich method, so it was more efficient in detecting virus than the other three OYDV antisera.)

Most of the main production areas were highly infected by potyviruses, carlaviruses, and allexiviruses. Garlic derived from meristem-tip culture, such as Euiseong B and Samcheok, showed low virus infection (Table 35). However, allexiviruses were still present in a high percentage of meristem-tip culture derived garlic. This indicates that the meristem-tip culture did not eradicate the allexiviruses.

To produce the antisera of viruses present in Korea, the following viruses have been isolated: K 513 for OYDV; K 813 and K 641 for SLV; Ch 1512 and K 811 for GCLV; K432 for GVA; Chl 43 for GVB; Ch 1513 for GVC; and K 413 for GVD.

Contact: SR Cheong

Table 33. *Virus reinfection in the field genebank maintained by the Allium breeding unit, AVRDC*

Year	Net	No. samples tested	% positive	% infected with[1]					
				MbFV	OYDV	LYSV	SLV	GCLV	SYSV
96/97	yes	280	3	72	14	29	0	0	0
97/98	yes	202	8	53	29	12	6	0	0
98/99	no	250	86	68	0	10	60	9	0
99/00	no	230	72	48	58	27	24	5	0

[1] MbFV = mite-borne filamentous virus; OYDV = onion yellow dwarf virus; LYSV = leek yellow stripe virus; SLV = shallot latent virus; GCLV = garlic common latent virus; SYSV = shallot yellow stripe virus.

Table 34. *Viruses in cultivated garlic identified in Taiwan and Korea*

Country[1]	Samples tested	% virus positive													
		Total[2] OYDV	OYDV1[4]	OYDV[2]	OYDV[3]	OYD[4]	LYSV	SYSV	SLV	GCLV	GVA	GVB	GVC	GVD	ShVX
Taiwan	88	85	85	-[5]	-	-	73	0	66	25	80	80	34	76	0
Korea 1	125	78	61	12	50	58	87	0	86	26	98	50	25	98	0
Korea 2	42	88	76	-	62	67	81	0	33	33	90	76	33	93	0
Korea 3	212	76[3]	76	-	-	-	83	0	78	33	83	72	42	87	0

[1] Taiwan : leaf samples from Mailiao, Hsilo, Tuku, Yunchang, Lumpei, Paochung, Tzutung, Huwei (March 2000) and kept in dry samples for testing.
Korea 1: bulbs from Danyang (October 1999) and planted in greenhouse (December 1999).
Korea 2: bulbs from Namhae, Cheonju, Euiseong, Cheju, Danyang, Taean, Muan (February 2000) and planted in greenhouse (March 2000).
Korea 3: bulbs from Namhae, Euiseong, Danyang, Muan, Seosan, Goheung, Samchuk (June 2000) and planted in green (October 2000).

[2] Total OYDV is total percent infection determined by using all four antisera.

[3] Korea 3 was tested by OYDV 1 antisera only.

[4] Antisera/monoclonal antibody (MAB) used.

[5] - not tested.

Table 35. *Virus infection of garlic main production areas in Korea*

Area[1]	Samples tested	% virus positive									
		OYDV[2]	LYSV	SYSV	SLV	GCLV	GVA	GVB	GVC	GVD	ShVX
Muan	40	100	100	0	100	10	53	60	25	60	0
Seosan	34	97	97	0	100	53	97	35	44	100	0
Euiseong A	18	94	100	0	100	78	100	100	89	100	0
Euiseong B	24	13	4	0	8	0	100	100	54	100	0
Samcheok	12	0	0	0	0	0	100	75	100	100	0

[1] Garlic of Muan, Seosan, and Euiseong A is from farmer's field. Garlic of Euiseong B and Samcheok is originally from meristem-tip culture and then propagated by bulbil in net house.

[2] Same applied with OYDV 1 as mentioned in foot note of Table 34.

Project 3. Legumes for crop diversification

Project 3 focuses on expanding the production of legumes in cereal-based cropping systems. Its major objective is to evaluate and promote the use of improved short-duration mungbean and soybean lines (including vegetable soybean) in these systems.

Nearly 75% of world mungbean area and 58% of world mungbean production are in South Asia. Mungbean yellow mosaic virus (MYMV), spread by whiteflies, is a major constraint limiting production—a severe epidemic can result in total loss. The best way to control the disease is through the use of resistant varieties.

A mungbean research subnetwork, established in March 1997 under the umbrella of the South Asia Vegetable Research Network (SAVERNET), collected MYMV resistant cultivars and organized multilocation trials in different seasons in the six South Asian countries. Each country was able to identify promising varieties.

At the same time, the variability of MYMV in different locations and seasons, both within and between countries, and its relation to environment was examined.

High yielding tropically adapted grain and vegetable soybean have been distributed to interested cooperators around the world.

High yielding, stable MYMV resistant mungbean lines

A total of 32 improved mungbean varieties have been collected from Bangladesh, India, Pakistan, Sri Lanka, Thailand, and AVRDC. Summer trials (dry season) were planted in March–April and *kharif* (wet season) trials were planted in June or July. As reported in 1999, the trials were conducted in 16 locations in Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. The trials used random complete block design (RCBD) with four replications. Plots were 4.0 × 1.8 m (harvest plot size 3.8 × 1.2 m) with six rows per plot. Spacing between plants within the row was 10 cm.

The results from 17 summer trials and 14 wet season trials were received and a preliminary analysis was conducted. The status in each country is presented below:

- **Bangladesh**—Seeds of NM-92 (released as BARI Mung 5), VC 6372(45-8-1) (released as BUMg 1), NM-94, VC 6368(46-40-4), and VC 6370-30-65 have been multiplied for extension to farmers. Eleven tons of seed of BARI Mung 5 and BUMg 1 have been produced.

Among the entries evaluated, the following four entries were selected and planted on 15 March, 30 March, and 15 April: The trials were RCBD with four replications, and plots were 1.8 × 4.0 m. Differences in yield between genotypes in the 15 March and 30 March plantings were insignificant. However, in the 15 April planting, NM 94 was significantly higher yielding than all other entries. NM-94 and VC 6368(46-40-4) were chosen as the best entries for further seed multiplication (Table 36).

Compared to BINA Mung 2 and BARI Mung 2, the two selected entries matured 10 days earlier and they can fit very well with a wheat-mungbean-rice cropping pattern.

In a trial conducted at the Bangladesh Institute for Nuclear Agriculture (BINA) in 2000, six lines were selected for further evaluation. VC 6173-B-10 matured in 71 days and had a 1000-seed weight of 68.6 g while the check BINAMOOG-5 was 37.9 g. Another line, VC 6370(30-65), was the earliest to mature, in 63 days, with a yield of 1.2 t/ha. The check, BINAMOOG-5, matured in 72 days and yielded 1.3 t/ha. VC 6348-46-7-2 has been irradiated and the resulting population will be planted for selection of early and uniformly maturing types.

Table 36. *Days to maturity and yield of selected mungbean entries at three different planting dates in Bangladesh*

Entry	Days to maturity when planted on			Yield (t/ha) when planted on		
	15 March	30 March	15 April	15 March	30 March	15 April
NM 94	61	58	55	1.50	1.37	1.29
VC 6368(46-40-4)	63	58	56	1.45	1.33	1.18

- **India** – The trials conducted in different regions of India showed that there is distinct genotype-by-location interaction. Therefore, it is necessary to select genotypes specifically suited to particular locations. The yield of the genotypes varied in response to moisture availability (both drought and flooding).

In Pantnagar, VC 3960-88, VC 6372(45-8-1), and NM-92 yielded 750, 648, and 641 kg/ha, respectively, compared to the 583 and 454 kg/ha for the check varieties Pant Mung 4 and Pant Mung 2, respectively.

In Coimbatore, local variety CO 6 was the highest yielder at 1046 kg/ha. NM-92 seeds have been multiplied and farmers are already growing the variety.

Lam (Guntur) and Akola were low yielding locations. VC 6372(45-8-1) was higher yielding than the local check varieties in both locations. In Akola, VC 3960-88, VC 6173B-6, and NM-92 also gave higher yield. Indian Agricultural Research Institute, New Delhi, and Punjab Agricultural University (PAU) in Ludhiana were high yielding locations. After several trials, a selection from NM-92 was officially released as Pusa Vaishal (initially Pusa Bold 1). It is recommended for India's northwest zone. It can yield more than 2.0 t/ha in about 70 days. VC 6372(45-8-1) also gave 2.4 t/ha in 70 days, compared to 2.2 t/ha in 77 days for the check. VC 6372(45-8-1) had an MYMV rating of 2.0 (resistant), compared to the check variety's rating of 7-8 (susceptible).

In Punjab, NM-94 and VC 3960-88 yielded 1.3 and 1.4 t/ha in 63 and 61 days, respectively. Check variety ML 673 yielded 1.3 t/ha in 70 days. Early maturity is a major advantage, enabling the test lines to fit in a wheat-rice cropping system.

PAU has planted 1.6 ha of NM-94. About 5000 kg of NM-94 is available for further multiplication.

- **Sri Lanka** – Trials were conducted and five promising entries were selected for further evaluation: NM-92, VC 6153B-20G, CN 9-5, VC# 6173B-6, and KPS #2. No MYMV was observed in the three trial locations.

Of the 14 trials conducted during the wet season, one trial was conducted at 7°N latitude and the rest were conducted between 23 and 34°N latitude. A pooled analysis of variance (ANOVA) showed that the differences in yield between variety (V), location (L), and V × L interaction were all highly significant. The ANOVA for the Additive Main Effect and Multiplicative Interation Effect (AMMI) model showed that all four AMMI components were highly significant and they accounted for 99.8 % of the sum of squares for V × L interaction.

Among the 17 entries evaluated, Basanti, KPS 2, NM-54, NM-92, VC 6372(45-8-1), VC 6173B-6, and BARI Mung 2 displayed the best adaptation to specific locations.

Fourteen varieties were evaluated in 17 locations in the summer. Three locations were between 7 and 11°N latitude and the rest were between 23 and 34°N latitude. A pooled ANOVA of yield showed highly significant differences for variety (V), location (L) and V × L interaction. Among the 14 varieties evaluated, NM-92, NM-94, VC 6173B-10, SML-132, and PDM-54 displayed the best adaptation to specific locations.

Contact: S Shanmugasundaram

Diversity of MYMV and interaction of environment and MYMV

The search for geminiviruses in mungbean, other leguminous crops, and weeds continued in 2000. Found viruses were cloned to determine whether they are the same virus, strains of one virus, or distinct geminiviruses. Leaf samples from eight countries (Table 37) were collected from plants showing symptoms typical of geminivirus infection, such as yellow, mottle or yellow mosaic, vein yellowing and/ or leafcurling. They were processed by nucleic acid hybridization as described in *AVRDC Report 1999* using two probes, MYMV-India (MYMV IN/Ban) and MYMV-Bangladesh (MYMV-BD3).

For polymerase chain reaction (PCR), a new more efficient primer pair (PAL1v1978B/PAR1c715H) was designed based on alignment and comparison of sequences of known legume geminivirus sequences, i.e., MYMV-INDIA (AF 126406), MYMV-Thailand (AB017341, D14703), and the cowpea golden mosaic virus (CGMV) from Nigeria (AF029217).

Two extraction methods were tried: the standard method (M 1), based on Gilbertson et al. 1991, and another method (M 2) which involved the standard extraction plus an additional extraction step by phenol/chloroform followed by CTAB precipitation (Rogers et al. 1998). Method 2, in conjunction with the new primer pair, was found to be more effective for PCR of legume geminivirus. Mungbean samples that gave a negative PCR reaction using M1 and any of the two primer pairs, reacted positively using M2 in conjunction with the new primer pair, but not with the old primer pair (PAL1v1978/PAR1c715). On the other hand, tomato samples gave positive reactions with M1 and either primer pair, but not with M2.

All PCR positive samples are being cloned and sequenced.

Contact: SK Green

Table 37. *Survey for mungbean yellow mosaic virus in legume crops and weeds, 2000*

Country	Crop	No. positive samples/ no. samples tested	Type of test[1] (probe)
Bangladesh	pea	0/2	PCR
	mungbean	0/1	PCR
	country bean	2/3	PCR
	bush bean	0/1	PCR
India	croton	11/14	PCR
	horse gram	2/2	PCR
	mungbean	0/18	NAH (MYMV IN/Ban, MYMV-BD3)
	mungbean	0/5	PCR, PCR *
	soybean	0/3	PCR, PCR *
	cowpea	0/1	PCR, PCR *
Indonesia	mungbean	0/2	PCR *
	soybean	0/3	PCR *
	yardlong bean	0/1	PCR *
	cowpea	0/1	PCR *
Nepal	cowpea	1/0	PCR *
	legume spp.	0/24	NAH (MYMV IN/Ban, MYMV-BD3)
	mungbean	0/1	PCR, PCR *
	blackgram	0/1	PCR, PCR *
Pakistan	cowpea	1/2	PCR *
	mungbean	0/13	PCR *
		5/7	PCR **
	soybean	5/5	PCR *
	blackgram	0/6	PCR *
Sri Lanka	garden bean	0/2	PCR *
Tanzania	mungbean	0/1	NAH (MYMV IN/Ban)
Vietnam	soybean	0/3	PCR

[1] PCR = the standard extraction method (M 1) and the standard primer pair PAL1v1978/PAR1c715 was used for PCR.
PCR* = the new extraction method (M 2) and the new primer pair was used for PCR.

Improvement of mungbean regeneration efficiency

Information on culture medium favoring in vitro high frequency regeneration is a prerequisite for achieving crop improvement via genetic transformation. Previous studies on mungbean, *Vigna radiata*, have been restricted to a few genotypes and their plant regeneration frequencies were relatively low. The objective of this study was to improve plant regeneration rates by modifying culture medium.

Seeds of mungbean cultivars NM92 and VC1973A, which are popular and widely grown in Asia, were harvested from an AVRDC field. To collect aseptic cotyledons, mature seeds were rinsed in 70% alcohol for 5 min and then sterilize in 0.2% mercuric chloride solution for 10 min. The seeds were then washed thoroughly in sterile distilled water and then put in petri dishes containing distilled sterile water. Seed coats were removed and cotyledons were cultured on half-strength Murashige and Skoog (MS), Gamborg's B5, and Phillips and Collins' L2 medium, with various concentrations TDZ (thidiazuron) or BAP (6-benzylaminopurine) added. All media were adjusted to pH 5.8 and then autoclaved. Cotyledons were planted with the proximal and embedded in the medium. Regenerated shoot buds were sub-cultured onto MB (MS salts and B5 vitamins) medium without growth regulator in Magenta® box for shoot elongation and root formation. The culture was maintained at 25^{o}C under cool-white fluorescent tubes set for a 16-hour photoperiod. Plantlets with developed roots were removed from the culture vessel, were washed under running tap water and transferred to pots containing growth mixture in the greenhouse. Plastic bags with holes were placed over the plants to maintain humidity during the first week.

Results of shoot bud formation are summarized in Tables 38 and 39. Addition of BAP to all three basal media induced some callus formation at the proximal ends of the cotyledons, which was followed by shoot differentiation. The shoots showed stunted growth and lacked roots even after prolonged incubation on medium containing BAP. The callus was green and compact in the beginning but later turned brown, probably due to the production of phenolic compounds. For VC1973A, BAP was better for the regeneration of shoot buds, compared to TDZ. Half strength of B5 and L2 medium supported better regeneration of shoot buds, compared to MS

Table 38. *Regeneration of mungbean variety VC1973A in different media*

Medium	0.50 mg/l TDZ	1.00 mg/l TDZ	2.00 mg/l TDZ	1.25 mg/l BAP	2.50 mg/l BAP	5.00 mg/l BAP
1/2 MS	85/477[1]	42/480	19/479	148/477	189/472	142/480
1/2 B5	167/478	78/480	40/474	242/480	394/476	348/479
1/2 L2	192/476	65/480	37/477	322/475	432/480	292/475

[1] Number of regenerated explants per number of cultured explants.

Table 39. *Regeneration of mungbean variety NM92 in different media*

Medium	0.50 mg/l TDZ	1.00 mg/l TDZ	2.00 mg/l TDZ	1.25 mg/l BAP	2.50 mg/l BAP	5.00 mg/l BAP
1/2 MS	36/473[1]	32/467	19/480	46/472	82/478	78/466
1/2 B5	137/480	67/472	36/479	270/477	248/478	252/480
1/2 L2	152/480	165/472	97/473	219/480	298/477	252/473

[1] Number of regenerated explants per number of cultured explants.

medium. The regeneration frequency on L2 medium was slightly higher than on B5. Addition of 2.50 mg/l BAP resulted in the highest frequency of shoot formation among tested growth regulators concentrations and media. However, morphology of some of the regenerated shoots was abnormal in media supplemented with BAP. The higher the concentration of BAP and the longer the culture time, the higher the percentage of abnormal shoots. Therefore, regenerated shoots were removed from the BAP-containing medium after shoot bud formation and transferred to the MB medium for shoot elongation and root formation. Shoot regeneration rate on MS medium was low and watery tissue was formed on the surface of regenerated shoots. Similar results were obtained with NM92, even though its regeneration frequency was a little lower than that of VC1973A.

Defoliation was observed on elongated shoots cultured on medium in Magenta® box. When elongated shoots were transferred to pots with growth mixture in the greenhouse after root formation, the plantlets continued to grow and extend their roots.

Among the 225 and 250 elongated shoots of VC1973A and NM92, respectively, transferred to the greenhouse, 167 and 132 were able to set seeds. However, the regenerated plants were small and precocity was observed, even though additional light and nutrition were supplied. Most plants were able to set only one or two pods, with a few tiny seeds inside. But the tiny seeds were able to grow into normal plants when cultured in soil. From the above data, for the regeneration of VC1973A and NM92, it is recommended to use half strength L2 medium supplemented with 2.5 mg/l BAP to induce shoot formation and to use MB medium for shoot elongation and root formation. The rate of abnormal shoots, watery tissue, and defoliation can be greatly reduced by reducing the time cotyledons are cultured on BAP-containing medium.

Contact: CA Liu

Early maturing, high yielding multiple disease resistant soybeans for the tropics and subtropics

AVRDC is the principal source of improved soybean lines for the tropics and subtropics, and is the primary source of enhanced lines with soybean rust resistance/tolerance. In 2000, the Center distributed eight AVRDC Soybean Evaluation Trials, 124 improved lines, and 212 accessions to 32 cooperators in 20 countries.

In a trial conducted in Pakistan from 23 July 1998 (34^{o}N, 526 m above sea level), AGS 129 and AGS 19 yielded 3.67 and 3.44 t/ha compared to the local check's 2.66 t/ha. AVRDC's seeds were excellent—no seeds shriveled or damaged by weathering, insect, or disease.

Seven AVRDC selections and two local checks were evaluated in autumn 1999 in Vietnam. Among the AVRDC selections, GC 84058-18-4 gave significantly higher yield, 2.45 t/ha in 76 days, compared to the best local check, HL 92, which yielded 1.45 t/ha in 83 days.

Soybean rust has become a serious constraint in southern Africa. Two evaluation trials were conducted in Zimbabwe at Rattray Arnold Research Station, Harare, to examine the response of fungicide to select soybean rust tolerant lines. Twenty AVRDC lines and two local varieties were evaluated using a split plot design. The varieties were replicated three times. The trial was conducted from December 1999 to April 2000. The yield losses due to soybean rust in the local check varieties were 57.3% to 73.6%. Five AVRDC selections did not have significant difference in yield and 100-seed weight between with- and without-fungicide plots. Two of them have a yield potential of 2.5 t/ha. From the trials, the promising entries are GC 00138-29B, GC 00138-29A, and GC 84058-184.

Contact: S Shanmugasundaram

High yielding tropically adapted vegetable soybeans

Vegetable soybeans have short maturity duration (70-75 days), enhance soil productivity, and add protein and micronutrients to cereal-based diets. For all of these reasons, vegetable soybeans are excellent for small farmers in developing countries.

Heritability of vegetable soybean traits

Breeding efforts continue to emphasize increased graded pod yield, pod color, 100 green bean weight, sugar content, and early maturity. Crosses have been made to combine the above traits. Two hundred F_4 and F_5 lines from 32 crosses were selected at random. From 1996 to 1999, lines were evaluated in spring, summer, and autumn. The plot size was 2 x 2 m and two rows were planted on each bed. Between row spacing was 40 cm and within row between plant spacing was 10 cm. In spring and summer, two seeds were planted per hill, while in autumn, three seeds were planted. RCBD with two replications was used. Data from the three seasons were analyzed. The total variance among the genotype means ($ó^2A$) representing additive, dominance, and epistatic variance was estimated by using the formula, $ó^2$ (G) + $ó^2$ (GXS)/S + $ó^2$ (Error)/ RS. Broad-sense heritability, H^2, was estimated by $ó^2$ (G)/$ó^2A$.

The estimates for broad-sense heritability for graded pod yield, 100 green bean weight, days to harvest, sugar content, and color value are given in Table 40. Heritability estimates were high for 100 green bean weight (0.58–0.93) and days to harvest (0.52–0.92) and lower for graded pod yield (0.11–0.75). Except for one estimate in 1998, the estimates for sugar content were fairly high (0.45–0.86). However, the estimates for color value varied a lot (Table 40).

Based on the results, five selections with significantly higher graded pod yield, 100 green bean weight, and sugar content were selected (Table 41). Graded pod yield in the spring was highest (14.8 t/ha), followed by summer (13.2 t/ha) and autumn (10.6 t/ha).

Contact: S Shanmugasundaram

Table 40. *Heritability estimates of graded pod yield and other traits estimated from variance components in 1999*

Trial	Year	Graded pod wt	100 green bean wt	Days to harvest	Sugar content	Color value
1	1996	0.688	0.933	0.523	0.677	0.242
2	1997	0.107	0.622	0.918	0.56	0.707
3		0.326	0.871	0.905	0.453	0.137
4		0.408	0.741	0.828	0.862	0.775
5	1998	0.214	0.698	0.824	0.486	0.529
6		0.367	0.577	0.729	0.241	0.789
7	1999	0.751	0.804	0.876	0.825	0.332

Table 41. *Promising selections adapted to two or three seasons*

Year	Season	Entry	Graded pod yield (t/ha)	100 green bean wt (g)	Sugar (% dry wt basis)
1997	SP	GC 92005-77-2-1	14.75	89.4	11.62
	AU	GC 92005-77-2-1	9.10	82.8	12.94
	SP	GC 93006-1-1-3-3	12.10	102.2	10.02
	AU	GC 93006-1-1-3-3	6.30	95.2	11.66
1998	SP	GC 92005-120-1-3-1	11.40	86.8	11.34
	AU	GC 92005-120-1-3-1	8.35	87.1	12.85
	SP	GC 94016-10-1	10.75	81.5	10.33
	SU	GC 94016-10-1	13.20	64.4	10.54
	AU	GC 94016-10-1	6.85	67.4	13.10
1999	SP	GC 94015-1-2-1	10.63	78.7	14.05
	AU	GC 94015-1-2-1	10.63	78.5	13.73

SP = spring, AU = autumn, SU = summer.

Program II

Year-round vegetable production systems

The goal of Program II is to develop and transfer technologies for improvement of year-round peri-urban and homestead vegetable production systems. Peri-urban vegetable production is being promoted as a response to some of the many problem associated with rapid urbanization, especially in developing countries. Most of the technologies being developed for peri-urban vegetable production will also be appropriate for homestead applications.

Vegetables are being evaluated and promoted as a practical and sustainable source of micronutrients for health improvement of urban and rural people in developing countries. Biological and socioeconomic constraints to vegetable production and consumption are being identified, and ways are being developed to overcome them. Technologies for year-round production of leafy vegetables and for off-season (hot-wet) production of high-value fruit vegetables, such as solanums and cucurbits, are being emphasiszed as means to overcome seasonal fluctuations in vegetable supply. The production technologies are being developed not only to enhance production, but also to minimize health and environmental risks through promotion of judicious use of pesticides and fertilizers. Spin-off benefits from concentrated areas of intensive year-round vegetable production (peri-urban) include income generation, employment opportunities (especially for women), and development of service sector enterprises.

The objectives of Program II are to:

- collect and improve technologies — including crops and production practices — for peri-urban and homestead production systems
- develop cost-effective and safe means of controlling vegetable pests, with reduced reliance on pesticides
- develop a better understanding of socioeconomic and nutritional aspect of vegetables
- develop improved decision-making tools for national agricultural research and extension systems to increase the effectiveness and efficiency of vegetable research and development efforts

Project 4. Improvement and stabilization of year-round vegetable supplies

Effects of shelter, shade, and fruit-set growth regulator on summer tomato yield and quality

High temperatures and excessive rainfall contribute to low tomato yields and reduced fruit quality in the lowland tropics and subtropics. In 1998, it was observed that protecting plants under colored shade nets improved fruit-set. The objective of these experiments was to evaluate the yield and quality of heat tolerant tomato lines produced under different combinations of shelter–shade treatments and fruit-set growth regulator treatments.

Experiments were conducted during the 1999 and 2000 summer seasons at AVRDC. The treatments were a 5 × 2 × 2 factorial in a split-split plot arrangement. Rain shelter–shading was the main-plot factor with five levels:

1) no rain shelter or shading (control).
2) 2.2-m-high clear polyethylene rain shelter supported by a metal frame and open at the sides from ground level to a height of 1.7 m (the polyethylene [supplied by the Kuu-Chea Co. of Taiwan] was 0.15 mm thick).
3) the rain shelter was as described above with the addition of a 16 mesh white nylon net (supplied by the Gu-Hong Co., Taiwan) supported by metal poles 50 cm above the rain shelter.
4) as described in 3) except that the nylon net was green.
5) as described in 3) except that the nylon net was black.

Main-plot treatments were replicated three times in a randomized complete block design (RCBD), and main-plots were in the same location both years. Replications were 6 m apart and subplots were 1 m apart. Variety was the subplot treatment with two levels: AVRDC cherry tomato inbred line CH154 and AVRDC fresh market inbred line CLN2116DC1F1-180-31-10-25-8 (CLN2116). Application of 4-chlorophenoxyacetic acid (CPA) at 0.15% was the sub-subplot treatment with two levels: 1) none or 2) CPAsprayed once to each flower cluster when 3–4 flowers were in bloom. Sub-plots included a single 25-cm-high raised bed, 4.8 m long and 1.5 m wide. Seedlings were transplanted at the five true-leaf stage, about 25 days after sowing, on 6 July 1999 and 1 June 2000. Two rows were established per bed with 60 cm spacing between rows and 40 cm within rows. Plants were staked and pruned to 4–6 stems per plant. Sub-subplots received a basal application of 180 kg N/ha, 100 kg P_2O_5/ha, and 180 kg K_2O/ha. Maximum and minimum air temperatures were noted daily within sub-subplots. Five plants per subplot were selected at random and measured for percent fruit-set and vine dry weight. Marketable fruit yield was measured on the 20 inner plants within sub-subplots. About 20 random ripe fruit from the second harvest of each sub-subplot were analyzed for solids (^{o}Brix), color (a/b), pH, and citric acid equivalent. Data were analyzed by PROC analysis of variance (ANOVA) using Statistical Analysis System (SAS) appropriate for a split-split plot design. Standard error number 12 (Gomez and Gomez) was used to calculate the least significant difference (LSD) for comparison of rain shelter–shade treatment means within variety and CPA treatments.

Plastic shelter alone reduced temperature and solar radiation slightly compared to the control. Addition of green or black shade lowered air temperatures by about 2°C and reduced solar radiation by 50–75%.

CPA treatment consistently produced beneficial effects on most characters both years (Table 42a-d). Averaged over shade shelters and varieties, application of CPA:

1) decreased days to fruit-set and days to maturity by an average of nine and seven days, respectively;
2) increased fruit-set by 18%;
3) increased marketable fruit yield by 8 t/ha;
4) increased fruit sizes of CH154 and CLN2116 by 3.7 g and 10.4 g, respectively, and
5) decreased vine dry weight by 28 g per plant.

CPA increased solids content of CH154 in 1999 but not in 2000 (data not shown). Treatments did affect color, acid content, and pH (data not shown). The response of most characters by addition of shelter–shading was inconsistent over years and between varieties. In general, there were no benefits

Table 42a. *Days to maturity of shade treatments within varieties and CPA treatments, AVRDC, 1999 and 2000*

Shelter/ shade treatment [1]	CH154						CLN2116					
	1999			2000			1999			2000		
	CPA	No CPA	Diff.	CPA	No CPA	Diff.	CPA	No CPA	Diff.	CPA	No CPA	Diff.
1	54.7	77.0	-22.3**	54.7	57.7	-3.0**	67.7	76.0	-8.3**	63.3	67.7	-4.4**
2	51.0	59.7	-8.7**	54.7	56.0	-1.3*	63.0	74.0	-11.0**	63.0	69.3	-6.3**
3	49.7	58.7	-9.0**	55.0	55.7	-0.7	61.3	74.0	-12.7**	62.7	64.3	-1.6**
4	49.0	55.3	-6.3**	55.0	55.3	-0.3	63.0	74.0	-11.0**	64.3	67.7	-3.4**
5	49.0	54.0	-5.0**	56.0	55.3	0.7	59.0	74.0	-15.0**	66.3	74.3	-8.0**
LSD (0.05)	3.6	3.6		2.2	2.2		3.6	3.6		2.2	2.2	
Mean	50.7	60.9	-10.2	55.8	56.0	-0.9	62.8	74.4	-11.6	63.9	68.7	-4.7

[1] 1 = plastic shelter + black shade; 2 = plastic shelter + green shade; 3 = plastic shelter + white shade; 4 = plastic shelter only; 5 = no shelter or shade.

Table 42b. *Fruit-set % of shade treatments within varieties and CPA treatments, AVRDC, 1999 and 2000*

Shelter/ shade treatment [1]	CH154						CLN2116					
	1999			2000			1999			2000		
	CPA	No CPA	Diff.	CPA	No CPA	Diff.	CPA	No CPA	Diff.	CPA	No CPA	Diff.
1	45.4	15.8	29.6**	39.7	11.0	28.7**	24.2	14.1	10.1**	23.0	11.0	12.0**
2	50.6	21.7	28.9**	37.3	22.7	14.6**	37.3	11.8	25.5**	24.0	7.7	16.3**
3	53.6	27.7	25.9**	36.3	17.7	18.6**	35.5	18.5	17.0**	29.0	14.0	15.0**
4	47.1	35.7	11.4**	36.7	25.7	11.0**	35.1	13.5	21.6**	26.0	11.3	14.7**
5	42.3	26.7	15.6**	42.0	19.7	22.3**	22.5	12.9	9.6**	20.3	5.7	14.6**
LSD (0.05)	9.6	9.6		8.6	8.6		9.6	9.6		8.6	8.6	
Mean	47.8	25.5	22.3	38.4	19.4	19.0	30.9	14.2	16.8	24.5	9.9	14.5

[1] 1 = plastic shelter + black shade; 2 = plastic shelter + green shade; 3 = plastic shelter + white shade; 4 = plastic shelter only; 5 = no shelter or shade.

Table 42c. *Marketable fruit yield (t/ha) of shade treatments within varieties and CPA treatments, AVRDC, 1999 and 2000*

Shelter/ shade treatment [1]	CH154						CLN2116					
	1999			2000			1999			2000		
	CPA	No CPA	Diff.	CPA	No CPA	Diff.	CPA	No CPA	Diff.	CPA	No CPA	Diff.
1	13.4	3.9	9.5**	6.5	1.7	4.8**	16.7	6.4	10.3**	9.6	6.4	3.2*
2	18.8	8.2	10.6**	10.8	4.8	6.0**	29.0	11.2	17.8**	14.9	10.5	4.4**
3	23.0	10.2	12.8**	8.0	5.9	2.1	28.2	13.7	14.5**	16.2	14.2	2.0
4	22.1	14.5	7.6**	10.1	6.3	3.8**	29.2	18.8	10.4**	16.0	11.8	4.2**
5	22.3	11.2	11.1**	13.7	7.1	6.6**	16.2	16.8	-0.6	20.0	9.2	10.8**
LSD (0.05)	5.6	5.6		8.6	8.6		5.6	5.6		8.6	8.6	
Mean	19.9	9.6	10.3	11.5	5.2	6.3	23.9	13.4	10.5	15.3	10.4	4.9

[1] 1 = plastic shelter + black shade; 2 = plastic shelter + green shade; 3 = plastic shelter + white shade; 4 = plastic shelter only; 5 = no shelter or shade.

to use of shade nets compared to plastic shelter alone and black shade often caused undesirable effects. In 1999, CLN2116 + CPA under plastic shelter with green, white, or no shade compared to no shelter-shade: 1) produced about 12–13 t/ha more marketable fruit; 2) added about 13.5% more fruit-set, and 3) increased average fruit size by 13.8 g. In 2000, however, there were few or no significant differences in fruit-set percent and marketable fruit yield between CLN2116 + CPA alone versus CLN2116 + CPA + shelter–shade. The high incidences (39–47%) of southern blight (caused by *Sclerotium rolfsii*) in 2000 in the CLN2116 + shelter–shade treatments (Table 42e) would explain the reduced yields under shelter, although the reason for the higher disease incidence under shelter is not

Table 42d. *Fruit size (g) of shade treatments within varieties and CPA treatments, AVRDC, 1999 and 2000*

Shelter/ shade treatment [1]	CH154						CLN2116					
	1999			2000			1999			2000		
	CPA	No CPA	Diff.	CPA	No CPA	Diff.	CPA	No CPA	Diff.	CPA	No CPA	Diff.
1	12.2	8.9	3.3**	12.0	10.0	2.0	63.9	49.0	14.9**	52.0	39.0	13.0**
2	11.8	8.3	3.5**	12.3	8.3	4.0	70.6	53.9	16.7**	54.7	40.7	14.0**
3	13.2	8.7	4.5**	12.0	7.6	4.4	66.7	57.9	8.8**	47.7	42.3	5.4**
4	12.5	8.3	4.2**	11.3	8.0	3.0	70.0	58.9	11.1**	45.3	38.3	7.0**
5	11.6	8.1	3.5**	11.0	6.7	4.3	55.3	45.9	9.4**	36.7	33.7	3.0
LSD (0.05)	8.6	8.6		9.8	9.8		8.6	8.6		9.8	9.8	
Mean	12.3	8.5	3.8	11.7	8.1	3.5	65.3	53.1	12.2	47.3	38.8	8.5

[1] 1 = plastic shelter + black shade; 2 = plastic shelter + green shade; 3 = plastic shelter + white shade; 4 = plastic shelter only; 5 = no shelter or shade.

clear. For CH154, CPA application + shelter–shade did not significantly improve marketable fruit yield or fruit size compared to CPA application alone without shelter.

Although application of CPA is labor intensive and adds to production costs, this experiment provides strong evidence that its application under high temperatures improves tomato fruit yield and size. A large yield increase was expected from CPA + shelter or shelter–shade, but it did not happen in 2000 because of higher southern blight (*Sclerotium rolfsii*) incidence in CLN2116 under shelter. This higher incidence has yet to be explained, but it suggests that ways to manage the disease under permanent shelter might have to be found.

Contact: P Hanson

Table 42e. *Southern blight incidence (%) in shelter–shade treatments within varieties and CPA treatments, AVRDC, 2000*

Shelter/shade treatment[1]	CH154			CLN2116		
	CPA	No CPA	Diff.	CPA	No CPA	Diff.
1	1.4	1.4	0	43.3	39.0	4.3
2	14.1	2.8	11.3	47.3	39.3	8.0
3	0	0	0	44.7	48.7	-4.0
4	11.0	9.8	1.2	44.3	47.3	-3.0
5	0	0	0	7.0	11.1	-4.1
LSD (0.05)	5.4	5.4		5.4	5.4	
Mean	5.3	2.8		37.3	37.1	0.2

[1] 1 = plastic shelter + black shade; 2 = plastic shelter + green shade; 3 = plastic shelter + white shade; 4 = plastic shelter only; 5 = no shelter or shade.

Effects of rain shelter, grafting, and planting date on yield of summer tomato

Appropriate planting dates and utilization of various management techniques—heat tolerant and disease resistant varieties, shelters, grafting, and mulches—have been shown to increase tomato yield in the hot-wet season. However, the benefits of these practices, individually and in combination, have yet to be determined. The aim of this study was to quantify the effects of shelter and grafting on productivity of summer tomato.

Heat tolerant, indeterminate AVRDC tomato line, CL5915-206D4-2-2-0 (CL5915), immune to tobacco mosaic virus (TMV) and moderately resistant to BW, was transplanted on 15 July and 12 August 2000 in an AVRDC field. Beds were covered with rice straw mulch immediately after transplanting. Two main stems of each plant were allowed to develop and were supported by a bamboo trellis. Side branches were pruned regularly and each flower cluster was treated once with 15 ppm of 4- CPA (Tomatotone®). Insecticide–fungicide mixtures were applied weekly.

Plots consisted of single 30-cm raised beds, 1.6 m wide (2.4 m row spacing) and 5 m long. Twenty plants per plot were transplanted in a double row with 80 cm between rows and 50 cm between plants in the row. There were two shelter treatments, i.e., shelter and no shelter. The shelters were 5 m long, 2.4 m wide, and 2.4 m high structures with an arched top. The frames were constructed from 1.25 cm (inside diameter) galvanized pipe. The arched top was covered with UV-resistant clear polyethylene film, but the sides and ends were left open. There were three grafting treatments, i.e., non grafted CL5915; CL5915 scions grafted onto BW resistant and flood tolerant eggplant rootstock Surya (EG203); and CL5915 scions grafted onto BW resistant tomato rootstock Hawaii 7996 (H7996). The two planting dates were treated as separate experiments. Plots in each planting were arranged in a randomized complete block design with three replications.

July planting. The tomato underwent final harvest on 16 November. Rainfall during the cropping period amounted to 1481 mm. There were three rainfall episodes during which the field was flooded over the bed tops for 24 hours or longer—28 July, 31 July, and 23 August. Non-grafted tomato plants and those grafted onto H7996 exhibited severe wilting about 48 hours after the onset of flooding, and many plants did not survive (Table 43). Those that did survive were severely stunted. Plants grafted onto EG203 did not wilt when flooded. Survival of non-grafted tomato plants was better in the open than under shelters, but percent survival was not different from other treatments in the field. Survival rate of tomatoes grafted onto EG203 was much higher than non-grafted plants and tomato grafted onto H7996 under shelters (Table 43). Yields without shelters were low. Under shelters, yields from tomatoes grafted onto EG203 were significantly higher than those from non-grafted or those grafted onto H7996. Moreover, tomatoes grafted onto EG203 that were grown under shelters gave significantly higher yields than those grown in the open. Thus, the combined benefits of grafting onto flood tolerant eggplant rootstocks and use of shelters were clearly evident in the July planting.

Table 43. *Effects of grafting and rain shelters on plant survival and yield of summer tomato transplanted 15 July 2000*

	Plant survival[1] (%)		Marketable yield[2] (t/ha)	
Rootstock	Shelter	No shelter	Shelter	No shelter
Nongrafted	7.5 c[3]	63.3 ab	3.5 c	7.6 c
Hawaii 7996	3.3 c	26.7 bc	0.8 c	2.1 c
EG203	90.0 a	65.0 ab	26.2 a	6.0 c

[1] Outliers excluded from analysis: trt4 (rep 1).
[2] Outliers excluded from analysis: trt3 (rep 1), trt4 (rep 1).
[3] Mean separation in a row and column at P<0.05 by Duncan's multiple range test.

August planting. The tomato underwent final harvest on 13 December. Rainfall during the cropping period amounted to 547 mm, with a single rainfall event on 23 August that resulted in flooding over the bed tops for 24 hours or longer. As in the July planting, non-grafted plants and those grafted onto H7996 exhibited severe wilting about 48 hours after the onset of flooding. Many plants failed to recover (Table 44) and those that did recover were severely stunted. Plants grafted onto EG203 did not wilt when flooded. There was no difference in plant survival between sheltered and non-sheltered plants within grafting levels. However, survival of plants grafted onto EG203 was significantly greater than non-grafted plants grown under shelters and those grafted onto H7996 and grown in the open. Yields from tomato grafted onto EG203 were significantly higher than those from non-grafted plants or plants grafted onto H7996, both under shelter and in the open. Yields of tomatoes grafted onto EG203 grown under shelter and in the open were not different. Thus, the benefits of grafting tomato onto eggplant rootstock was evident, but no benefit was observed from shelters, due to the limited amount of rainfall during most of the crop duration. These results show that plantings made late in the rainy season might not benefit from shelters.

In conclusion, grafting tomato onto flood tolerant eggplant rootstocks enhances plant survival and yield of tomatoes subjected to flood. Shelters provide additional benefit if the tomato plants are subjected to repeated heavy rainfall. BW did not occur in the experiment. However, based on previous work, had BW occurred, potential benefits from the BW resistant EG203 rootstocks would have been realized but not from H7996, because a high number of plants grafted onto H7996 succumbed to flooding.

Contact: LL Black

Table 44. *Effects of grafting and rain shelters on plant survival and yield of summer tomato transplanted 12 August 2000*

	Plant survival[1] (%)		Marketable yield (t/ha)	
Rootstock	Shelter	No shelter	Shelter	No shelter
Nongrafted	36.7 b[1]	51.7 ab	7.2 b	5.5 b
Hawaii 7996	50.0 ab	20.0 b	10.9 b	4.4 b
EG203	95.0 a	96.7 a	28.8 a	25.4 a

[1] Mean separation in a row and column at P<0.05 by Duncan's multiple range test.

Use of liquid nutrient supplements to enhance efficiency of organic fertilizers in leafy vegetables

Previous studies at have shown that liquid NPK supplements as starter solutions can boost early growth of cherry tomato and common cabbage grown with organic fertilizers (*AVRDC Reports, 1998* and *1999*). Field studies were conducted at in 2000 to determine the effects of liquid NPK supplements in combination with inorganic and organic fertilizer (Table 45) on the yield of three leafy vegetables.

Non-heading Chinese cabbage (bai-tsai), *Brassica rapa* L. cvg. *Chinese cabbage*; kangkong, *Ipomea aquatica* Forsk; and choysum (yu-tsai) *Brassica rapa* L cvg. *caisin* were studied. All experiments were arranged in RCBD with three replications. Beds were 1-m wide with four rows of plants per bed; within-row spacing was 10 cm for bai-tsai and yu-tsai, and 6.7 cm for kangkong. Seeds of local varieties of bai-tsai and yu-tsai were sown on 1 June and harvested on 3–4 July 2000, while seeds of kangkong were sown on 18 September and harvested on 20 October 2000. At harvest, 30 plants from each plot were sampled to determine plant height, marketable fresh weight, and dry weight. Samples were also analyzed on NPK levels in the edible portion of these crops.

The bai-tsai trial showed inorganic liquid supplement fertilizer resulted in significant increases in both fresh and dry matter yield at 15 days after sowing (DAS) (Table 46). The liquid supplement had no effect on bai-tsai fertilized with the 1× rate of composted chicken manure (CM) regardless of time of application. However, the liquid supplement used in combination with the 1.5× rate of CM increased both fresh weight and dry matter yield when applied 20 DAS as compared with other CM treatments.

As for kangkong, inorganic liquid supplement had no effect on the fresh weight yield (Table 47). Treatments receiving liquid supplements in combination with the 1.5× rate of CM from 6 to 20 DAS boosted yields 18–28% over other CM treatments. Treatments receiving liquid supplements at 12, 15, and 21 DAS gave dry matter yields that were significantly higher than the treatment receiving the supplement at the time of transplanting. The supplementary treatments that were most effective were those made during the period just prior to or at the beginning of the rapid growth phase.

Leafy vegetables are fast growing. About 85–90% of their total dry biomass accumulates during the last third of the growth period (Figure 10). Results of this study suggest that application of starter solution just before or at the beginning of the fast growth stage is effective in boosting leafy vegetable yields.

The yu-tsai trial was conducted to compare

Table 45. *Various fertilizer applications evaluated on leafy vegetables*

Leafy vegetable	Solid fertilizer: Types	Solid fertilizer: $N\text{-}P_2O_5\text{-}K_2O$ (kg/ha)	Liquid NPK supplement: Formulation[2]	Liquid NPK supplement: $N\text{-}P_2O_5\text{-}K_2O$ (kg/ha)
Bai-tsai	Inorganic	160- 90 -100	No. 4	3.6-7.2- 3.6
	Chicken manure-1x N equivalent [1]	160-495-410		
Yu-tsai	Inorganic	160- 90 -100	Urea	3.6-0.0- 0.0
	Chicken manure-1x N equivalent	160-495-410	Ammonium sulfate	3.6-0.0- 0.0
			Potassium nitrate	3.6-0.0-12.1
			No. 1	3.6-1.8- 1.8
			No. 4	3.6-7.2- 3.6
			No. 5	3.6-7.2- 7.2
			Tien-Pao # 1[3]	3.6-1.8- 1.8
Kangkong	Inorganic	180- 90 -120	No. 4	3.6-7.2- 3.6
	Chicken manure-1x N equivalent	180-557-461		

[1] Composted chicken manure (CM) applications were equivalent to 1× and 1.5× the rate of N applied as inorganic solid fertilizer.

[2] Formulations of liquid NPK supplements were: commercial liquid compound fertilizer No. 1, composition = $N\text{-}P_2O_5\text{-}K_2O$: 12-6-6%; No. 4, composition = $N\text{-}P_2O_5\text{-}K_2O$: 6-12-6%; and No. 5, composition $N\text{-}P_2O_5\text{-}K_2O$ = 4.5-9-9%, produced by Taiwan Fertilizer company; all liquid fertilizers were diluted and applied in 370 ml water per 1 m^2.

[3] Tien-Pao No.1, organic liquid fertilizer, composition = $N\text{-}P_2O_5\text{-}K_2O$: 12- 6-6%, produced by Taiwan Sugar Company.

Table 46. *The effects of organic fertilizer and timing of liquid NPK supplements on yield and nutrient contents of bai-tsai, summer 2000*

Fertilizer treatment	Time for liquid NPK supplements[3] (DAS)	Total fresh wt yield (t/ha)	Total dry wt yield (t/ha)	Nutrient content (%) in edible parts	
				N	P
CM*1.5 N[1]	0	17.4 de[4]	1.01 de	2.95 b	0.77 a
CM*1.5 N	5	18.3 cd-e	0.97 de	3.03 b	0.71 ab
CM*1.5 N	10	17.4 de	1.01 de	3.00 b	0.69 ab
CM*1.5 N	15	20.0 cd	1.15 cd	2.95 b	0.71 ab
CM*1.5 N	20	21.9 c	1.24 c	3.04 b	0.76 a
CM*1.5 N	25	18.3 cd-e	1.07 cd-e	2.73 b	0.75 a
CM*1.0 N	0	17.0 de	1.02 de	2.84 b	0.69 ab
CM*1.0 N	10	17.5 de	0.97 de	3.19 b	0.67 ab
CM*1.0 N	20	15.8 e	0.94 e	2.90 b	0.71 ab
SI fertilizer[2]	None	37.5 b	1.84 b	4.41 a	0.62 b
SI fertilizer	0	41.2 a	1.92 ab	4.44 a	0.61 b
SI fertilizer	15	44.1 a	2.04 a	4.64 a	0.64 b

[1] Composted chicken manure (CM) applications were equivalent to 1.0× and 1.5× the rate of N applied as inorganic solid fertilizer.
[2] Standard inorganic fertilizer (SI) comprised a basal application of N-P_2O_5-K_2O, 60-90-60 kg/ha, and top dressing of N-K_2O, 50-20 kg/ha at 10 and 20 days after sowing (DAS), respectively.
[3] Liquid NPK supplement was formulation No. 4, composition = N-P_2O_5-K_2O : 6-12-6%; 0 = applied at sowing.
[4] Means followed by the same letter do not differ significantly at $P<0.05$ by Duncan's multiple range test.

Table 47. *The effects of organic fertilizer and timing of liquid NPK supplements on yield and nutrient contents of kangkong, autumn 2000*

Fertilizer treatment	Time for liquid NPK supplements[3] (DAS)	Total fresh wt yield (t/ha)	Total dry wt yield (t/ha)	Nutrient content in edible parts	
				N (%)	P (%)
CM*1.5 N[1]	0	10.2 bcd[4]	1.06 c	2.55 b	0.47 ab
CM*1.5 N	3	10.7 bcd	1.12 bc	2.31 bc	0.48 a
CM*1.5 N	6	12.3 bcd	1.24 bc	2.37 bc	0.47 ab
CM*1.5 N	9	12.1 bcd	1.22 bc	2.35 bc	0.46 ab
CM*1.5 N	12	13.1 b	1.31 b	2.40 bc	0.45 ab
CM*1.5 N	15	13.1 b	1.32 b	2.42 bc	0.44 b
CM*1.5 N	18	12.9 bc	1.27 bc	2.41 bc	0.44 b
CM*1.5 N	21	12.9 bc	1.30 b	2.42 bc	0.45 ab
CM*1.0 N	6	10.0 cd	1.08 bc	2.21 c	0.44 b
CM*1.0 N	18	9.9 d	1.06 c	2.28 bc	0.44 b
SI fertilizer[2]	None	23.3 a	2.06 a	3.73 a	0.34 c
SI fertilizer	6	23.3 a	1.89 a	3.66 a	0.35 c
SI fertilizer	18	24.3 a	2.03 a	3.53 a	0.34 c

[1] Composted chicken manure (CM) applications were equivalent to 1.0× and 1.5× the rate of N applied as inorganic solid fertilizer.
[2] Standard inorganic fertilizer (SI) comprised a basal application of N-P_2O_5-K_2O, 60- 90-60 kg/ha, and top dressing of N-K_2O, 60-30 kg/ha at 10 and 20 days after sowing (DAS), respectively.
[3] Liquid NPK supplement was formulation No. 4, composition = N-P_2O_5-K_2O : 6-12-6%; 0 = applied at sowing.
[4] Means followed by the same letter do not differ significantly at $P<0.05$ by Duncan's multiple range test.

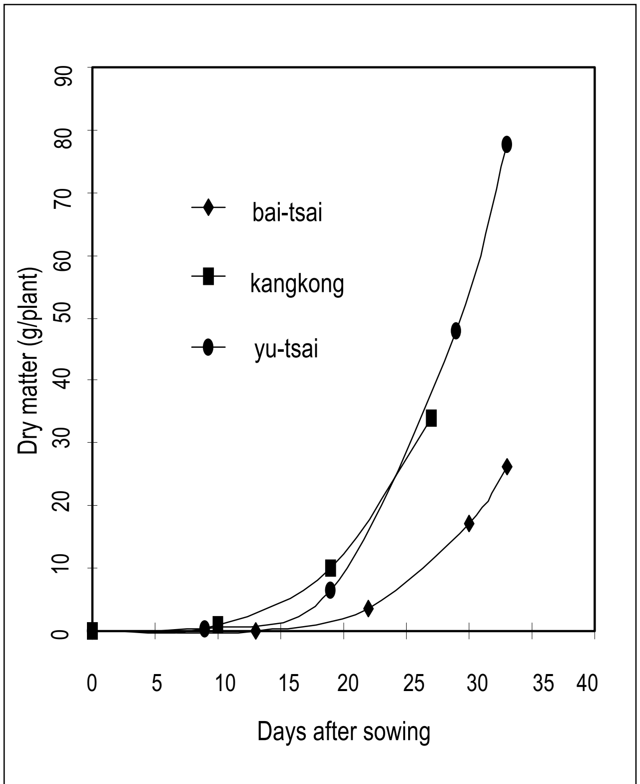

Figure 10. *Crop duration and growth pattern as measured by dry weight accumulation of three leafy vegetable crops.*

various liquid supplement formulations for their effect on yield. There were no yield differences among treatments receiving the different types of liquid supplement. The time of application of the liquid supplements in this trial was 6 DAS, which in retrospect was probably too early to see any benefits of the supplements on yield.

Nitrogen content in edible plant parts was significantly higher in plants receiving inorganic fertilizer than in those grown with CM (Tables 46-48). On the other hand, percentage dry matter and phosphorus content were higher in vegetables grown with CM as the main fertilizer source. Due to the high concentrations of phosphorus in CM, plants grown with CM took up more P than those grown with inorganic fertilizers. The effect of fertilizer source on levels of K (data not shown) in vegetables was not as clear as it was for N and P.

Regardless of application timing for liquid supplements or amount of chicken manure, both fresh and dry matter yields of all three leafy vegetables fertilized with CM were only about half the yield from the standard inorganic fertilizer check Organic fertilizers release nutrients slowly, thus larger quantities might have to be applied well in advance of planting in order to minimize the yield depression associated with their use in short duration crops, such as leafy vegetables.

Contact: CH Ma

Composts as an alternative to peat moss for vegetable transplant production

Composting has become popular as a means of recycling nutrients in waste. But compost can also be used as cultivation media, to replace expensive peat-moss-based seedling media. This study was undertaken to develop and evaluate composts suitable for production of Chinese cabbage and cherry tomato transplants.

Chinese cabbage ASVEG #1 and cherry tomato CHT 154 were sown in 35-cell (142.6 cm^3/cell) and 70-cell (56.8 cm^3 /cell) trays, respectively. Six replications (trays) of each of four composts (Table 49) were sown with each crop on 11 January 2000 and arranged in RCBD in the greenhouse. Twenty days after sowing Chinese cabbage, and 30 days after sowing tomato, 10 Chinese cabbage plants and 30 tomato plants were removed from each tray to determine height and fresh and dry weights. On the same day, 20 seedlings from each tray were transplanted into field plots using RCBD with six replications. A single harvest of Chinese cabbage was made 39 days after transplanting. Tomatoes were harvested three times—80, 87, and 101 days after transplanting.

Chinese cabbage

Emergence of seedlings in all the media reached or approached 100% by 6 days after sowing (DAS), except for the AVRDC medium in the peat-moss treatment (Table 50). Seedling emergence was fastest and seedlings were significantly taller and had greater fresh and dry weights than those from other treatments, with or without supplemental fertilizer. Figure 11 shows the relationship between seedling height at 20 DAS and head yield of Chinese cabbage at 59 DAS. Although seedling height varied among treatments, there were no yield differences if seedling height exceeded 9 cm. The results suggest that composts 1 and 7 could be substituted for peat moss media to grow Chinese cabbage transplants.

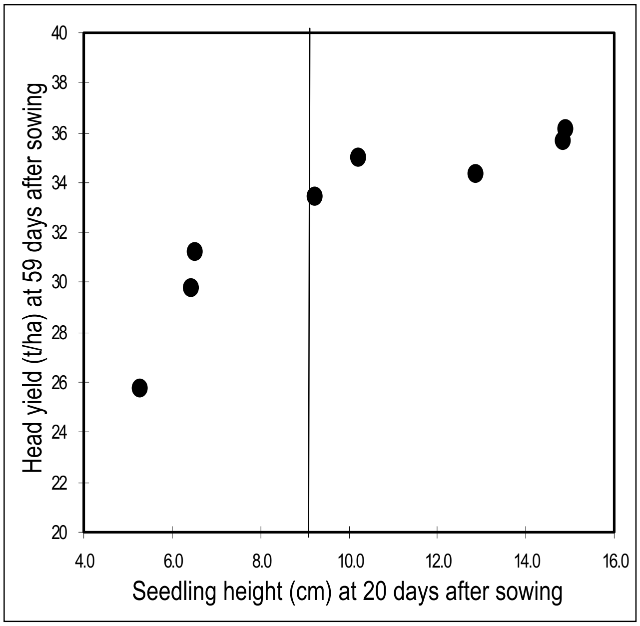

Figure 11. *Relationship between seedling height and head yield of Chinese cabbage.*

Cherry tomato

At 8 DAS, percent germination was lowest in the AVRDC growth medium and compost 7 (Table 51). Germination reached 100% only in compost 1 and the peat moss media. Seedlings were largest in peat moss, and smallest in composts 4 and 5. Despite of the size of transplanted seedlings, there were no obvious differences in total fruit number and fruit yields (Table 51). Yields of tomato appear to be less affected by transplant size than are Chinese cabbage yields. As an example, compost 5 produced the smallest transplants, but these plants produced the highest fruit yield. Based on this study, any of the composts tested could replace peat moss as a medium for cherry tomato. Compost 1 was best among the composts tested based on percent germination, its greater water holding capacity, and its lower bulk density. Furthermore, its pH and total inorganic N are similar to those of the peat moss medium.

Contact: CH Ma

Cabbage varieties for hot-wet season production in tropical lowlands

Common cabbage production in the tropics is largely concentrated in highland areas to take advantage of the lower temperatures. Several heat tolerant common cabbage hybrids with potential for lowland summer production have been developed by seed companies. The purpose of these studies was to identify the most useful standard size and mini-head cabbage varieties adapted for hot–wet season production in tropical lowlands.

Table 48. *The influences of different liquid NPK supplements on yield and nutrient contents of yu-tsai, summer 2000*

Fertilizer treatment	Time for liquid NPK supplements[3] (DAS)	Marketable: Total fresh wt yield (t/ha)	Marketable: Total dry wt yield (t/ha)	Nutrient content in edible parts: Nitrogen (%)	Nutrient content in edible parts: P (%)
CM*1.5 N[1]	Urea	14.9 b[4]	1.16 b	2.89 cd	0.58 a
CM*1.5 N	Ammonium sulfate	16.5 b	1.31 b	3.07 cd	0.59 a
CM*1.5 N	Potassium nitrate	15.0 b	1.18 b	2.76 cd	0.59 a
CM*1.5 N	No. 1	14.9 b	1.21 b	2.67 d	0.56 a
CM*1.5 N	No. 4	13.3 b	1.05 b	2.81 cd	0.56 a
CM*1.5 N	No. 5	16.4 b	1.21 b	3.18 c	0.58 a
CM*1.5 N	Tien-Pao # 1	16.6 b	1.25 b	2.87 cd	0.56 a
SI fertilizer[2]	None	35.9 a	2.11 a	4.88 a	0.46 b
SI fertilizer	No. 4	37.9 a	2.25 a	4.31 b	0.49 b

[1] Composted chicken manure (CM) applications were equivalent to 1.5× the rate of N applied as inorganic solid fertilizer.
[2] Standard inorganic fertilizer (SI) comprised a basal application of N-P_2O_5-K_2O, 60-90-60 kg/ha, and top dressing of N-K_2O, 50-20 kg/ha at 10 and 20 days after sowing (DAS), respectively.
[3] Formulations of liquid NPK supplements were: commercial liquid compound fertilizer No. 1, composition = N-P_2O_5-K_2O : 12-6-6%; No. 4, composition = N-P_2O_5-K_2O : 6-12-6%; and No. 5, composition N-P_2O_5-K_2O = 4.5-9-9%, produced by Taiwan Fertilizer company; all liquid fertilizers were diluted and applied in 370 ml water per 1 m^2. Application time was 6 DAS.
[4] Means followed by the same letter do not differ significantly at P<0.05 by Duncan's multiple range test.

Table 49. *Compositions and properties of seedling growth media, spring 2000*

Seedling media	pH	EC (mmhos/cm)	NH_4-N (ppm)	NO_3-N (ppm)	Total inorganic-N (ppm)	Maximum water holding capacity (%)	Bulk density (g/cm^3)
Compost 1[1]	5.15	4.02	168.1	247.6	415.8	76.6	0.14
Compost 4[2]	6.61	5.42	35.9	86.0	121.9	67.0	0.22
Compost 5[3]	7.57	4.74	36.4	1351.5	1387.9	61.8	0.33
Compost 7[4]	4.70	6.23	130.6	117.1	247.8	58.3	0.31
Peat moss[5]	4.95	0.82	0.9	401.8	402.7	78.4	0.13
AVRDC medium[6]	7.39	0.65	99.3	266.7	366.0	22.8	0.88
Peat moss + Fert[7]	5.01	4.06	912.9	408.0	1320.9	76.1	0.14

[1] Compost 1 = rice bran : pig dung : saw dust : rice hulls (1:1:4:4 by volume).
[2] Compost 4 = pig dung : pig bone powder : rice hulls : rice straw (5:1:16:18 by volume).
[3] Compost 5 = chicken dung : pig bone powder : rice hulls : rice straw (5:1:16:18 by volume).
[4] Compost 7 = legume residues : rice hulls : rice straw (1:1:2 by volume).
[5] Peat moss medium = commercial growing medium, manufactured by Veldkamp Veenproducten B.V. Company, the Netherlands; imported by Known-You seed company, Taiwan.
[6] AVRDC medium = soil : compost : sand : rice hulls (3:2:1:1 by volume).
[7] Fert = addition of 2.4-0.48-1.6 g/tray of NPK fertilizer to the peat moss medium in both 35- and 70-cell trays.

Table 50. *Emergence rate, seedling height and size and head yield of Chinese cabbage as influenced by the growth media, spring 2000*

Seedling media	Emergence rate (%)			Seedling height[2] (cm)	Leaf fresh weight[1] (g/plant)	Leaf dry weight[2] (g/plant)	Head yield[3] (t/ha)
	2 DAS[1]	3 DAS	6 DAS				
Compost 1[4]	0 b	86 ab	100 a	9.2 c	2.22 d	0.15 d	33.4 ab
Compost 4[5]	0 b	43 de	99 a	6.5 d	1.14 e	0.09 e	31.2 bc
Compost 5[6]	0 b	36 e	100 a	5.3 d	0.89 e	0.07 e	25.8 d
Compost 7[7]	0 b	79 b	98 a	10.2 c	2.98 c	0.21 c	35.0 a
Peat moss[8]	50 a	100 a	100 a	14.8 a	6.92 a	0.37 a	35.7 a
AVRDC medium[9]	0 b	61 c	91 b	12.9 b	4.50 b	0.28 b	34.4 a
Peat moss + Fert[10]	48 a	100 a	100 a	14.9 a	6.63 a	0.39 a	36.1 a

[1] DAS =Days after sowing.
[2] Seedling height, leaf fresh weight, and leaf dry weight measured 20 days after sowing.
[3] Fertilization comprised a basal of 60-60-60 kg/ha N-P_2O_5-K_2O and 30-7.5-15 kg/ha N-P_2O_5-K_2O. as top-dressing at 20 days after transplanting.
[4] Compost 7 = legume residues: rice hulls: rice straw (1:1:2 by volume).
[5] Compost 4 = pig dung : pig bone powder: rice hulls : rice straw (5:1:16:18 by volume).
[6] Compost 5 = chicken dung : pig bone powder : rice hulls : rice straw (5:1:16:18 by volume).
[7] Compost 7 = legume residues : rice hulls : rice straw (1:1:2 by volume).
[8] Peat moss medium = commercial growing medium, manufactured by Veldkamp Veenproducten B.V. company, the Netherlands; imported by Known-You seed company, Taiwan
[9] AVRDC medium = soil : compost : sand : rice hulls (3:2:1:1 by volume).
[10] Fert = addition of 2.4-0.48-1.6 g/tray of NPK fertilizer to the peat moss medium in both 35-and 70-cell trays

Standard cabbage varieties

Eight cabbage varieties were compared with two heat tolerant check varieties (Shiafong #1 and KK Cross) for their performance in the open field during summer 2000. Yield and number of days from transplant to harvest were determined in three separate plantings made in May, June, and July. Each planting was arranged in RCBD with three replications. Plots were two 5 × 1.5 m, 30-cm-high beds. Two rows of plants were grown in each bed with 50 cm between rows and 50 cm between plants in the row, for 40 plants/plot. Yield and time between transplanting and harvest were recorded for each entry.

Table 51. *Emergence rate, seedling height and size, fruit number and yield of cherry tomato as influenced by the growth media, spring 2000*

Seedling media	Emergence rate (%)			Seedling height [2] (cm)	Seedling fresh weight[2] (g/plant)	Seedling dry weight[2] (g/plant)	Total fruit no.[3] (no./m^2)	Total yield[2] (t/ha)
	6 DAS[1]	7 DAS	8 DAS					
Compost 1	91 a	99 a	100 a	17.1 b	2.47 b	0.18 b	589 ab	44.6 b
Compost 4	58 b	92 ab	96 ab	12.3 c	1.43 c	0.10 d	580 ab	45.8 ab
Compost 5	31 c	85 bc	94 ab	7.2 d	0.75 d	0.06 e	653 ab	52.1 a
Compost 7	34 c	79 cd	86 b	13.9 c	1.57 c	0.10 d	580 ab	45.9 ab
Peat moss	100 a	100 a	100 a	19.8 b	1.78 c	0.14 c	571 b	43.6 b
Peat moss + Fert	100 a	100 a	100 a	18.0 ab	2.84 a	0.21 a	673 a	48.8 ab

[1] DAS = Days after sowing.
[2] Seedling height, leaf fresh weight, and leaf dry weight measured 30 days after sowing.
[3] Tomatoes transplanted February 10, 2000.; fertilization comprised a basal of 60-60-60 kg/ha N-P_2O_5-K_2O and 60-60-60 and 60-15-30 kg/ha of N-P_2O_5-K_2O were top-dressed at 3 and 7 weeks after transplanting.

Varieties NV10, Heat Toler, and NV01 gave yields equal to or significantly higher than the checks across the three plantings, and their average yields were 2–7 t greater than the checks (Table 52). On average, the three varieties were ready for harvest in 65, 67, and 71 days after transplanting, respectively, similar to the check varieties.

Mini-head cabbage varieties

Some small-headed cabbage varieties have shown promise because of their early maturity and uniformity of heading. In this study, two mini-head varieties, Golden Cross and Miniball, were compared in the open field with two standard size varieties, Shiafong #1 and KK Cross, for earliness and yield. The trial was arranged in RCBD with three replications. Mini-head plots consisted of three 3.6 × 1 m, 30-cm-high beds with 72 plants in a double row with 30 cm in-row spacing, which is equivalent to 66,666 plants/ha. Standard cabbage plots consisted of two 3.5 × 1.5 m, 30-cm-high beds with 28 plants in a double row with 50 cm in-row spacing, which is equivalent to 26,666 plants/ha.

The mini-head varieties matured 11–15 days earlier but yielded about the same as the standard varieties (Table 53). Because of their heat tolerance and size, mini-head varieties has a potential for

Table 52. *Yield and days from transplant to harvest of common cabbage varieties evaluated during the hot–wet season, 2000*

Variety	Days from transplant to harvest				Yield (t/ha)			
	I[1]	II[2]	III[3]	Mean	I[1]	II[2]	III[3]	Mean
NV 10	59 c[4]	62 cd	74 b-e	65	25.1 a	18.8 a	21.5 a	21.8
Heat Toler	62 b	61 d	78 b-d	67	21.8 b	17.6 a	21.2 a	20.2
NV 01	60 bc	69 a	85 a	71	24.7 a	13.5 b	19.1 bc	19.1
KK Cross, ck	60 bc	64 b-d	73 c-e	66	26.6 a	7.4 de	17.3 de	17.1
Keep King	61 bc	66 a-c	79 bc	69	17.8 d	10.4 c	19.7 b	16.0
Green Beauty	60 bc	64 b-d	72 de	65	19.9 c	9.4 cd	17.9 cd	15.7
Summer Sea YR	62 b	67 ab	69 e	66	17.6 d	8.8 cd	19.4 bc	15.3
Shiafong #1, ck	61 bc	65 a-d	75 b-e	67	17.0 d	8.5 c-e	18.5 b-d	14.7
Shia Bao	61 bc	64 b-d	74 b-e	66	18.2 cd	6.6 e	17.7 c-e	14.2
DG 658	66 a	69 a	80 ab	72	7.6 e	2.0 f	16.2 e	8.6
CV (%)	2.7	3.7	4.3		5.5	10.9	4.7	

[1] I Date sown: 17 Apr 2000; Date transplanted: 11 May 2000.
[2] II Date sown: 15 May 2000; Date transplanted: 7 June 2000.
[3] III Date sown: 15 June 2000; Date transplanted: 5 July 2000.
[4] Mean separation within columns in each trial at P<0.05 by Duncan's multiple range test.

Table 53. *Comparison of standard size and minihead cabbage varieties for earliness and yield*[1]

Variety	DAT[2]	Head density (g/cm^3)	Head weight (g)	Yield (t/ha)
Shiafong #1, standard	57 a[3]	0.51 b	1071 b	28.6 b
KK Cross, standard	58 a	0.51 b	1271 a	33.9 a
Golden Cross, mini-head	43 c	0.77 a	407 d	27.2 b
Miniball, minihead	46 b	0.70 a	550 c	36.7 a
CV (%)	1.7	11.4	7.1	11.4

Mean separation within columns in each trial at P<0.05 by Duncan's multiple range test.
Date sown: 9 Aug 2000; date transplanted: 1 Sep 2000.
DAT = days after transplanting.

intensive year-round cropping systems in the tropics, and will further be evaluated.

Contact: LL Black

Evaluation and selection of leafy vegetable cultivars

Evaluation and selection of leafy vegetable cultivars, which began in 1998, continued in 1999 and 2000. All accessions were directly seeded in 20 to 30–cm high raised beds, 2–m long, with 60–cm-wide bed tops. Seeds were sown in five rows, 10 cm apart, with 15 cm between plants within rows. Plants were harvested based on optimum growth for marketing. Ten plants in the middle three rows were measured for yield and other traits. But only yield data are reported here. Evaluations were in the open field and inside a 32–mesh nylon, fully enclosed net house.

1999 trials

One hundred seventy two accessions of five leafy vegetable crops—pakchoi, choysum, Indian mustard, non-heading Chinese cabbage, and Chinese kale—were evaluated.

- **Cool–dry season**. Five brassica accessions were sown in February and evaluated in the open field and inside a net house. At the same time, kangkong and lettuce accessions were evaluated in the open field only. Data from this trial were highly variable, so results are not presented.
- **Hot–wet season**. Persistent rain caused flooding and prevented planting in July.
- **Hot–dry season**. Brassicas were sown in September and November.

The later planting (same accessions) was in the open field only.

2000 trials

A total of 159 accessions (including some not tested in 1999) were evaluated in the open field and the net house in the cool–dry and hot–wet seasons in 2000. Chinese celery and non-heading lettuce were added for evaluation in the hot–wet season. Yield data reported for Chinese celery, non-heading lettuce, and kangkong are for the top 10–15 yielding accessions.

Non-heading Chinese cabbage (*Brassica rapa* L. cvg. Chinese cabbage)

In general, average yield in the open field is higher than in the net house during the hot–dry season (Table 54). In the open field, Wan-chuan, Nylon bai-tsai (Gung-nung), Black dragon tsai (F_1), Nylon bai-tsai (Guo-shuei-lu) and Fiberless bai-tsai were outstanding during hot–dry season 1999, with average yields ranging from 38.4 to 41.3 t/ha. The top five in the net house were Black dragon tsai (F1), Nylon bai-tsai (Guo-sheuei-lu), Late siao bai-tsai, Semi-heading bai-tsai, and Diamond bai-tsai. Yields during the cool–dry season were similar to those in the hot–dry season (Table 54), and yields in the open field were higher than in the net house. The promising accessions were Nylon bai-tsai (guo-shuei-lu), Late siao bai-tsai, Dai Tokyo bekana (F_1), Season pearl bai-tsai, and 492 Semi-heading bai-tsai in the open field and Wan-chuan (F_1), Nylon bai-tsai (Gung-nung), Dai Tokyo bekana (F_1), Juang-jing bai tsai, Semi-heading bai-tsai (F_1) and 492 Semi-heading bai-tsai (F_1) in the net house. During the hot–wet season, the net house offers an advantage over the open field. However, average yields during the hot–wet season were lower than in the hot and cool–dry season. For hot–wet season production, accessions Native bai-tsai, Semi-heading bai-tsai (F_1), 490 Semi-heading bai-tsai (F_1), and 492 Semi-heading bai-tsai were found promising in the open field and in the net house. Fiberless bai-tsi (F_1) did

Table 54. *Yields (t/ha) of non-heading Chinese cabbage from different field trials, AVRDC, 1999-2000*

Varietal Name	Hot-dry season			Cool-dry season		Hot -wet season	
	Sept. 1999	Nov. 1999	Sept. 1999	Feb. 2000		July 2000	
	Open	Open	Nethouse	Open	Nethouse	Open	Nethouse
Wan-chuan (F_1)	40.6 ab[1]	-	30.2 d	37.1 b	34.0 bc	16.5 a-c	19.6 b-d
Nylon bai-tsai (Gung-nung)	41.3 a	40.5 a	21.3 e	27.2 c	24.7 e	9.5 d	10.7 e
San-feng pai-tsai	-	-	-	-	-	16.3 a-c	18.1 cd
017 Black dragon tsai (F_1)	39.5 ab	-	33.4 a	-	-	15.4 a-d	14.5 de
Nylon bai- tsai (Guo-shuei-lu)	40.0 ab	37.8 b	31.6 a-d	38.0 b	35.8 b	13.2 b-d	18.4 cd
Late siao bai-tsai	35.8 cd	35.9 c	32.4 a-c	37.5 b	28.3 d	15.5 a-d	16.8 cd
Dai-Tokyo bekana (F_1)	37.4 bc	37.7 b	31.1 b-d	42.2 a	39.3 a	15.6 a-d	20.1 b-d
Black pearl bai-tsai	-	-	-	-	-	16.4 a-c	16.9 cd
Golden native bai-tsai	33.3 d	-	30.5 cd	-	-	14.7 a-d	18.8 cd
Huang-jing bai-tsai (Y.S.Wang)	-	-	-	36.0 b	32.3 bc	11.8 cd	17.7 cd
Native bai-tsai	-	-	-	-	-	19.0 a	20.4 b-d
123 Semi-heading bai-tsai (F_1)	35.9 cd	-	32.8 ab	37.3 b	34.2 bc	16.7 a-c	22.2 a-c
Season's Pearl bai-tsai (F_1)	-	-	-	37.5 b	31.8 c	-	-
Diamond bai-tsai (F_1)	35.0 cd	-	31.9 a-d	-	-	-	-
Fiberless bai-tsai (F_1)	-	38.4 b	-	-	-	18.5 ab	18.5 cd
490 Semi-heading bai-tsai (F_1)	-	37.2 b	-	-	-	16.9 a-c	26.5 a
492 Semi-heading bai-tsai (F_1)	-	37.3 b	-	39.7 ab	34.1 bc	18.1 a-c	25.0 ab
Mean	37.6	38.1	30.6	36.9	32.7	15.6	18.9
CV (%)	4.6	1.2	3.6	5.8	5.7	20.4	15.6

[1] Mean separation in a column at P<0.05 by Duncan's multiple range test.

well in the open field, while Dai Tokyo bekana (F_1) did well in the net house. Nylon bai-tsai (Guo-shuei-lu) produced high yields consistently across production systems, especially during the hot–dry and cool–dry seasons. Generally, yield performance for each accession varied across production systems. Accessions that perform well under in the field might not do well in the net house. During the hot–dry and cool–dry seasons, non-heading Chinese cabbage yield is reduced 18% and 11%, respectively, when grown in the net house. By contrast, production in the net house offers a 21% yield advantage over the open field in the hot–wet season. However, yield variation is generally higher during the hot–wet season compared to the hot–dry and cool–dry seasons.

Pakchoi (*Brassica rapa* L. cvg. Pakchoi)

Average yields of pakchoi accessions were higher in the open field than in the net house across all planting seasons (Table 55). Except for Bp11 and Bp06, all the accessions evaluated during the hot–dry season did well in both the open field and net house. However, five accessions (Zhuong chi white, Ching-fang (F_1), No. 341 (F_1), Tall-stem Ching-jiang tsai, and Super black behi) produced high yields consistently in both systems during the hot–dry season. Very high yields were obtained during the cool–dry season. Average yields greater than 50 t/ha were obtained in both systems. The top five accessions in open field production during the cool–dry season were Ai-jeo yellow, Ching-fang (F_1), Wase kakyo (F_1), Black behi (Condor), and BP20 Pai-chai (F_1), while Zhuong chi white, Wase kakyo (F1), Black behi (Condor), BP20 Pai-chai F_1, and BP21 Pai-chai (F_1) were the best in the net house (Table 55). Average yields during the hot–wet season were lower than yields in the hot–dry and cool–dry seasons. The net house did not provide benefit to pakchoi during the hot–wet season. Zhuong chi-white produced the highest yield in both systems. When grown inside a net house, accessions Ai-jeow yellow, Pavo black behi type, and Kao no. 2 (F_1) were the highest yielders. In general, results indicate yield performance of pakchoi is much better in open field than in a net house. As with non-heading Chinese cabbage, coefficient of variation was higher in the hot-wet season.

Choysum (*Brassica rapa* L. cvg. Caisin)

Average yields of choysum were higher in open field than in the net house, except in the hot-wet season (Table 56). Out of 12 accessions evaluated in the

Table 55. *Yields (t/ha) of pakchoi from from different field trials, AVRDC, 1999-2000*

Varietal Name	Hot -dry season			Cool-dry season		Hot -wet season	
	Sept. 1999	Nov. 1999	Sept. 1999	Feb. 2000		July 2000	
	Open	Open	Nethouse	Open	Nethouse	Open	Nethouse
Shanghai green	-	-	-	57.9 c[1]	48.7 e	22.6 abc	15.7 b
Ai-jeow yellow	-	-	-	60.5 bc	50.7 e	22.9 abc	22.6 ab
Zhuong-chi white	34.7 ab	38.0 a	34.6 a	37.1 d	61.4 a	29.3 a	28.1 a
Ching-fang (F_1)	37.3 ab	37.9 a	33.9 a	63.0 ab	53.3 d	27.0 abc	15.9 b
Gracious	-	-	-	-	-	27.4 ab	14.7 b
No. 341(F_1)	38.4 a	-	32.6 ab	-	-	26.5 abc	16.0 b
Wase kakyo (F_1)	-	-	-	60.1 bc	58.0 bc	-	-
Sia-Leu (F_1)	34.2 b	-	30.1 b	-	-	23.8 abc	12.9 b
Tall-stem ching-jiang tsai	35.2 ab	-	33.0 ab	-	-	-	-
Black behi (Condor)	36.6 ab	37.3 ab	31.7 ab	59.8 bc	56.2 bc	21.8 bc	19.5 ab
Pavo black behi type	-	-	-	-	-	24.7 abc	28.7 a
Super black behi	37.4 ab	-	32.5 ab	-	-	29.4 a	16.0 b
Kao no. 2 (F_1)	-	38.5 a	-	-	-	21.9 bc	22.3 ab
Black leaf bai-tsai	-	-	-	-	-	26.3 abc	19.1 ab
BP-14 Pai-chai (F_1)	-	37.9 a	-	58.9 c	49.7 e	20.1 c	19.9 ab
BP-20 Pai-chai (F_1)	-	36.2 b	-	65.4 a	58.4 b	26.9 abc	16.6 b
BP-21 Pai-chai (F_1)	36.6 ab	37.1 ab	31.7 ab	59.0 c	55.7 cd	22.0 bc	16.3 b
Mean	36.3	37.6	32.5	58	54.7	24.8	18.9
CV (%)	5.6	1.6	4.9	3.4	2.6	14.7	28.9

[1] Mean separation in a column at P<0.05 by Duncan's multiple range test.

Table 56. *Yields (t/ha) of choysum from different field trials, AVRDC, 1999–2000*

Varietal name	Hot-dry season			Cool-dry season		Hot-wet season	
	Sept 1999	Nov 1999	Sept 1999	Feb 2000		July 2000	
	Open	Open	Nethouse	Open	Nethouse	Open	Nethouse
981 Hybrid bai-tsai (F_1)	-	-	-	-	-	15.7 bc[1]	16.0 cd
Tsuei-fang choysum (F_1)	-	-	-	-	-	16.0 bc	16.8 b-d
45 days choysum	23.1 d	-	17.0 b	-	-	9.9 d	11.8 e
Hsiu-jean choysum (F_1)	34.8 b	33.9 c	30.2 a	50.0 c	30.9 cd	13.8 b-d	15.5 cd
Green choysum no. 213	41.6 a	36.5 ab	30.4 a	55.9 ab	34.4 b	19.4 ab	17.6 bc
100 days late choysum	34.9 b	36.3 ab	32.1 a	49.0 c	35.7 b	16.2 bc	15.1 c-e
No. 211 choysum F_1	37.0 b	-	31.4 a	-	-	21.3 a	21.9 a
613 hybrid choysum (F_1)	37.8 b	38.4 a	32.4 a	52.8 bc	33.2 bc	15.1 b-d	15.8 cd
049 choysum	36.7 b	35.6 bc	36.2	21.8 e	19.5 f	14.3 b-d	14.4 c-e
Green kwang futsai	35.9 b	-	27.2 a	-	-	15.8 bc	13.6 de
FT 80 days choysum	-	-	-	-	-	15.0 b-d	17.5 bc
60 days green-stem choysum	31.3 c	-	27.9 a	-	-	11.2 cd	11.6 e
Ao-nisai (F_1)	-	-	-	57.7 a	30.0 cd	11.0 cd	11.8 e
Tosakan 37	-	-	-	50.3 c	29.6 d	-	-
Bangluang 006 (F_1)	-	37.9 a	-	26.6 d	24.3 e	-	-
Early komatsuna	-	-	-	49.2 c	39.8 a	14. 4 b-d	19.9 ab
Late komatsuna	-	-	-	52.7 bc	35.5 b	-	-
Late-flower choysum	-	37.4 ab	-	-	-	-	-
Summer fest komatsuna (F_1)	-	38.0 a	-	52.7 bc	33.3 bc	11.8 cd	14.2 c-e
Mean	34.8	36.8	28.8	47.2	31.5	14.7	15.6
CV (%)	5.1	3.1	6.8	5.5	6.6	20.5	12.4

[1] Mean separation in a column at P<0.05 by Duncan's multiple range test.

open field during the hot-dry season, 11 produced yielded more than 30t/ha. Yields in the cool-dry season were relatively higher than in hot-dry and hot-wet seasons. Only two sccessions produced yields lower than 49 t/ha in the open field in the cool-dry season. Yields in the hot-wet season were only 30-50% of yields obtained during the hot-dry and cool-dry seasons. Green choysum no. 213 (F_1) seems to be the best accession.

Chinese kale (*Brassica oleracea* L. cvg. alboglabra)

Yield response of Chinese kale was similar to that of pakchoi. Generally, average yields were higher in the open field than inside the net house (Table 57). Net house yield reduction was greater in the hot-dry season than in the cool-dry and hot-wet seasons. The hot-wet season produced lower yields than did the hot-dry and cool-dry seasons. Planting Chinese kale inside the net house did not result in increased yiled during the hot-wet season. Yield varied widely during the hot-wet season.

Indian mustard (*Brassica juncea* Coss)

As with other crops, Indian mustard yield was lower in the net house (Table 58), especially in the hot-dry and hot-wet seasons. A large difference in mean yield was observed during the hot-wet season. Average yield in the net house was only 58% of the yield in the open field. There was also high variation in yield. Red-leaf Indian mustard yielded well across growing seasons and production systems.

Table 57. *Yields (t/ha) of Chinese kale from different field trials, AVRDC, 1999-2000*

Varietal Name	Hot-dry season			Cool-dry season		Hot-wet season	
	Sept. 1999	Nov. 1999	Sept. 1999	Feb. 2000		July 2000	
	Open	Open	Nethouse	Open	Nethouse	Open	Nethouse
Black kailaan	27.6 b[1]	-	19.3 bc	-	-	14.7 ab	11.3 b-e
Black leaf kailaan	-	-	-	-	-	16.1 ab	13.0 ab
White leaf kailaan	-	-	-	-	-	12.0 ab	10.2 b-e
Full white Chinese kale	-	-	-	-	-	13.6 ab	9.3 b-e
Green kailaan	18.6 e	30.6 b	11.6 e	26.0 d	23.6 de	11.7 b	9.5 b-e
Yellow kailaan	17.0 e	33.4 a	13.7 de	17.5 f	22.3 e	12.0 ab	6.9 de
Si-Luo black kailaan	-	-	-	-	-	13.7 ab	12.5 a-c
Savoy black kailaan	23.6 c	-	21.8 a	-	-	11.6 b	9.8 b-e
Kailaan (Chia-tai)	28.2 b	33.8 a	18.4 bc	29.2 c	26.0 cd	15.3 ab	10.3 b-e
Savoy-leaf black kailaan	-	-	-	-	-	14.0 ab	8.1 c-e
Kailaan L_1	-	30.2 b	-	32.0 bc	25.7 cd	-	-
Kailaan L_2 (Round-leaf)	-	34.8 a	-	35.9 a	30.4 b	-	-
Kailaan L_3 (Big-flower)	-	30.7 b	-	35.8 a	34.7 a	-	-
Round-leaf black kailaan	31.2 a	30.2 b	20.7 ab	38.3 a	29.7 b	12.9 ab	17.0 a
High-stem Round-leaf kailaan	-	-	-	-	-	16.2 ab	8.9 b-e
Kailaan (White-flower)	21.3 d	-	14.9 d	22.4 e	21.9 e	11.4 b	7.7 c-e
Black kailaan (F_1)	30.5 a	29.7 b	17.7 c	32.7 b	27.9 bc	16.6 a	6.3 e
Pointed-leaf large-stem kailaan	-	-	-	-	-	13.0 ab	10.6 b-e
Mean	24.8	31.7	17.3	30.0	26.9	13.7	10.1
CV (%)	5.2	2.7	7.6	5.6	5.8	18.1	24.1

[1] Mean separation in a column at P<0.05 by Duncan's multiple range test.

Table 58. *Yields (t/ha) of Indian mustard from different field trials, AVRDC, 1999-2000*

Varietal Name	Hot-dry season			Cool-dry season		Hot-wet season	
	Sept. 1999	Nov. 1999	Sept. 1999	Feb. 2000		July 2000	
	Open	Open	Nethouse	Open	Nethouse	Open	Nethouse
Da-Ping-Pu heading mustard	30.9 a[1]	38.1 a	24.7 c	39.8 ab	39.3 a	-	-
Sueh-li-hung No. 2	30.8 a	35.0 b	30.6 a	36.0 b	30.8 c	28.3 a	16.8 ab
Red-leaf mustard	31.8 a	38.1 a	30.1 a	45.5 a	37.0 ab	27.9 a	21.7 a
Si-Luo heading mustard	31.6 a	-	26.2 bc	-	-	30.1 a	17.0 ab
RN No. 1	32.2 a	37.3 a	27.9 ab	40.0 ab	36.9 ab	26.6 a	10.7 b
RN No. 2	31.9 a	35.2 b	25.9 bc	38.9 ab	30.1 c	17.2 ab	
Max 018 mustard	32.8 a	35.6 b	26.8 bc	-	-	-	-
Mustard N.P.	34.0 a	35.4 b	30.8 a	32.8 b	36.2 b	-	-
Monteverde mustaza	28.8 b	-	30.1 a	33.6 b	22.2 d	-	-
FT Red-leaf heading mustard	30.7 a	-	28.9 ab	-	-		
Taoyuan No. 1 heading mustard	-	-	-	-	-	29.2 a	18.0 ab
EX Red-leaf heading mustard	32.5 a	-	28.4 ab	-	-	25.6 a	14.4 ab
Feng-wei-chuen mustard	31.9 a	34.8 b	28.4 ab	40.2 ab	36.0 b	25.6 a	11.1 b
Red-leaf mustard	31.8 a	-	30.2 a	-	-	29.1 a	21.1 a
FN Red-leaf heading mustard	-	-	-	-	-	32.5 a	11.7 b
FN Feng-wei-chuen mustard	-	-	-	-	-	33.5 a	19.2 ab
Summer fiberless mustard	-	-	-	-	-	28.3 a	17.5 ab
Large heading mustard	-	-	-	-	-	26.0 a	16.1 ab
GN Red-leaf heading mustard	-	-	-	-	-	28.4 a	17.0 ab
Mean	31.7	36.2	28.4	38.4	33.6	28.3	16.4
CV (%)	3.9	2.8	6.0	11.4	5.1	19.8	28.1

[1] Mean separation in a column at P<0.05 by Duncan's multiple range test.

Chinese celery (*Apium graveolins* L.)

All Chinese celery accessions performed well during the hot season in the open field (Table 59).

Non-heading lettuce (*Lactuca sativa* L.)

Out of 39 accessions evaluated in the open field during the hot-wet season, 10 had yields ranging from 25-33 t/ha (Table 60).

Table 59. *Yield of 10 promising Chinese celery grown in open field. AVRDC, June-July, 2000*

Varietal name	Yield (t/ha)
Late Celery (White stem, White leaf)	31.1 a[1]
Si Luo Celery	31.3 a
Si-Luo White Stem, Green Leaf Celery	31.6 a
Celery (Yellow Leaf)	31.5 a
Chinese Celery	29.8 a
Celery	32.5 a
Yellow Leaf Celery (F1)	32.4 a
Tien-Wei Celery	31.7 a
Yi-Lan green Stem Celery	30.4 a
FN Tien-Wei Celery	28.8 a
Mean	31.1
CV (%)	12.4

[1] Mean separation within a column at P<0.05 by Duncan's multiple range test.

Table 60. *Yield of 10 promising non-heading lettuce grown in open field. AVRDC, June-July, 2000*

Varietal name	Yield (t/ha)
Erect-leaf lettuce	25.5 ab[1]
Yellow-leaf lettuce No. 3	29.6 ab
Point-leaf lettuce No. 1	25.3 b
Round-leaf improved lettuce	28.0 ab
High-Yield lettuce	28.2 ab
White-stem point-leaf lettuce	28.2 ab
VNM-449 lettuce	29.2 ab
Okayama salad lettuce	25.8 ab
Tau-yuan semi-heading lettuce	33.1 a
Batavian lettuce	25.7 ab
Mean	27.9
CV (%)	18.5

[1] Mean separation within a column at P<0.05 by Duncan's multiple range test.

There was wide variation in yield within accessions.

Kangkong (*Ipomea aquatica* Forsk)

Of the 25 accessions evaluated in the open field during the hot-wet season, 14 accessions produced yields of over 30 t/ha (Table 61). Bamboo green kangkong produced the highest yield and was the only accession that surpassed 40 t/ha. In general, the high yields of kangkong can be attributed to a favorable growing season. Kangkong is well adapted to hot-wet season.

Contact: LL Black

Table 61. *Yield of promising kangkong grown in open field, AVRDC, June–July, 2000*

Varietal name	Yield (t/ha)
EX Bamboo green	41.1 a[1]
Local Bamboo green	39.4 ab
Taoyuan No. 1	37.3 a-c
White-stem	35.6 a-c
GN Bamboo green	35.5 a-c
Bamboo-leaf sharp	35.3 a-c
Taoyuan No. 3	33.6 bc
Rau muong trang (white-stem)	33.6 bc
K-25 broad-leaf	32.7 bc
WC-002C	32.5 bc
NF Bamboo-leaf	32.0 c
Water convolvulus	31.9 c
Abroad Bamboo-green	31.9 c
Green-stem	31.9 c
Mean	27.9
CV (%)	18.5

[1] Mean separation within a column at $P<0.05$ by Duncan's multiple range test.

Project 5. Integrated insect and disease management (IPM) for environment-friendly production of safe vegetables

Study of insect pests of leafy vegetables under net houses

Vegetable production in protective net houses, if managed carefully, can reduce insect pest problems with little or no use of pesticide. This study was undertaken to assess insect problems of leafy vegetables under protective structures.

Temporary net house

A net house measuring 20 × 20× 2 m was constructed using a wood frame and 16-mesh nylon net. In the first experiment, common cabbage was grown inside and outside the structure and incidence of insect pests was monitored throughout the season. In the second experiment, half (20 × 10 m) of the net house top was covered with plastic sheets to prevent insect eggs or larvae from dropping into the net house. Insect pests were monitored in the area under the plastic cover, under the net only, and in the open field.

In both experiments, diamondback moth (DBM) (*Plutella xylostella*) was the major pest. However, its infestation inside the net house was barely noticeable until just before harvest (Table 62). In the open field, DBM number increased gradually to 45 larvae/plant.

Table 62. *Infestation of cabbage by DBM grown inside a net house and in a neighboring open field*

Dates/yield	No. of DBM larvae + pupae/plant	
	Net house	Open field
23 Nov. 1999	0	0.32
30 Nov. 1999	0	2.80
7 Dec. 1999	0.44	17.70
14 Dec. 1999	0.44	14.08
22 Dec. 1999	0.20	9.72
28 Dec. 1999	0.24	15.14
6 Jan. 2000	0.14	22.94
13 Jan. 2000	1.62	45.08
Head weight (kg)	1.93	1.45
Yield (t/ha)	56.53	34.45

Transplanting date: 9 Nov. 1999. Harvest date: 18 January 2000. Net house used 16-mesh net. Plot size: 20 x 20 m.

DBM reduced yield in the open field. In the second experiment, covering half the roof with plastic had no effect on DBM. DBM adults were found squeezing through the 16-mesh net walls and initiating infestation randomly inside the net house. This led us to use 32-mesh net for the permanent net house.

Permanent net house

A permanent net house was built with 6-cm-diameter galvanized iron tubing. It has a double door and 32-mesh nylon netting stretched on a 35 × 21 × 2 m frame. Four leafy vegetables, initially all crucifers, but later two crucifers and two non-crucifers, were grown in rotation. The rotation consisted of pak choi (*Brassica chinensis*), Ethiopian kale (*B. carinata*), amaranth (*Amaranthus mangostanus*), and kangkong (*Ipomoea aquatica*). Each crop was planted in three randomly selected 5 × 6 m plots in a randomized complete block design. To control beet armyworm (BAW) (*Spodoptera exigua*) and common armyworm (CAW) (*S. litura*), (Z, E)-9,12-tetradecadienyl acetate was dispensed throughout the net house by placing the chemical in 2-mm-diameter, open ended polyethylene tubes 1 m above the soil at the junctions of a 2-m grid. Once a week 30 plants of each crop were observed at random. Number of damaged plants, number of insects, and insect species were recorded.

In the first crop cycle, planted 29 February and harvested 4 April 2000, leaf miner (*Linomyza* spp.) was the major pest, damaging more than 80% of plants. CAW was found occasionally on Ethiopian mustard and Chinese kale. Only two striped flea beetle adults were found. All crops in the open field were destroyed by cabbageworm (*Pieris rapae*). On the second crop, planted 11 April, CAW was the major pest, feeding on 38–74% of plants. BAW infestation occurred towards the end of the season. In response to this heavy infestation, the net house was flooded to a depth of 15–20 cm for two weeks after harvest of the second crop to kill pupae in the soil. After the flooding, pak-choi (*B. rapa*), Ethiopian mustard, amaranth, and kangkong were grown.

In the third crop, frequent and heavy rains made it difficult to carry out weeding and fertilization on time. Harvest was also delayed. Only kangkong survived the flooding, and gave a yield of 34 t/ha. The fourth crop was planted on 21 September and harvested on 24 October. Starting with this crop, special precautions were taken to reduce armyworm infestation. This included daily inspection of the net house, followed by prompt repair of holes; daily checks and rouging of damaged plants found with insect larvae; and ensuring 1–1.5 m empty space between the net and planting area. CAW was the major insect, but it attacked only Ethiopian kale and pak choi. Two non-crucifers were free of any pest damage.

In the fifth crop, smaller replicated plots were abandoned. Instead four crops were planted in four non-replicated 9 × 15 m plots. Insect damage was monitored daily and net holes were repaired promptly. Insect damage was reduced drastically compared to the damage normally observed over several years (Table 63), but the continued infestation by CAW was puzzling. Damage was scattered, with only individual larvae found on most damaged plants. Neither CAW nor BAW egg masses were found inside the net house, but CAW egg masses were found on the outer net walls. Likely some eggs from these egg masses initiated infestation. Because such infestation is very sporadic, physical removal of larvae and damaged plants is feasible and economical.

Table 63. *Insect pest infestation of leafy green vegetable species inside a permanent net house, crop cycle 5*[1]

Dates	Insect pest	Pak-choi	Ethiopian kale	Amaranth	Kangkong
		Larvae/100 plants			
16 Nov 2000	CAW[2]	0	6	1	0
24 Nov 2000	CAW	0	0	1	1
30 Nov 2000	CAW	0	17	1	0
	BAW	1	1	1	1
	TFW	0	1	0	0
		Harvest data			
4 December					
Total plant no./plot		1196	1274	1305	1393
Yield (t/ha)		24.1	14.4	3.9	5.8

[1] Plot size: 9 × 15 m. Sowing date: 25 Oct 2000.
[2] CAW = common armyworm, *Spodoptera litura*; BAW = beet armyworm, *S. exigua*; TFW = tomato fruitworm, *Helicoverpa armigera*.

Mass-rearing of striped flea beetle and differentiation of male and female adults

Striped flea beetle (SFB), *Phyllotreta striolata*, is a major crucifer-specific pest. Adult beetles feed on tender leaves, causing numerous shot holes. Eggs are laid on the soil near the host plant, and larvae feed and pupate on plant debris in the soil. Larval feeding on roots can weaken plants. Serious infestation in the seedling stage results in plant death. The insect is especially serious in net houses.

To facilitate studies on SFB, AVRDC developed a simple procedure for mass rearing the pest. Characters to distinguish male and female adults were also sought.

Rearing procedure

Stock culture – SFB adults were collected in AVRDC fields. Adults were maintained on potted *B. chinensis* plants in 32-mesh nylon net cages.

Collection of eggs – Two *B. chinensis* plants were uprooted and their roots washed throughly. The roots were then wrapped in moist cotton, which in turn was wrapped in 8 × 15 cm tissue paper. The plants were placed in a 15-cm-diameter, 30-cm-long acrylic cylinder, one end of which was tightly closed with 64 mesh nylon net. The root was maintained moist by dipping one end of the tissue paper in water. Cotton soaked in 5% honey solution and placed in a petri dish inside the cylinder supplied food for SFB adults. Adults laid many eggs on the cotton/tissue paper. These eggs were washed off with running water and collected in a 64-mesh sieve.

Rearing of larvae – Eggs were transferred on various food media for freshly hatched larvae. These media included fresh roots of *B. chinensis*, radish, and artificial diet of DBM. However, the larvae did not feed on any of these, and were reared instead on potted *B. chinensis* plants. A clay pot with 5–10 plants was placed in a tray of water. The SFB eggs were carefully transferred to the base of each plant. The least destructive method of transfer was by floating the eggs in water, sucking them up in a dropper, and placing them in drops at the base of the plant. The water in the bottom tray kept the soil moist, so there was no need to water over the developing larvae.

Collection of adults – Two methods were followed. In the first method, 3–4 weeks after placing the eggs on the soil, the *B. chinensis* plants were excised at the root–shoot junction and SFB pupae were collected by hand-sifting through the soil. The pupae were placed on moist tissue paper in an enclosed petri dish. The high humidity facilitated pupal survival and most pupae emerged into normal adults.

In the second method, adults were collected directly from the plants. Three weeks after placing the eggs on the soil, the plants were confined in 32-mesh nylon net wrapped tightly around the pot. Adults emerged from the soil and then fed on leaves. The net was opened every 2–3 days to collect adults.

Starting with 200 adults collected from the field, some 500–1200 eggs could be collected every 2–3 days. About 70% of eggs hatched into larvae (because the larvae develop in soil, we were not able to record the number of larval instars), and 8% to 30% of the eggs became pupae. When pupae were dug from the soil and maintained in the laboratory, the adult emergence was low. Collecting the adults as they emerged from the soil was found to be a more productive method.

Since most of our research involved SFB adults, it was essential to keep adults alive for as long as possible. We tested various foods for their effect on longevity. SFB adults survived more than 6 weeks on host plant *B. chinensis* and honey (Table 64).

Table 64. *Longevity of SFB adults provided with various food sources*[1]

Food source	Longevity (days)
No food	1.67 ± 0.12
Water only	4.13 ± 0.66
Honey	37.04 ± 7.68
Host plant (*B. chinensis*)	30.19 ± 3.98
Host plant + honey	44.09 ± 4.54

[1]Data are means of three replicates. Incubator temperature: 25 - 31°C.
Egg hatching at 25 - 28°C was 70.63 ± 9.60.
All adults were maintained inside 50 x 50 cm, 32- fine mesh net cages.

Morphological differences between male and female

A large number of adults were examined for external morphological characteristics, such as shape of the body, posterior, abdomen, and antennae. Although females were bigger than males, it was not possible to ascertain sex by this criterion. The antennae of male and female adults were, however, found to be distinctly different. Both male and female have filiform antennae with 11 segments. The fifth segment in males is thicker than the rest, whereas in females all segments are uniform (Figure 12). The swollen segment of the male antennae was 50% larger than the other segments. We assume this thickened segment has pheromone receptors, but further investigation is needed.

Contact: NS Talekar

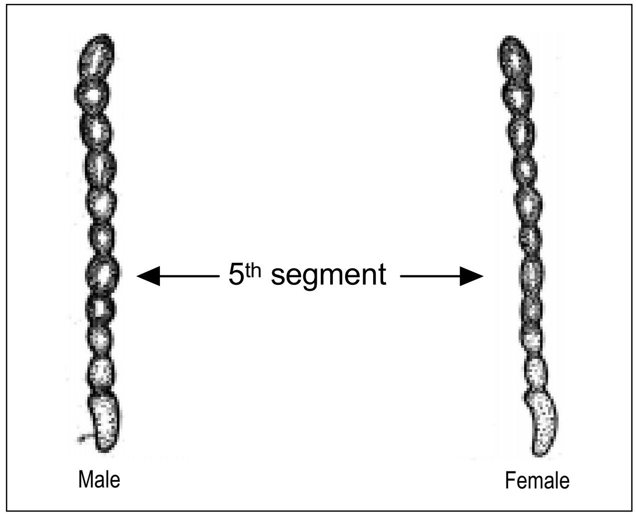

Figure 12. *Antennae of male and female adults of striped flea beetle. Note swollen 5th segment of male antenna.*

Studies on host-plant interaction and cultural control of onion thrips

Onion thrips, *Thrips tabaci*, is an endemic pest of onions in most of the tropics and subtropics. The adults and larvae of this polyphagous insect feed on onion foliage by scraping the leaf surface and feeding on the plant sap. In onions grown for their leaves, the damage cause by thrips reduce market value. AVRDC has undertaken an in-depth study of the interaction between the insect and the plant, with the intention of developing economical ways to control the pest. Experiments were conducted in autumn–winter 1999–2000 to investigate: 1) the plant growth stage most vulnerable to thrips attack; 2) the effect of onion thrips damage on yield and yield components; and 3) timing of insecticide application to achieve optimum control of the pest with minimum use of insecticide.

Influence of plant age on onion thrips infestation

Onions were transplanted weekly from 1 November 1999 to 16 January 2000, and monitored weekly for thrips damage. A parcel of land was rotor-tilled and divided into 3 × 3.3 m plots spaced 3 m apart, with four 0.75-m-wide raised beds per plot. Six-week-old onion (CAL606) seedlings were transplanted in four randomly selected plots. Seedlings were transplanted in a single row (10 cm between plants) on the top of each bed in each plot. The crop was managed with hand weeding, irrigation, and fertilizer application. Starting two weeks after transplanting, we inspected four, 1-m rows of onion in each plot. Foliage damage was recorded on a scale of 0 to 5, where 0 = no damage, 1 = 20% leaf area affected, 2 = 40% leaf area affected, 3 = 60% leaf area affected, 4 = 80% leaf area affected, and 5 = entire leaf area affected.

There was a steep increase in insect damage between 11 and 13 weeks after transplanting, and this damage remained high until harvest (Figure 13a). This period coincided with beginning of bulb enlargement. There was also a sudden increase in the pest population at that time. In order to determine whether the increased damage was due to plant age we analyzed insect damage observation on fixed dates towards the end of the season, when plants of various ages were standing in the field and subject to the same conditions. Again we found that thrips damage was proportionately higher in older plants (11 and 13 weeks after transplanting) and the damage remained high until harvest (Figure 13b).

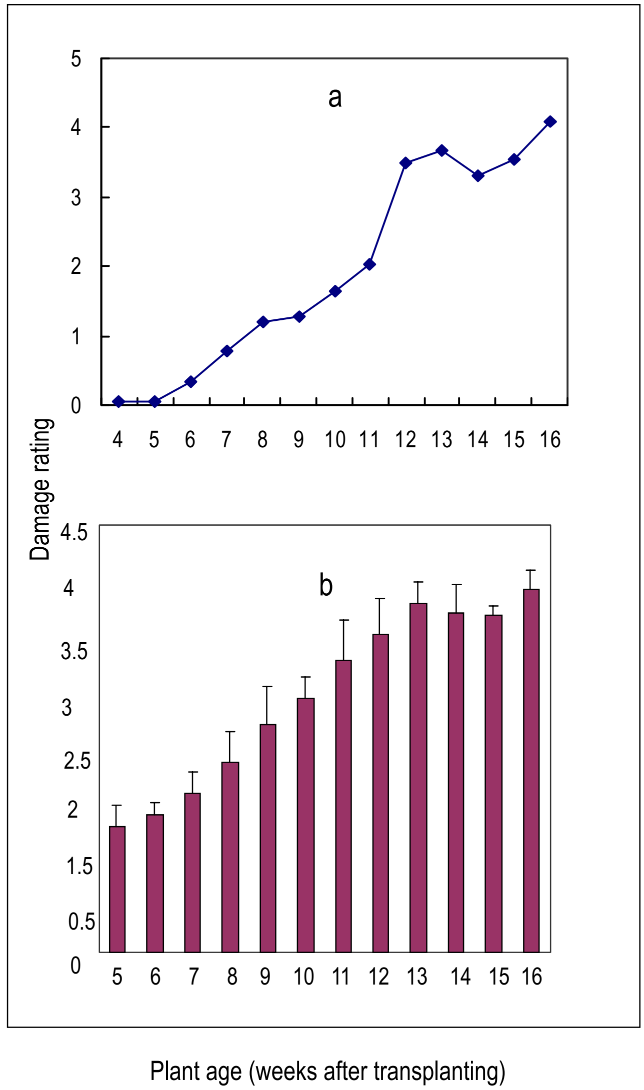

Figure 13. *Effect of plant age on onion thrips damage. Top (a), observations recorded once a week from 24 December 1999 to 17 March 2000 on crop transplanted on 22 November 1999. Bottom (b), observations recorded on 25 February 2000 on plants transplanted once a week from 1 November 1999 to 17 December 2000.*

Dry matter partitioning in bulb and shoot and its effect on onion thrips infestation

Eight 15 × 10 m plots were prepared, arranged in four blocks (replicates), each with two plots. Five-week-old onion (CAL606) seedlings were transplanted in 0.75-m-wide beds in each plot on 2 November 1999. Starting soon after planting, one plot in each block was sprayed weekly with either profenofoes or carbosulfan, in rotation. The other plot in each block was maintained as a check. Once a week, 30 randomly selected plants in each plot were rated for pest damage. After each observation, 10 plants were uprooted at random. The fibrous roots were discarded and the plant was cut in the bulb. Bulbs were weighed and plant parts were dried at 100°C for 24 hours (bigger bulbs were sliced into 0.5-1.0 cm slices before drying) and bulbs were weighed separately. At harvest, the remaining bulbs were dug up and weighed. Insecticide sprays reduced pest damage practically throughout the season, but especially starting 11 weeks after transplanting (Figure 14). Dry matter accumulation in the bulb took off from 13 weeks after transplanting and increased after harvest (Figure 15). This dry matter accumulation coincided with increased thrips damage to foliage starting two weeks earlier. In healthy plants (plants treated with insecticides) the dry matter accumulation in bulbs increased exponentially, but in thrips-damaged plants there was leveling off of dry matter accumulation in the two weeks before final

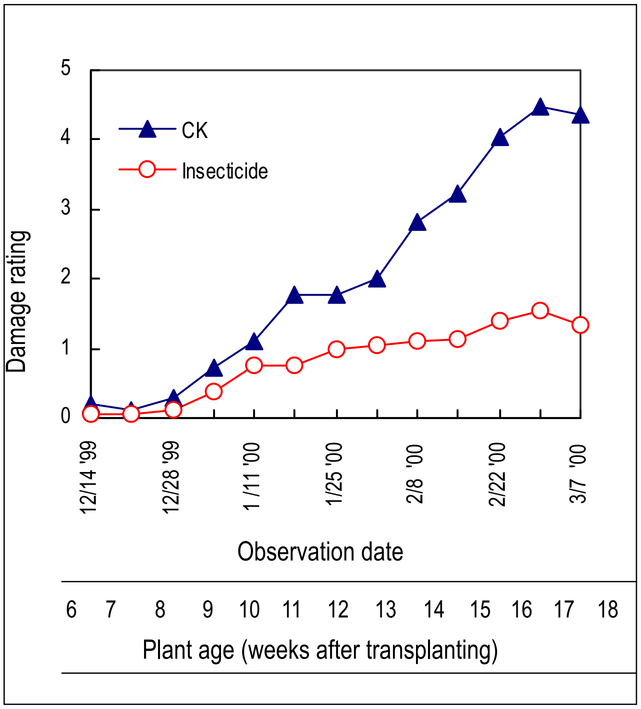

Figure 14. *Onion thrips damage to onion foliage in insecticide-treated and check plants. Each point is mean of four replicates.*

harvest. Dry matter accumulation in foliage of thrips-damaged and healthy plants leveled off around 11 weeks after transplanting. Although thrip-damaged plants and healthy plants accumulated about the same amount of foliage dry matter, dry matter accumulation in the bulbs of healthy plants increased exponentially, while accumulation in the bulbs of thrips-damaged plants was much less (Figure 15). This difference is likely the result of thrips-damaged leaves causing a reduction in photosynthate for bulbing. It could also be due to less total dry matter for bulbs. The bulb yield in healthy plots (37.64 t/ha) was significantly higher (t = 3.18*) than in thrips-damaged plots (31.67 t/ha), amounting to yield loss of 16%.

Effect of timing of insecticide application on infestation of onion thrips infestation

Twenty 3 × 3.3 m plots were prepared, arranged in four blocks (replicates), each with five plots. Six-week-old onion (CAL606) seedlings were transplanted in each plot on 1 November 1999. Starting 4, 6, 8, or 10 weeks after transplanting, and once a week thereafter, four randomly selected plots (one plot in each block) were sprayed with either profenofos or carbosulfan, in rotation, to control onion thrips. The remaining four plots were

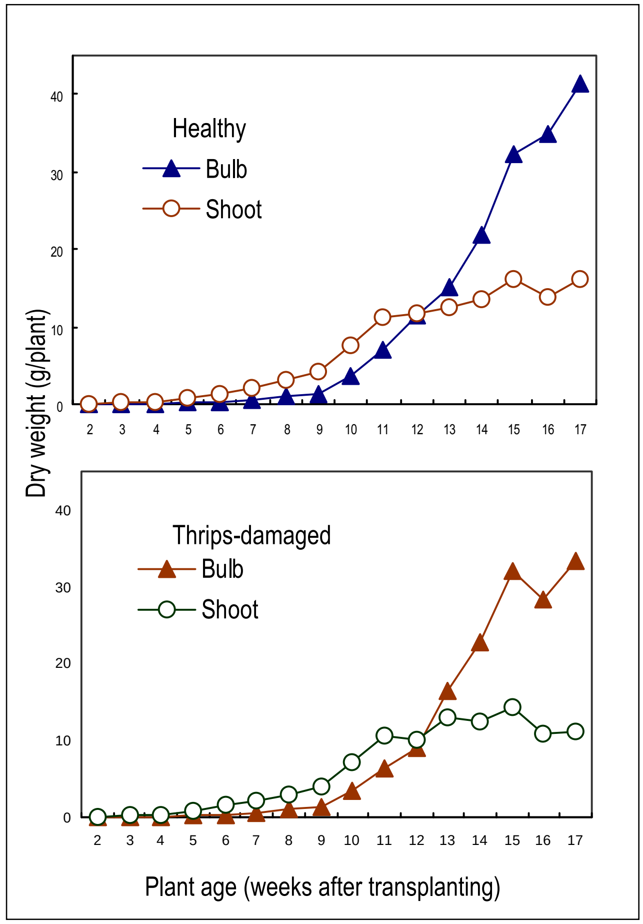

Figure 15. *Accumulation of dry matter in onion shoot and bulb throughout the season in healthy (above) and thrips-damaged (below) plants.*

maintained as untreated check plots. Starting 10 weeks after transplanting, onion thrips infestation was rated (scale described in previously) weekly on two 1-m-long sections of the central two rows of crop in each plot. The bulb yield was measured at harvest.

Pest damage was significantly lower in plots sprayed 4, 6, or 8 weeks after transplanting, compared to the check and the plot sprayed 10 weeks after transplanting (Table 65). There was no significant difference in the damage amongst the plots sprayed 4, 6, or 8 weeks after transplanting. The plants that began receiving insecticide spray 10 weeks after transplanting were about as damaged as the plants in the check plots. The period 10 weeks and onwards coincides with bulb enlargement, when, the plant becomes highly susceptible to onion thrips. Bulb yield in all sprayed plots was higher than in check plots. In practical terms, these findings suggest that spraying can be postponed until well into the eighth week after transplanting.

Contact: NS Talekar

Table 65. *Onion thrips damage to onion plants where insecticide swas sprayed at various intervals after transplanting*

Observation date	Damage rating in plots where spraying was initiated at weeks after transplanting[1]				Check plot	LSD 0.05
	4	6	8	10		
10 Jan	0.55	0.65	0.68	1.10	0.95	0.47
17 Jan	0.73	0.98	0.93	2.10	2.10	0.56
24 Jan	1.08	1.38	1.48	2.53	2.28	0.89
31 Jan	1.05	1.20	1.38	2.10	2.10	0.61
8 Feb	1.18	1.43	1.43	2.68	2.95	0.65
14 Feb	1.28	1.58	1.63	2.80	3.05	0.75
21 Feb	1.60	1.80	1.90	3.13	3.80	0.88
29 Feb	1.65	1.85	2.03	3.53	4.20	0.70

[1] Transplanting date: 1 Nov 1999.

Effect of flooding on survival of *Ralstonia solanacearum*

Bacterial wilt (BW) caused by soil-borne *Ralstonia solanacerum*, is the most important disease affecting tomato production in the lowland tropics. Resistant cultivars are often location-specific. Thus, it is important to use BW-controlling cultural practices in combination with resistant cultivars. Rotation with paddy rice is being used as a means to reduce initial inoculum density in the soil. This study was conducted to determine the effect of different flooding periods with or without rice plants on the survival of *R. solanacearum* and on tomato yield. The experiment was conducted in a screen house from April to December, and followed a randomized complete block design (RCBD) with three replications. The treatments consisted of two factors: flooding period (35, 70, and 105 days) and, the other, with and without rice plants. Plastic boxes 50 × 30 × 30 cm (LWH) were used as experimental plots. Thirty-five kilograms of infected soil was placed in each box. Infected soil was prepared by mixing 100 ml of bacterial suspension (108 cell/ml) of Pss4 strain (race 1, biovar 3) per kilogram of air-dried field soil (sandy loam, pH = 6.3). For flooding treatments, water level was maintained at 5–10 cm above the soil line during the entire period. Eight bundles of rice (Peng-lai 14) seedlings were transplanted and kept during the entire period. Water level in treatments with rice was kept similar to the no-rice flooding treatments. After treatment, rice plants were removed and the water was drained. The soil was dried for 7 days before tomato (Tainan ASVEG No.6, BW-susceptible cherry type) seedlings were transplanted on 9 August. Each plot was comprised of two boxes with four plants per box (30-cm spacing). Tomato transplanted to newly infected soil was used for treatment comparison. Soil samples were collected from 10 cm below the soil surface every 1–2 weeks, and the population of *R. solanacearum* in the soil was measured by plating soil suspension on selective media (modified SM-1). Incidence of BW on tomato was rated after transplanting. Tomato plants received N-P_2O_5-K_2O, 120-240-240 kg/ha as basal application and N-P_2O_5-K_2O, 45-45-45 kg/ha sidedressed. Yield per plant, fruit number per plant, and fruit size were measured.

Density of *R. solanacearum* right after mixing infected soil 10^6 to 10^7 cfu per gram of dry soil. Flooding drastically reduced the density and no pathogen could be detected 32 days (average) after flooding (Figure 16). The treatments produced a similar declining pattern of pathogen population. Pathogen was detected after transplanting tomato in treatments of 35-day flooding with rice and 70-day flooding without rice, and 17% and 18% of plants became wilted, respectively (Figure 17). The 105-day flooding treatment with rice resulted in 6% wilted plants, although pathogen was not detected. Flooding period (F), rice (R), and F × R had no significant effect on disease severity, which means that they do not differ in their ability to control BW.

Apparently, flooding for 35–105 days can kill most of the pathogen, but not completely eradicate it. (The detection limit of modified SM-1 is around 10^2 cfu/g dry soil.) The pathogen that survived multiplied exponentially after the tomato was planted, which resulted in random wilted plants. The mean yield of each treatment ranged from 368 g to 456 g per plant. The effects of flooding period with or without rice on tomato yield, fruit size, and fruit number were not

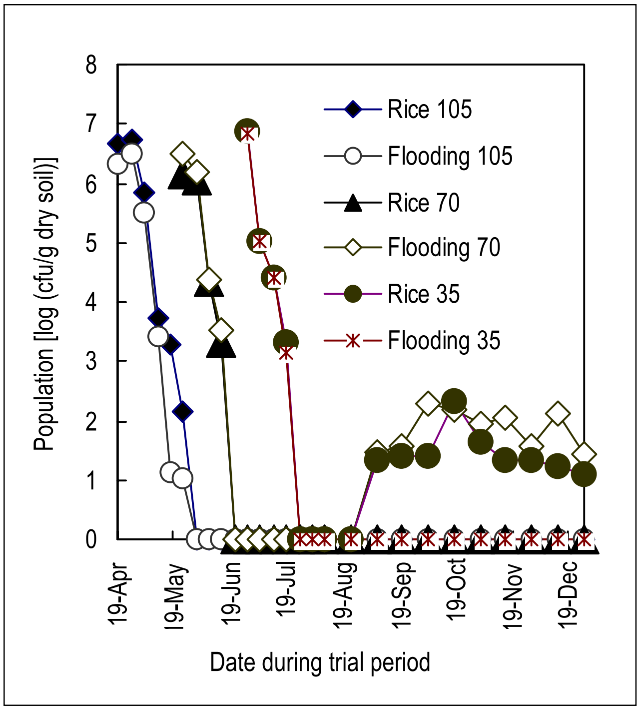

Figure 16. *Changes of* R. solanacearum *population in the soil when flooded 35, 70, or 105 days with or without rice, and with tomato cultivar Tainan ASVEG No. 6 transplanted afterward, on 9 August.*

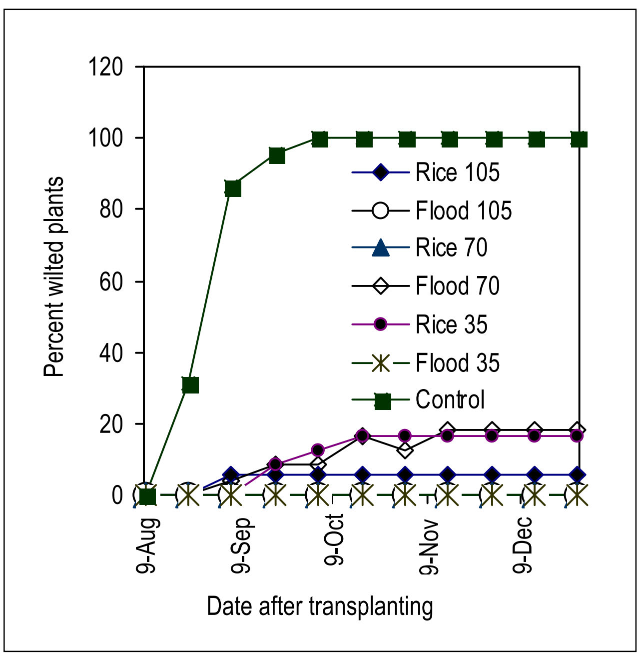

Figure 17. *Progress of bacterial wilt on tomato cultivar Tainan ASVEG No.6 after treatments of 35, 70, or 105 days of flooding, with or without rice.*

significant. However, tomato yield per plant, fruit size, and fruit number per plant after rice were significantly lower than those with no-rice (with the same flooding period): 382.4 g and 440.1 g; 3.9 g and 4.1 g; and 99.2 and 107.1, respectively.

Contact: JF Wang

Identification and management of viral diseases of vegetables

Effect of virus infection on the yield of leafy brassicas

This experiment investigated the effect of turnip mosaic virus (TuMV), radish mosaic virus (RaMV), and cucumber mosaic virus (CMV) infection on the yield of six leafy *Brassica* species common in peri-urban production systems.

The experimental layout was split block with three replications, with species (Chinese cabbage, pak-choi, choy sum, Chinese kale, mustard, or radish) as the main plots and viruses as subplots. The species were mechanically inoculated 18 and 25 days after sowing (DAS). Treatments consisted of eight plants. Yield (fresh leaf weight) was measured at 56 DAS. Uninoculated plants served as checks.

Yield reduction was highest in TuMV infected plants and lowest in CMV infected plants (Figure 18). Yield reduction was higher in the plants infected earlier (18 DAS).

Testing for resistance

In a search for resistance, 24 plants of 105 commercially available and F_1 open pollinated cultivars (22 Chinese cabbage, 23 pak-choi, 22 choy sum, 21 Chinese kale, 11 mustard, and 4 radish) were mechanically inoculated with TuMV, RaMV, and CMV.

The plants were inoculated at the 3–4 leaf stage and ELISA tested 20 days later. None of the cultivars was resistant to TuMV and only 6 Chinese cabbage cultivars were resistant to RaMV. CMV resistance was more common. All but one of the Chinese kale cultivars, 45% of the Chinese cabbage cultivars, and one of the pak choi cultivars were found to carry CMV resistance.

TuMV and RaMV infection resulted in severe symptoms, such as mosaic, systemic chlorotic or necrotic rings and ring spots, which would reduce yield and marketability.

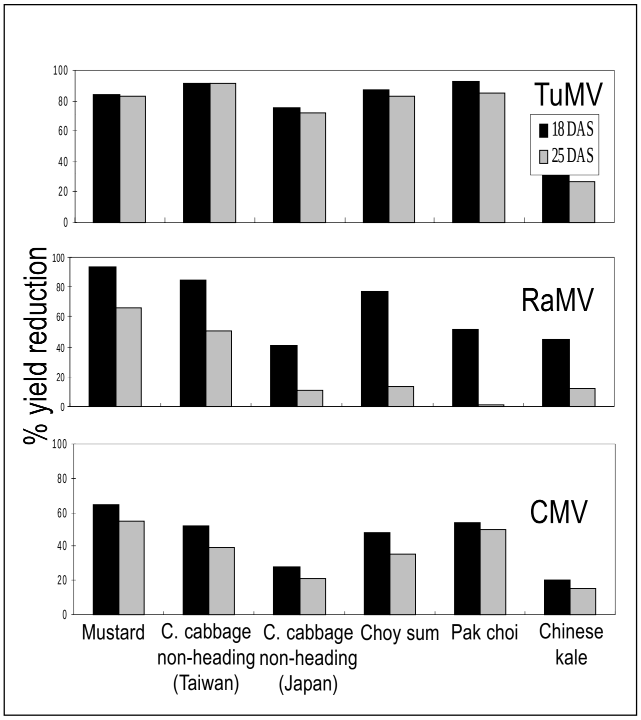

Figure 18. *Yield reduction with respect to non-inoculated checks of* Brassica *sp. (at two inoculation dates) due to infection with three viruses. TuMV = Turnip Mosaic Virus, RaMV = Radish Mosaic Virus, CMV = Cucumber Mosaic Virus.*

Heat tolerant, TuMV resistant Chinese cabbage

Heat tolerant, TuMV resistant Chinese cabbage populations (BC2, F4, BC2, F3) have been developed by AVRDC using BP58 and BP79 as resistance sources. The resistance levels were determined by ELISA following mechanical inoculation with TuMV strains C1 and C5 at the four-leaf stage. Results indicate that the resistance is improving (Table 66), and will need 1–2 more generations to be fixed.

Table 66. *Turnip mosaic virus resistance in AVRDC heat tolerant Chinese cabbage breeding populations*

Cross	Generation	Total no. inoculated	% TuMV resistance
BP58/B18	$BC_3\ F_2$ (97)	668	15
	$BC_2\ F_3$ (99)	840	75
	$BC_2\ F_4$ (00)	524	91
BP79/E9	$BC_1\ F_2$ (97)	268	35
	$BC_2\ F_2$ (99)	11	45
	$BC_2\ F_3$ (00)	30	56

Virus surveys

The objective of this ongoing work is to determine the presence, distribution, and importance of known or new viruses affecting AVRDC's target crops. The information is important in setting research priorities and in developing disease control strategies.

Samples of tomato, pepper, and weeds were collected from six countries and tested by enzyme-linked immunosorbent assay (ELISA). Garlic samples from major garlic production areas in Taiwan and Korea were tested. See Project 2 for results.

Contact: SK Green

Project 6. Economic and human nutritional impacts from enhanced peri-urban vegetable production

The objective of Project 6 is to develop information to enhance the understanding of researchers and policymakers about the socioeconomic and nutritional impacts of vegetables. Methodologies are developed to assess the potential contribution of vegetables in the nutritional and socioeconomic development of producers and consumers, and to conduct ex-ante and ex-post impact evaluation of vegetables and AVRDC technologies.

Nutrient content of the Center's principal crops is being analyzed to develop a comparative database, and food preparation methodologies are being developed that will enhance micronutrient availability.

Agroeconomic aspects of mungbean cultivation in Bangladesh

While Bangladesh's population continues to rise, pulse production in Bangladesh remains stagnant at about 500,000 t annually, of which mungbean accounts for about 6.5%. This has contributed to reduced per capita availability and higher prices (Table 67) (Figure 19).

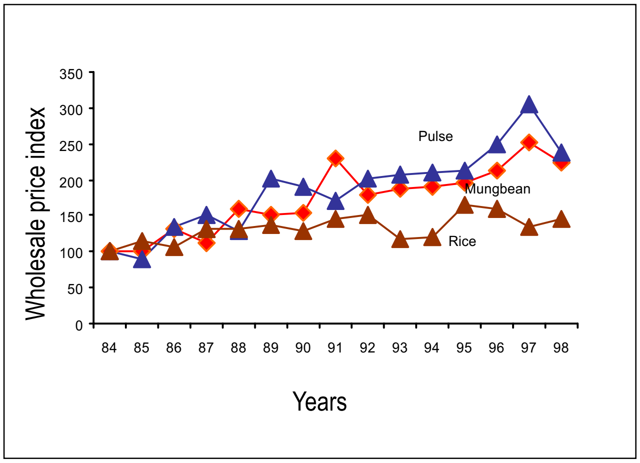

Figure 19. *Mungbean, pulses, and rice prices in Bangladesh, 1984-98.*

Table 67. *Area, production, yield, and availability of mungbean and all pulses in Bangladesh, 1984-98*

Year	Mungbean				All pulses				Mungbean share of total pulse (%)
	Area (000 ha)	Production (000 t)	Yield (kg/ha)	Availability (kg/capita)	Area (000 ha)	Production (000 t)	Yield (kg/ha)	Availability (kg/capita)	
1984	59.9	34.0	568	0.34	801	521	651	5.3	6.5
1985	60.3	35.0	580	0.35	784	558	711	5.5	6.3
1986	59.5	33.0	555	0.32	744	519	698	5.0	6.4
1987	57.4	34.6	602	0.32	716	510	712	4.8	6.8
1988	57.9	33.1	572	0.30	737	539	731	4.9	6.1
1989	58.9	29.4	500	0.27	735	496	674	4.5	5.9
1990	60.1	31.3	521	0.29	738	512	694	4.7	6.1
1991	57.9	31.6	545	0.29	728	523	718	4.7	6.0
1992	55.6	32.3	582	0.29	722	519	719	4.6	6.2
1993	53.2	31.1	586	0.27	713	517	725	4.5	6.0
1994	53.8	30.3	564	0.26	709	530	748	4.5	5.7
1995	54.0	31.7	588	0.27	710	534	751	4.5	5.9
1996	54.9	32.1	585	0.27	697	524	752	4.4	6.1
1997	55.2	33.8	612	0.28	687	523	762	4.3	6.5
1998	55.0	34.4	626	0.28	683	518	758	4.1	6.6
Growth (%)	-0.81*	-0.26^{ns}	0.55^{ns}	-0.66*	-0.88*	-0.05^{ns}	0.82*	-1.58*	-0.23^{ns}

* = significant at 0.05 level of probability; ns = not significant.

This study was undertaken to evaluate the status of mungbean production and consumption in Bangladesh. Data were collected from secondary sources and through a survey of 100 mungbean growers in three districts (Barisal, Noakhali, and Jessore). Bangabandhu Sheikh Mujibur Rahman Agricultural University and Bangladesh Agricultural Research Institute conducted the survey.

The survey found that average family size ranged from 5.36 to 7.47, number of years of schooling (adults) ranged from 4 to 6 years, farm size ranged from 1.10 to 2.76 ha, and the size of mungbean plot ranged from 0.16 to 0.59 ha. On average, two adult laborers were available on each farm. Only 11% of land in Barisal and 22% in Noakhali was irrigated, compared to 68% in Jessore. In Barisal and Jessore, mungbean was grown mainly on loam and sandy loam soils, while in Noakhali, mainly on heavy clay loam soils. The farm implements and the types and number of farm livestock owned by the respondents indicated that mungbean farmers are resource poor, especially in Noakhali and Barisal. In Jessore, Barisal, and Noakhali, 9%, 19%, and 12% of the total cropped area was allocated to mungbean, and mungbean accounted for 53 %, 61%, and 50% of the total pulses area, respectively.

In Jessore, a relatively high yielding variety, BARIMUNG-2 (Kanti), is widely cultivated in March–May under irrigation after the harvest of *rabi* (winter) crops, and in September–November, also under irrigation after the harvest of transplanted rainy season or t-aus rice. In Barisal and Noakhali, on the other hand, farmers were found to grow rain-fed mungbean in late *rabi* season (January–April). In Jessore, mustard/lentil/potato/wheat–mungbean–t-aus was the dominant crop rotation. In Barisal, the most common rotation was transplanted (t-) aman–local mungbean–t-aus/fallow. In Noakhali, t-aman–local mungbean–broadcast aus/t-aus, and t-aman–local mungbean–fallow were the major crop rotations.

Nine modern varieties are available to farmers in Bangladesh: BARIMUNG-1, 2, 3, 4, and 5 and BINAMOOG-1, 2, 3, and 4. Most were released in the early and late 1990s, and have yet to be popularized. Farmer field trials were begun recently. Only Kanti, released in 1987, was found adopted by farmers in Jessore. In other parts of Bangladesh, farmers grow local, unspecified varieties.

Bullock plowing and laddering (harrowing) is the main method of land preparation. On average, farmers plowed 3–4 times. Broadcasting was the only method of sowing in all areas. The crops were handpicked, Kanti three times and the local varieties one time. Hand beating and bullock treading were the common method of threshing. Table 68 shows inputs per hectare of mungbean, by variety, season, and district.

Table 68. *Physical inputs per hectare of mungbean by variety, season, and district*

Inputs	Jessore			Barisal	Noakhali
	Kharif 1[1] Kanti	Kharif 2 Kantil	Rabi LV	Rabi LV	Rabi LV
Plowing (no.)	3.9	3.2	4.1	2.8	2.8
Seed (kg)	16.9	18.3	22.9	28.1	16.8
Fertilizer (kg)	119.9	102.3	54.4	26.4	5.4
Weeding (no.)	2.0	1.6	0.0	0.3	0.3
Irrigation (no.)	1.6	2.0	0.0	0.0	0.0
Labor (days)	128.3	94.9	54.1	41.7	37.6
Land preparation	30.9	19.9	28.3	21.4	18.3
Weeding	42.7	28.3	0.0	1.1	0.6
Harvesting	51.4	43.4	24.3	17.8	17.8

Kharif 1[1] = March–May; *kharif* 2 = September–November; Rabi = winter; LV = local variety.

The total cost of Kanti production in Jessore was higher than the cost of local variety production in Barisal and Noakhali. The cost of producing local varieties was comparable across locations (Table 69). Irrespective of variety, harvesting accounted for about 23% of the total cost of production.

Net return (money the farmers keeps after covering costs) from Kanti was higher than from local varieties. Benefit-cost ratio, return per BDT (currency: Bangladesh taka) of investment, was greater than one, except in Noakhali. Which means that mungbean cultivation is an economically viable option, even using local varieties, in Jessore and Barisal.

Mungbean yellow mosaic virus and podborer were the two most common problems in all seasons in all locations. Early drought was reported to be a problem for mungbean grown in March–May. Waterlogging, due to excessive rainfall, and shortage of good quality seed were constraints in all growing seasons and locations.

Annual per capita mungbean consumption by its producers ranged from 4.5 kg in Jessore to 7.5 kg in

Table 69. *Economics of mungbean cultivation in Bangladesh*

District	Season	Variety	Yield (kg/ha)	Total cost[1] (BDT[2])	Gross return (BDT)	Net return (BDT)	B-C ratio (BDT)
Jessore							
	Kharif 1	Kanti	1182	9707	24822	15115	1.6
	Kharif 2	Kanti	1044	7978	22455	14477	1.8
		LV	530	4579	12748	8170	1.8
Barisal	Rabi	LV	397	4610	10703	6093	1.3
Noakhali		LV	200	3872	4400	528	0.1

[1] This includes all input costs, evaluated at market prices, except land rent. If an input was produced at home, it was evaluated at the average market price in the district.

[2] BDT = Bangladesh taka = US$0.02; LV = local variety; B-C = benefit cost; *Kharif* 1 = March–May; *kharif* 2 = September–November; Rabi = winter; LV = local variety.

Barisal, significantly higher than the average consumption in the country (< 0.5 kg). This implies that an increase in the number of mungbean growers will lead to an increase in mungbean consumption.

Most farmers preferred large and shiny green mungbean grain, but local varieties lack in these attributes. All farmers preferred sweet mungbean. They consume mungbean prepared as *dhal* (soup), cooked with meat or fish, as *khesari* (dehulled, split and fried/roasted), and baked in cakes. Split mungbean deep-fried in oil is sold in bakeries as a snack, for which large seed size is preferred.

Contact: M Ali

Economic and nutritional impact of AVRDC–USAID/Bangladesh project

The AVRDC/USAID Bangladesh project, 1991–2000, developed and introduced improved plant materials and technologies to enhance year-round vegetable production to help overcome micronutrient deficiency in the country.

To assess the project's impact, farmers were surveyed simultaneously in Savar, Jessore, Rangpur, and Noakhali districts in 1999. The 673 respondents were categorized as adopters (those who adopted AVRDC promoted technologies in some of the vegetable crops), non-adopters (those who did not adopt AVRDC technologies in any of the vegetable crops), and non-vegetable farmers (who did not grow vegetables on commercial scale).

The production survey covered farmer characterization, crops grown in 1999 inputs, outputs, and prices of major vegetable and non-vegetable crops; and information on adoption of new vegetable technologies. Adopters were also asked about the crops they grew previously. Input-output data were collected by crop, and a total of 1504 crop parcels were recorded.

The consumption survey covered quantities, prices, and sources of all food commodities consumed during 24 hours prior to the survey interview. It also included information on home gardens and the contribution of home gardens to overall consumption.

The difference in various production related parameters between adopters and before adoption was defined as total effect of technological innovation; non-adopters and before adoption as spillover effect; and adopters and non-adopters as non-exploited effect. In case data on before adoption were missing, the difference between non-adopters and non-vegetable farmers was considered the effect of vegetable cultivation, and the difference between adopters and non-adopters as technology effect.

Production trend

Based on secondary data collected from the Bureau of Agricultural Statistics, trend in vegetable production in Bangladesh was estimated for 1973-90 (innovation period) and 1991-99 (pre-innovation period). This analysis suggests that annual growth in total vegetable production (including chili, onion, and garlic, but excluding potato) more than doubled from 1.8% during the pre-innovation period to 3.1% during the innovation period (Figure 20). Per capita availability of farm-produced vegetables (excluding home garden production) increased from 34 g in 1990 to 40 g in 1999. This is the first such increase since such records have been kept. The proportion of summer vegetables increased from 25% in 1991 to 28% in 1998, an indication of reduced seasonality.

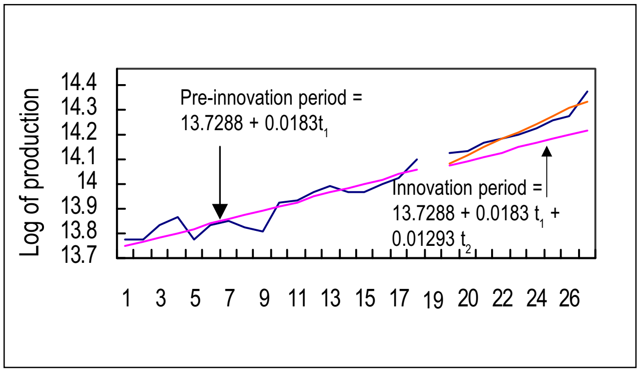

Figure 20. *Trend in vegetable production by period in Bangladesh during 1973-1999.*

Adoption pattern

Adoption of varieties and/or technologies is widespread in gourd, tomato, eggplant, okra, leafies, beans, and heading cole crops. Adopter farmers also used raised beds, polythene shelters, fruit-set regulators, and staking. Most farmers adopted variety and raised beds together. In tomato, variety and fruit-set regulator were adopted together, but in other crops, variety led to other technology adoption, such as staking and raised beds.

Farm input

Adopters generally increase their use of manure and irrigation after adoption, and they use more manure and irrigation than do non-adopters. However, they use less pesticide per hectare, which suggests that training in the judicious use of pesticide is working. Vegetable cultivation is known to create more productive employment opportunities than does cereal cultivation. Adoption of modern technologies was found to increase these opportunities, by about 10% (Table 70).

Input use efficiency

Adoption of new technologies increased vegetable yield by 38.3% and increased cost of production by about 12.8% (Table 71). This improved input use efficiency (output per unit input), especially from land, labor, and water used for vegetable cultivation by 65%, 40%, and 11.5%, respectively. Cost of production (per-unit output) was reduced 20%. Moreover, the skills farmers gained from adopting new vegetable technologies led to improved efficiency in producing other crops (Table 72).

Table 70. *Impact of adoption on input use in Bangladesh*

Type of farmer	Fertilizer (kg NPK/ha)	Manure (kg/ha)	Pesticide liter/ha (no. sprays)	Labor (days)	Irrigation (no.)
Non-adopters	276 a[1]	3995 a	5.02 a (6.5 a)	321 a	3.2 ab
Adopters	279 a	6258 b	3.51 b (3.2 b)	353 b	3.6 a
Before adoption	211 b	7041 b	4.53 ab (4.8 a)	341 ab	2.8 bc
Non-vegetable farmers	-	-	-	-	0.0

[1] Means followed by the same letter in a column are not significantly different at P (0.10) level of probability.

Table 71. *The effects of adoption on yield and cost in vegetables and cereals across farmer type in Bangladesh*

Type of farmer/efficiency	Yield (kg/ha)	Cost (BDT/ha)		
	Vegetables	Cereals	Vegetables	Cereals
Non-adopters	10,221 a[1]	2033 ab	34,069 a	11,473 a
Adopters	12,455 b	2109 a	37,853 b	9,815 b
Before adoption	9,004 c	1931 b	33,549 a	11,035 ab
Non-vegetable farmers	-	2106 a	-	12,175 ca
		Effect of technologies (%)		
Spillover effect	13.5	5.3	1.5	4.0
Un-exploited effect	24.8	3.9	11.3	-15.0
Total effect of technology	38.3	9.2	12.8	-11.1

[1] Means followed by the same letter in a column are not significantly different at P (0.10) level of probability.

Table 72. *Land use efficiency measured in net revenue from vegetables and cereals by farmer type in Bangladesh*

Type of farm/effect	Land		Labor		Irrigation		Output	
	Vegetable	Cereal	Vegetable	Cereal	Vegetable	Cereal	Vegetable	Cereal
	Net revenue (BDT/ha)		Return on labor (BDT/day)		Return on irrigation (% return on cost)		Production cost (BDT/kg)	
Non-adopters	27,659 a[1]	1508 a	140.6 a	49.0 a	32 a	13 a	4.0 a	6.3 a
Adoptesr	36,775 b	4306 b	160.4 b	68.3 b	29 b	19 b	3.3 b	5.1 b
Before adoption	22,223 c	1625 a	114.6 c	48.4 a	26 b	10 a	4.1 a	6.1 a
Non-vegetable farmers	-	1939 a	-	50.3 a	-	23 c	-	6.1 a
Effect of technology (%)								
Spillover	24.5	-7.2	22.7	1.2	23.1	30.0	2.4	-3.3
Non-exploited	41.0	172.2	17.3	39.9	-11.5	60.0	17.1	19.7
Total	65.5	165.0	40.0	41.1	11.5	90.0	19.5	16.4

[1] Means followed by the same letter in a column are not significantly different at P (0.10) level of probability.

Consumption and nutrition

Daily per capita consumption of vegetables in Bangladesh is only 126 g, much less than the minimum 200 g recommended by AVRDC. This is despite the fact that the survey was conducted during the peak supply period. The main vegetables consumed are fruit types, which are generally low in vitamin A and iron. Leafy vegetables, which are generally rich in vitamin A and iron, have a small share in total vegetable consumption.

Adopter farm families consume 67.3% more vegetables than non-vegetable farm families and 26.2% more than non-adopter farm families. Non-adopters consumed 32.5% more vegetables than did non-vegetable farmers, which implies that converting non-vegetable farmers into vegetable farmers can improve vegetable consumption. While non-vegetable farmers and non-adopters consumed about 50% less than the recommended levels of vitamin A, the adopters were 25% below the recommended level. The difference in nutrient availability between non-adopters and non-vegetable farmers was insignificant (Table 73). This implies that vegetable production alone is not enough to enhance nutrient consumption at the family level. People must also be made aware about the importance of good nutrition and about how to prepare nutritious food. Such awareness building and training was part of the Bangladesh project.

Family income

Adopters enjoyed farm cash income about 10% higher than the cash income of non-adopters and 32% higher than that of non-vegetable farmers. Adopters also earned significantly higher off-farm

Table 73. *Nutrient uptake by farmer type in Bangladesh*

Nutrient	Unit	Recommended level	Adopters	Non-adopters	Non-vegetable farmers	Bangladesh
Calories	kcal	1800-2400	2002.4 a[1]	1986.5 a	2029.0 a	2005.7
Protein	g	45-65	70.2 a	64.9 ab	61.2 b	66.8
Fat	g	-	17.4 a	16.3 a	15.7 a	18.2
Carbohydrate	g	-	351.7 a	355.0 a	379.8 b	357.2
Calcium	mg	800-1200	347.8 a	315.2 ab	294.8 b	329.8
Iron	mg	10-15	14.4 a	12.4 b	11.7 b	13.2
Vitamin A	µg	4200-5000	3271.3 a	2133.5 b	2027.0 b	2619.8
Vitamin B1	mg	1.1	0.6 a	0.5 a	0.5 b	0.5
Vitamin B2	mg	1.2	0.7 a	0.6 b	0.6 b	0.7
Niacin	mg	14.7	11.8 a	11.6 a	11.7 a	11.8
Vitamin C	mg	50-70	73.5 a	60.2 b	50.0 c	61.5

[1] Means followed by the same letter in a column are not significantly different at P (0.10) level of probability.

income. Adopters saved more money and spent more on food.

Economic viability

The marginal rate of return on investment made by adopters was 241%, which means that 100 BDT invested will return 241 BDT after recovering cost. It is estimated that the technological innovation in vegetable production generated about US$8.8 million in economic surplus for Bangladeshi farmers and consumers during the 10 years of the project, producers benefited (US$4.6 million) from reduced cost of production and higher resource use efficiency, while consumers benefited (US$4.2 million) from lower vegetable prices as a result of increased supply. The project continues to generate benefits. The internal rate of return (IRR) on the investment in vegetable research and development was estimated to be as much as 41%. This suggests that investment in vegetable research is a very effective way to improve the lot of rural and urban poor.

Contact: M Ali

Role of vegetables in food and nutrient consumption in rural India

This study looks at the state of food and nutrient consumption in relation to vegetables in rural India by income group. The analyses are based on data from the rural sample of the 50th Socioeconomic Survey of the National Sample Survey Organization (NSSO), which was executed from July 1993 to June 1994. The NSSO collects food consumption data based on consumer expenditure. The reference period for data collection on all items of consumer expenditure is the previous 30 days. Probably due to the long reference period, the intake levels, as assessed by NSSO, are high compared to those from other data sources. The data, collected from some 56,000 rural households, present a detailed picture of consumption habits. Per capita nutrient intake was estimated using a data set on the nutritive value of Indian foods published by the Indian Institute of Nutrition in 1999.

Expenditure quintiles were constructed statewise, based on household per capita total expenditure, with daily average per capita consumption expenditure ranging from 53 INR (rupee) to 211 INR. The poorest households (expenditure quintile 1) spent, on average, as little as 39 INR per household member per day on food, while the most wealthy households (expenditure quintile 5) spent almost 105 INR per household member per day. Food accounted for nearly three-quarters of the poorest households' total expenditure, while it accounted for about half of the wealthiest households' total expenditure (Table 74).

Table 74. *Household characteristics*

Quintile	Per capita expenditure (INR)	Range of per capita expenditure (INR)	Per capita food expenditure (INR)	Food budget share (%)
Lowest	53	13–138	39	73.6
2	74	50–172	53	71.6
3	93	64–218	64	68.8
4	121	79–280	77	63.8
Highest	211	103–2116	105	49.8

Source: 56,085 rural household respondents in the 50th round of the Socioeconomic Survey of the National Sample Survey Organization.

Cereals account for the biggest share of all expenditure for food. The poor spend about half their food budget on cereals. The share of pulses and vegetables was fairly stable across expenditure groups, accounting for about 6% and 10% of total food expenditure, respectively (Table 75). The biggest differences between the poorest and wealthiest, in terms of budget share allocation, were found in cereals (50.5% versus 32%, respectively), milk and egg products (7% versus 18.9%), and meat (4.6% versus 7.1%) (Table 75). Consumption of cereals will drop relative to income, and consumption of milk and egg products, and meat, will increase dramatically as the incomes of rural households increase. In contrast, the relative consumption of pulses and vegetables will remain fairly constant, even if actual consumption increases.

Table 76 shows average daily per capita nutrient availability, which is in line with the budget shares shown in Table 75. Cereals constitute the single most important source of energy, protein, and iron. Most of the daily calcium intake comes from milk. Vegetables are the single most important source of vitamins A and C, accounting for a relatively small share of household consumption. However, they also account for only a minor share of iron availability.

Poor households are deficient in all nutrients, but the deficiency is particularly severe for the micronutrients iron, vitamin A, vitamin C, and

Table 75. *Daily per capita food expenditure (INR) by food group and expenditure quintiles*

Quintile	Lowest		2		3		4		Highest	
Food group	Expense	%	Expense	%	Expense	%	Expense	%	Expense	%
Cereals	19.5	50.5	23.6	45.3	23.6	41.4	28.5	37.6	32.7	32.0
Pulses	2.5	6.4	3.3	6.3	3.3	6.2	4.7	6.2	6.3	6.2
Milk and eggs	2.7	7.0	5.6	10.7	5.6	13.6	12.2	16.1	19.3	18.9
Meat	1.8	4.6	2.8	5.4	2.8	5.8	4.8	6.3	7.3	7.1
Vegetables	3.9	10.4	5.3	10.4	5.3	10.4	7.5	10.3	9.8	10.0
Fruits	0.5	1.2	1.0	1.6	1.0	2.0	2.1	2.4	3.8	3.2
Other foods	8.2	20.0	11.5	20.3	11.5	20.7	17.6	21.2	26.2	22.5

Note: Figures may not add up to 100 in % column because of rounding.
Source: 56,085 rural household respondents in the 50th round of the Socioeconomic Survey of the National Sample Survey Organization.

Table 76. *Average daily per capita nutrient availability in rural India*

Food group	Calories (kcal)	Protein (g)	Calcium (mg)	Iron (mg)	Vitamin A (µg)	Vitamin C (mg)
Cereals	1541	39	116	11	16	1
Pulses	95	6	24	1	2	0
Milk and eggs	133	6	225	0	113	4
Meat	37	4	27	0	2	0
Vegetables	83	3	66	2	206	39
Fruits	47	1	5	0	16	10
Other foods	263	1	95	2	11	2
Total	2198	60	559	17	365	56

Source: 56,085 rural household respondents in the 50th round of the Socioeconomic Survey of the National Sample Survey Organization.

calcium (Table 77). Lowest expenditure quintiles are also deficient in protein, although on the average protein is available in India.

However, the availability of micronutrients is insufficient in rural India. This is true especially for iron and vitamin A. Only 57% and 61%, respectively, of the recommended levels are met for rural India as a whole. None of the income groups meets the recommended level of intake. As far as calcium and vitamin C are concerned, only the two highest expenditure quintiles manage to achieve the recommended levels of daily intake. The differences in intake between quintiles are particularly striking for calcium and vitamins A and C. Consumption of these by the lowest expenditure group is less than half that of the highest expenditure group.

In terms of unit cost of selected nutrients (expenditure for a group of commodities per the nutrient content of that group), vegetables represent the most inexpensive source of vitamins A and C, and one of the most economical sources of calcium and iron (Table 78). Increasing vegetable production would, therefore, be a good way to enhance micronutrient supply in India.

Contact: M Ali

Folate contents of tropical vegetables

Folic acid (pteroylmonoglutamate) is a water-soluble B vitamin. Folates, are essential coenzymes for growth and proliferation of cells. In animals, deficiency causes impaired cell division and macrocytic megaloblastic anemia which is associated with neural tube defects, cardiovascular disease, and cancers. Thus, folate nutrition has drawn much attention in recent years. Vegetables are a major source of folate in human diets, but information on folate content of vegetables, especially the tropical type is limited. This study measured and compared folate contents of tropically grown vegetables.

A microbiological assay was used to screen 101 vegetables collected from markets near AVRDC headquarters in Shanhua, Taiwan in 2000. Most

Table 77. *Fulfillment of recommended levels of nutrient intake (%)*

Expenditure quintile	Energy	Protein	Calcium	Iron	Vitamin A (retinal)	Vitamin C
Lowest	69.7	81.8	60.0	44.5	39.7	59.2
2	82.4	96.6	75.1	50.7	49.9	76.0
3	90.9	107.3	88.6	56.0	58.0	87.9
4	99.5	118.6	103.9	61.4	67.2	103.2
Highest	114.2	138.1	129.3	71.9	84.8	132.9
Average	91.6	109.0	93.2	56.9	60.9	92.9
Lowest/highest quintile	61.0	59.2	46.4	61.8	46.9	44.6
Recommended daily intake	2400 kcal	55 g	600 mg	29 mg[1]	600 µg	60 mg

Source: 56,085 rural household respondents in the 50th round of the Socioeconomic Survey of the National Sample Survey Organization.

[1] The recommended level of iron intake is relatively high for India (29 mg). Because meat is relatively less prominent in the Indian diet, and because iron from plant sources has low bioavailability, plant based diets need to ensure a higher iron intake.

Table 78. *Nutrient cost (INR) of 100 units of selected nutrients*

	Energy (100 kcal)	Protein (100 g)	Calcium (100 mg)	Iron (100 mg)	Vitamin A (Retinol, 100 µg)	Vitamin C (100 mg)
Cereals	1.6	67.0	33.1	420.8	1425.9	*
Pulses	4.2	80.8	19.7	354.0	438.0	2445.2
Milk and eggs	11.0	310.3	12.1	*	13.9	504.2
Meat	22.5	181.1	413.0	4214.8	973.6	5626.4
Vegetables	9.1	258.2	12.9	520.5	13.3	20.2
Fruits	7.3	772.1	58.1	1341.1	151.5	233.1

Source: 56,085 rural household respondents in the 50th round of the Socioeconomic Survey of the National Sample Survey Organization.

* Only a few commodities contain these nutrients, so prices seem unreasonably high and are not reported.

vegetables contained 10 ug/100 g to 60 ug/100g (Table 79). Spinach had the highest folate content among the leaf vegetables; okra and wild balsam pear were outstanding among the fruit vegetables; flowers of vegetable sponge and day lily contained more folate than flowering vegetables, such as cauliflower and broccoli; vegetable soybean was 2–3 times higher in folate content than common bean and garden pea, but equivalent to cowpea. (We noted exceptionally high amounts of folate in the shoots of wild balsam pear and garden pea. It is reported that mitochondria contain the most cellular folate in plants, and folate is known to function in one-carbon transfer reactions, which are active during cell proliferation. It is expected then, that more folate would accumulate in parts with more active mitochondria, such as shoots).

The recommended daily allowance (RDA) of folate is 0.2 mg for adults and 0.4 mg for pregnant women. An adult would need to take, for example, about 200 g of vegetable with 100 ug/100g of folate to meet the RDA. Spinach, wild balsam pear, green asparagus, and vegetable soybean are good sources of folate.

Contact: CS Tsou

Comparison of carotenoid contents of high beta-carotene, high lycopene, and normal pigmented tomato lines

Tomato fruit contain two major carotenoids, lycopene and beta-carotene, both of which possess anti-oxidizing properties that might be beneficial to human health. Development of tomato varieties with increased total carotenoid levels is, therefore, a valuable breeding objective. Genetic differences exist among tomato varieties in lycopene and beta-carotene content. A single recessive allele called high pigment (*hp*) increases lycopene and total carotenoid content, and a single dominant allele called beta (*B*) increases the production of beta-carotene at the expense of lycopene. The objective of this study was to measure and compare

Table 79. *Folate contents of tropical vegetables*

Common name	Scientific name	Folate, µg/100 g
Alfalfa, sprout	*Medicago polymorpha*	30 ± 2
Aloe	*Aloe vera*	15 ± 2
Amaranth, green	*Amaranthus mangostanus*	2 ± 1
Amaranth, wild, green	*Amaranthus viridis*	41 ± 2
Amaranth, wild, red	*Amaranthus viridis*	39 ± 1
Angled luffa	*Luffa acutangula*	61 ± 1
Asparagus, green	*Asparagus officinalis*	93 ± 1
Asparagus, white	*Asparagus officinalis*	68 ± 4
Balsam pear shoot, wild	*Momordica charantia*	133 ± 1
Balsam pear stem, wild	*Momordica charantia*	41 ± 2
Balsam pear, white	*Momordica charantia*	55 ± 1
Balsam pear, wild, green	*Momordica charantia*	82 ± 0
Bamboo heart	*Bambusa oldhami*	33 ± 1
Bamboo, green	*Bambusa oldhami*	50 ± 0
Basil	*Ocimum basilicum*	42 ± 1
Betel-nut palm	*Areca catechu*	36 ± 3
Bird-nest fern	*Asplenium nidus*	21 ± 1
Black nightshade	*Solanum nigrum*	51 ± 2
Broccoli	*Brassica oleracea*	55 ± 2
Cabbage mustard	*Brassica juncea*	28 ± 0
Cabbage stalk	*Brassica oleracea*	33 ± 1
Cabbage, Chinese heading	*Brassica pekinensis*	67 ± 3
Cabbage, red	*Brassica oleracea*	19 ± 2
Calabash gourd	*Lagenaria siceraria*	16 ± 1
Carrot	*Daucus carota*	19 ± 7
Cauliflower	*Brassica botrytis*	27 ± 1
Celery, Chinese	*Apium graveolens*	19 ± 2
Celery, western	*Apium graveolens*	46 ± 2
Chayote	*Sechium americanum*	60 ± 7
Chayote leaves	*Sechium americanum*	66 ± 1
Chinese cedar	*Cedrela sinensis*	41 ± 0
Chinese chive with flower	*Allium tuberosum*	71 ± 2
Chinese chives	*Allium tuberosum*	23 ± 2
Chinese leek	*Allium ordorum*	61 ± 5
Chinese water chestnut	*Eleocharis tuberosa*	13 ± 2
Common bean	*Phaseolus vulgaris*	41 ± 1
Common white basella	*Basella rubra*	33 ± 7
Coriander	*Coriandrum sativum*	72 ± 0
Corn shoot	*Zea mays*	26 ± 1
Corn, sweet	*Zea mays*	19 ± 0
Cow-pea	*Vigna unguiculata*	117 ± 1
Cucumber	*Cucumis sativus*	26 ± 1
Cuming cordia	*Cordia dichotoma*	46 ± 0
Dasheen stalk	*Colocasia esculenta*	20 ± 0
Day lily, green	*Hemerocallis fulva*	77 ± 0
Day lily, orange	*Hemerocallis fulva*	87 ± 4
East Indian lotus	*Nelumbo nucifera*	14 ± 4
Edible rape	*Brassica chinensis*	49 ± 1
Eggplant	*Solanum melongena*	18 ± 1
Endive	*Cichorium endivia*	36 ± 1
Garden pea	*Pisum sativum*	33 ± 0
Garden Pea shoot	*Pisum sativum*	83 ± 0

Contd. Table 79. *Folate contents of tropical vegetables*

Common name	Scientific name	Folate, µg/100 g
Garlic	*Allium sativum*	58 ± 5
Ginger, old	*Zingiber officinale*	12 ± 10
Ginger, young	*Zingiber officinale*	20 ± 1
Great burdock	*Arctium lappa*	56 ± 1
Gynura	*Gynura bicolor*	28 ± 0
Indian salad	*Lactuca indica*	24 ± 1
Japanese yam	*Dioscorea japonica*	21 ± 2
Jew's ear	*Auricularia auricula*	16 ± 2
Kohlrabi	*Brassica oleracea*	31 ± 1
Lettuce	*Lactuca sativa*	60 ± 1
Lettuce, heading	*Lactuca sativa*	39 ± 5
Ma bamboo	*Dendrocalamus latiflorus*	19 ± 1
Madeira-vine	*Anredera cordifolia*	37 ± 1
Mungbean sprouts	*Vigna radiata*	28 ± 0
Mushroom	*Agaricus brunnescens*	39 ± 1
Okra	*Abelmoschus esculentus*	86 ± 7
Onion	*Allium cepa*	13 ± 1
Oriental pickling-melon	*Cucumis melo*	1 ± 0
Pak Choi , ching-geeng	*Brassica chinensis*	41 ± 1
Pak Choi , crispifolius	*Brassica chinensis*	55 ± 1
Pak Choi , upright	*Brassica pekinensis*	21 ± 2
Pepper mint	*Mentha x piperita*	18 ± 2
Pepper, hot, green	*Capsicum annuum*	38 ± 0
Pepper, hot, red	*Capsicum annuum*	28 ± 1
Pepper, sweet, green	*Capsicum annuum*	22 ± 1
Pumpkin	*Cucurbita moschata*	35 ± 1
Purslane	*Portulaca oleracea*	45 ± 3
Radish	*Raphanus sativus*	21 ± 1
Serpent gourd, green	*Trichosanthes anguina*	39 ± 6
Serpent gourd, white	*Trichosanthes anguina*	36 ± 1
Shallot	*Allium ascalonicun*	23 ± 6
Shiitake	*Lentinus edodes*	46 ± 2
Soybean sprouts	*Glycine max*	52 ± 1
Spinach	*Spinacia oleracea*	118 ± 3
Swamp morning glory	*Ipomoea reptans*	32 ± 3
Sweet potato vine	*Ipomoea batatas*	20 ± 2
Taro	*Colocasia esculenta*	20 ± 1
Tomato	*Lycopersicon esculentum*	18 ± 0
Vegetable fern	*Anisogonium esculentum*	14 ± 1
Vegetable soybean	*Glycine max*	104 ± 9
Vegetable sponge flower	*Luffa aegyptiaca*	66 ± 1
Vegetable sponge flower bud	*Luffa aegyptiaca*	91 ± 4
Vegetable sponge, long	*Luffa aegyptiaca*	43 ± 1
Vegetable sponge, short	*Luffa aegyptiaca*	34 ± 5
Water bamboo	*Zizania latifolia*	57 ± 0
Wax gourd	*Benincasa hispida*	23 ± 1
Welsh onion	*Allium fistulosum*	68 ± 2
West Indian gherkin	*Cucumis anguria*	25 ± 1
White-flowered gourd	*Lagenaria siceraria*	23 ± 2

the lycopene, beta-carotene, and total carotenoid contents of lines carrying *hp*, *B* or normal fruit pigment alleles. The trial included the 10 entries listed in Table 80. T5020 was provided from the US Department of Agriculture, UC204A is a processing tomato line from California, and lines with the CLN prefix are from AVRDC.

Entries were sown on 20 October 1999 and transplanted on 18 November 1999. Trial plots were single 1.5-m beds with one 4.8-m-long row per bed. Twenty fruits per plot from the second harvest were subjected to HPLC analysis. Total carotenoid content was determined as the sum of the lycopene and beta-carotene contents. The *B* entries produced about nine times more beta-carotene than the other entries, while the lycopene content of the *hp* entry was about two times greater than the normal pigmented lines and about nine times greater than the *B* entries. High beta-carotene content resulted in orange pigmentation of the *B* entry fruit and lower color values. The group mean total carotenoid content of the *B* lines (8.48 mg/100 g fresh weight) was not significantly different from the mean of the *hp* line (8.14 mg/100 g) according to linear contrast. The group mean for total carotenoid content of the normal pigmented entries (4.63 mg/100 g) was significantly less than group means of the *hp* and *B* entries. Use of *B* or *hp* alleles increases both individual carotenoids and total carotenoid content.

Contact: P Hanson

Isoflavone content in soybean

Isoflavones, a group of the flavonoids, are best known for protecting plants against fungi and bacteria. They are found mostly in legumes. Two types of non-glycoside conjugated isoflavones, genistein and daidzein, exist in a few plant families. Their ß-glycoside conjugates are the principal isoflavone forms in soybean. The two glycoside-free compounds have similar structures to human estrogens and have been proven to inhibit the growth of human breast and prostate cancer in cell lines. The high isoflavone level in soybean and soybean products have drawn much attention in cancer prevention.

Isoflavone concentration in soybean is strongly affected by environmental factors, such as temperature and location. Despite the significant genotype × environment interactions, the differences between the cultivars with the highest and lowest total and individual isoflavone contents are reported to be relatively consistent. Consequently, breeding for high isoflavone content is possible. The objective of this work was to evaluate isoflavone variation in

Table 80. *Mean carotenoid and solids contents, and color values of tomato entries with or without fruit pigment genes, AVRDC, November 1999–April 2000*

Entry	Gene[1]	Beta-carotene (mg/100 g)	Lycopene (mg/100 g)	Total carotenoids (mg/100 g)	Solids (°brix)	Color[2] (a/b)
CLN2070A	ß	8.88	0.59	9.46	5.3	0.70
CLN1314A	ß	8.87	1.06	9.93	4.4	0.86
CLN1314G	ß	7.58	0.95	8.53	4.4	0.83
CLN2070	ß	5.62	0.38	6.00	5.4	0.58
T5020	*hp* + og^c	0.87	7.28	8.14	3.7	2.32
CLN1466Q	w-t	1.15	3.49	4.63	3.5	1.68
CLN1466R	w-t	1.28	3.81	5.09	3.5	1.78
CLN2026D	w-t	0.70	4.21	4.91	3.9	1.92
UC204A	w-t	0.52	4.65	5.17	4.2	2.11
Moneymaker	w-t	0.51	3.16	3.67	4.2	1.75
Minimum significant distance (Waller-Duncan k-ratio *t*-test)		0.92	1.30	1.68	0.70	0.15
CV (%)		11.9	20.0	11.4	7.3	4.7

[1] ß = Beta-carotene allele conditioning elevated beta-carotene levels; *hp* = high pigment allele; og^c = crimson allele; w-t = wild type (normal genotype).
[2] Values for a and b were measured with a chromometer using a red standard surface. Immature green tomatoes have an a/b ratio less than 0. The a/b ratio increases to zero and above as the fruits ripen toward a dark red.

soybean accessions. Isoflavone composition differences in seeds of several vegetable soybean varieties harvested from 1995 to 2000 were also determined.

Eighty-three soybean accessions (*Glycine max*) from AVRDC's Genetic Resources and Seed Unit were selected for study representing 50 countries; small, medium, and large seed size; and green, yellow, brown, and black seed coats. Nineteen samples from eight wild Glycine species (*canescens, clandestina, falcata, gracilis, javanica, soja, tabacina,* and *tomentella*) were also evaluated. High performance liquid chromotography (HPLC) was used to analyze contents of the two glycoside-free forms, genistein and daidzein, and their conjugated glycans, genistin and daidzin. Water, protein, and oil contents were measured by near infrared spectroscopy for correlation analysis.

The highest total content value was about 8.1- to 10.9-times that of the lowest value, but only 2.4-times that of the averages (Table 81). Average isoflavone content of wild Glycine was higher than *G. max*. Contents of the four isoflavones were not correlated with country of origin, seed size, seed color or moisture, protein and oil contents. Cancer inhibiting genistein and daidzein made up less than 10% of the total isoflavone contents of 85% of the samples tested. A wild accession, G09937 (*G.canescens* from USA), was found to contain exceptionally high genistein (113 µg/g) and daidzein (187 µg/g). Another accession, G10385 (*G.canescens* from Australia), contained a lower total isoflavone content of 307 µg/g, but 72% of its isoflavone was in the free form. These two accessions have potential use in production of free-form, natural isoflavones, but genetic stability of isoflavone composition of these accessions needs further study.

Table 81. *Variation of isoflavone contents (µg/g) in soybean accessions and wild soybean*

	Genistein	Daidzein	Genistin	Daidzin	Total
Glycine max (83)*					
Range	1 - 42	1 - 61	65 - 532	43 - 409	120 - 974
Average	8 ± 6	18 ± 11	192 ± 89	189 ± 84	407 ± 174
Wild species (17)*					
Range	0 - 115	1 - 187	57 - 588	0 - 624	120 - 1312
Average	12 ± 37	56 ± 45	233 ± 157	242 ± 161	556 ± 308

Sample source: Genetic Resources and Seed Unit, AVRDC.
* No. of samples tested.

Tests showed less isoflavone synthesis in freshly harvested seeds. Higher isoflavone contents were found in various batches of soybean seeds shipped from North and South America. Although age was not correlated with the isoflavone contents when soybean seeds were maintained at low temperature (5ºC, 45%RH), we observed that total isoflavone content increased in longer stored seeds under 18ºC and 45% RH. (Figure 21). Storage conditions probably affected isoflavone dynamics in harvested seeds; and changes in their isoflavone composition in seeds could possibly be manipulated.

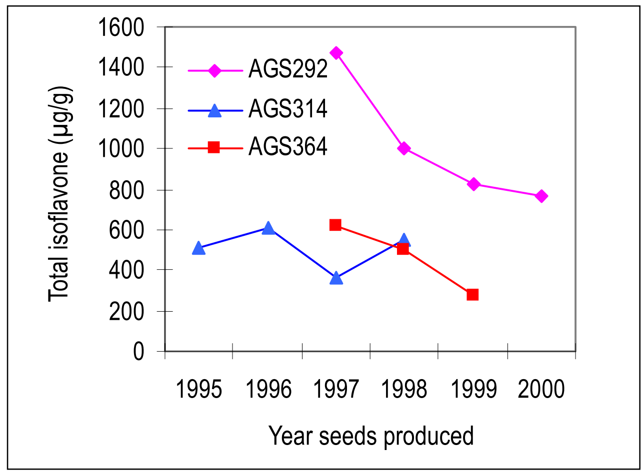

Figure 21. *Change in total isoflavone contents in seeds of three vegetable soybean varieties harvested in different years and stored at 18°C and 45% RH.*

Seeds of four vegetable soybean varieties varying from low to high isoflavone contents and harvested in 2000, were stored at 37ºC and 95-100% RH for 72 hours to study the effect of stress and accelerated aging on isoflavone contents. Similar trends in composition change in total and individual isoflavone were observed among varieties (Figure 22). Genistein and daidzein gradually increased with aging time, whereas their conjugated glycans decreased to the equivalent amounts of genistein and daidzein at 72 hours. Total isoflavone contents remained constant over time. These evidences suggest no new isoflavone synthesis but free-form isoflavone accumulation from the degradation of their relative glycans. Genistein and daidzein contents have been found to vary in soy products, and are generally much lower than the content of conjugated glycans in seeds. Higher genistein and daidzein concentrations have been detected in certain traditional Asian soy

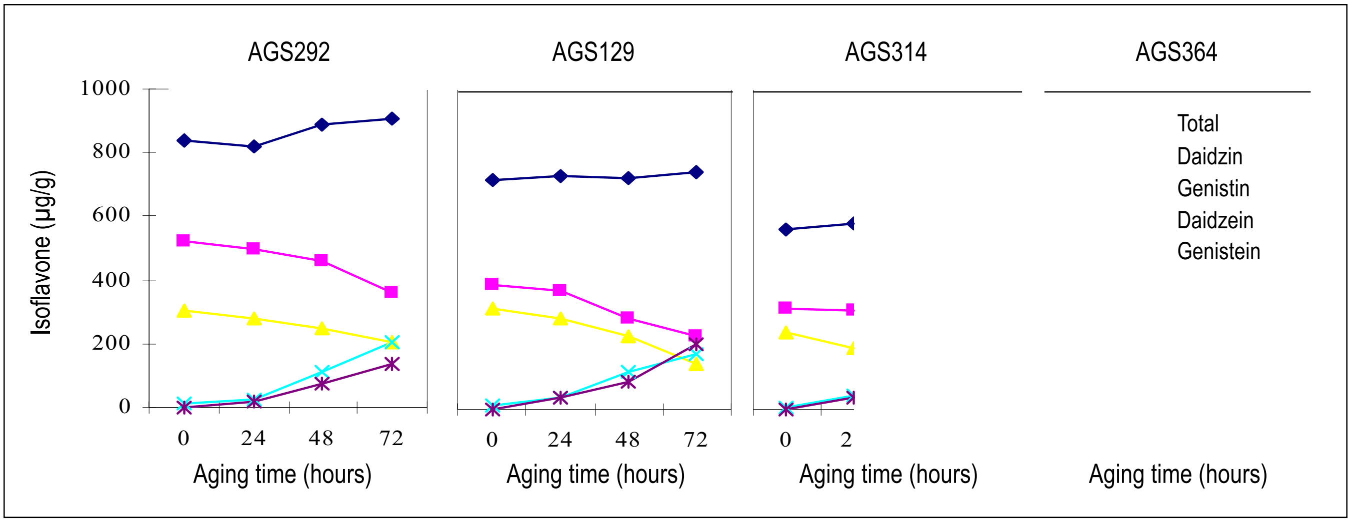

Figure 22. *Changes in isoflavone composition in seeds of four vegetable soybean varieties stored at 37°C and 95–100% RH.*

products, such as miso and tempe, which have undergone whole cell fermentation. These results would support our finding that aging of intact seeds under higher temperature and humidity triggers changes in isoflavone composition.

We concluded that (1) for total isoflavone density, genetic differences among soybean accessions' isoflavone were not large; (2) two wild Glycine accessions with exceptionally high ratios of genistein and daidzein were found that could be used in the isolation of natural soy isoflavones; (3) total isoflavone content of seeds changes and increases during storage and/or transportation; and (4) increase of genistein and daidzein contents of seeds could be manipulated with the treatment of 37ºC, 95-100% RH for three days.

Contact: CS Tsou

Project 7. Computer-based decision-making tools

Research on different vegetable crops at AVRDC involves a multi-disciplinary and problem-oriented approach conducted by teams of plant breeders, plant pathologists, entomologists, soil scientists, and others. In the course of their work improving the productivity of vegetable crops, these research teams generate much useful and diverse data. To extract the full benefit of this information, it must be assembled, collated, and packaged in a form useful to other researchers and extensionists—it should be understandable, adaptable, and available.

The objective of Project 7 is to develop computer-based decision-making tools to help our partners in national agricultural research and extension systems and nongovernmental organizations design year-round vegetable production systems.

As the first step, various databases structures were set up (using Microsoft Access® software) for tomato, including: available inbred lines, available commercial varieties, field management practices, plant diseases, soil nutrient deficiencies, and insect pests. Using the plant diseases and nutrient deficiencies database, two diagnostic systems were developed, namely: the *Tomato Disease Diagnostic System* (TDDS) and the *Nutrient Deficiency Diagnostic System* (NDDS).

The information the inbred lines developed by AVRDC's tomato breeding unit and the commercial varieties available from seed companies have been gathered in separate databases, which are part of a master database on tomato. The inbred line database includes variable fields for name of line, fruit and plant photos, plant habit, fruit weight, type, maturity, heat tolerance, levels of resistance to important diseases, target environments, and other varietal characteristics. The commercial variety database includes fields for name, fruit maturity, plant habit, resistance levels, the names and addresses of seed distributors, and other fields.

The field management database includes information on tomato production procedures, materials, etc., from seed preparation to harvest and storage. It also includes photos of field operations.

The plant disease database includes fields for common name, pathogen name and description, symptoms (with photos), conditions for development, and control measures.

The TDDS helps users to diagnose plant diseases through observation of symptoms. Users respond to a series of questions that guide them to a diagnosis, and information on control of the disease, the organism that causes the disease, environmental conditions favorable to the development of the disease, etc. The 25 most common tomato diseases found in the tropics and sub-tropics are included in the TDDS. The system had already been evaluated and is being revised and improved.

The nutrient deficiency database includes fields for symptoms, causal mechanisms, and control measures and is the basis for the NDDS, a tool for detecting nutrient deficiencies based on symptoms.

The insect database includes information on insect characteristics, damage symptoms, other technical information, and photos.

The different databases can later be linked within a master database system, which might draw on other diverse sources of data.

Contact: D Ledesma

Program III

Collaboration in research and germplasm management

The principal aims of Program III are to build up the research capacity of national agricultural research systems and to promote international multidisciplinary collaboration in vegetable research and development through networking. To these ends, projects in Program III focus on collection, conservation, and exchange of germplasm; publishing, communications, information exchange, and documentation; and training. The program also provides management support to the Center's farm operations, bilateral and regional programs and special projects, and coordinates the Center's collaborative links with national and international agricultural research centers, universities, and advanced laboratories.

Project 8. Germplasm conservation, characterization, and exchange

The objective of Project 8 is to improve production and increase biodiversity through collection and exchange of germplasm. Within the project there are two subprojects: 1) *ex-situ* conservation of vegetable germplasm for preservation and exchange; and 2) enhancing the efficiency of vegetable germplasm utilization.

The activities in subproject 1 include: 1) a vegetable germplasm collection conserved *ex-situ* in the Center's Genetic Resources and Seed Unit (GRSU); and 2) vegetable accessions conserved at GRSU regenerated for preservation and exchange. Subproject 2 has four activities: 1) vegetable germplasm utilization enhanced through widespread distribution; 2) genetic diversity in the vegetable germplasm collection characterized and analyzed; 3) documentation done for effective genebank management; and 4) strategies for producing healthy seeds for preservation and exchange developed.

In addition, there are two special projects: 1) collection, conservation, and utilization of indigenous vegetables; and 2) duplication at the Taiwan Agricultural Research Institute (TARI), of vegetable germplasm conserved at AVRDC.

GRSU works in close collaboration with the Center's research and training units, outreach offices, and national agricultural research systems worldwide to collect, characterize, and conserve vegetable germplasm for utilization. In 1999-2000, more attention was placed on vegetable species indigenous to South and Southeast Asia.

Table 82. *Accessions of vegetable germplasm conserved at AVRDC, as of December 31, 2000*

Crop	TOTAL
Principal crops	
Glycine	14,154
Capsicum	7,413
Lycopersicon	7,203
Vigna radiata	5,644
Solanum	2,538
Brassica	1,675
Allium	1,075
Sub-total	39,702
Other crops	
Vigna unguiculata	1,390
Phaseolus	605
Luffa	584
Vigna mungo	481
Cucumis	452
Amaranthus	404
Cucurbita	338
Vigna unguiculata ssp *sesquipedalis*	328
Abelmoschus	315
Lablab	234
Pisum	216
Vigna unguiculata ssp *unguiculata*	77
Others	2,502
Sub-total	7,926
TOTAL	47,628
No. of genera	115
No. of species	227
No. of countries	151

Germplasm collection maintained at AVRDC

A total of 1822 accessions were acquired in 2000, bringing the total number of accessions in the collection to 47,628 (Table 82). Forty genera and 36 species were added to the collection.

Collection, conservation, and utilization of indigenous vegetables

Special project on conservation of indigenous vegetables

AVRDC is coordinating an Asian Development Bank (ADB)-funded project designed to enhance the collection, conservation, and utilization of indigenous vegetables in Bangladesh, Indonesia, the Philippines, Thailand, and Vietnam. The project defines indigenous vegetables as species that originated in South and Southeast Asia, as well as those that have been introduced and have adapted in the region over a long period. Expeditions were mounted in Bangladesh, Thailand, and Vietnam in April–June 2000 to: 1) collect farmers' varieties and landraces of priority species; 2) collect other species and their relatives whenever encountered; and 3) obtain ethnobotanical information on indigenous vegetable germplasm. Each participating country listed its priority species, and the species most often cited were assigned high over-all priority. Within this group, leafy vegetables were given top priority, in line with the project's focus on leafy vegetables. Priority was also given to materials with greater potential for utilization, especially farmers' varieties and landraces, preferably those that had undergone some selection.

Material was collected from 23 sites in the provinces of Kontum, Quang Ngai, and Quang Binh in the central highlands of Vietnam. In Bangladesh, material was from 39 sites in the districts of Dhaka, Gazipur, Chittagong, Cox Bazaar, and Khagrachari and Rangamati in the hill tracts of the southeast. In Thailand, material was collected from 38 sites in the provinces of Ayuthaya, Bangkok, Chainat, Nakhon Pathom, Phetchaburi, Ratchaburi, and Uthai Thani. Sites included farmers' fields, kitchen gardens, farm stores, and village markets where farmers' varieties could be found. Farming communities of tribal groups were given particular attention. Market visits were conducted to gauge the range of species and varietal diversity in a given place. Itineraries were modified on the basis of information obtained during the market visits.

Location descriptors, site characteristics, plant characteristics and uses, and other relevant observations were recorded. A hand-held geographical positioning device was used to determine location. Indigenous practices on variety, plant and seed selection, seed storage, and maintenance of genetic diversity were recorded.

A total of 982 samples of at least 73 species were collected (Table 83) A relatively large number of samples of amaranth (101 samples), yardlong bean (78), squash (63), ridged gourd (61), bittergourd (53), cucumber (50), eggplant (45), lablab bean (45), and bottle gourd (44) were collected.

In Bangladesh, 682 samples of at least 40 species were collected, including yardlong bean (75 samples), amaranth (68), ridged gourd (58), cucumber (44), lablab bean (44), squash (44), bottle gourd (41), bittergourd (33), eggplant (31), okra (30), wax gourd (28), jute mallow (25), sponge gourd (25), Indian spinach (24), snakegourd (24), and others. In Thailand, 152 samples of at least 50 species were collected, including amaranth (15 samples), bittergourd (15), ivy gourd (10), *Sesbania grandiflora* (10), and others. In Vietnam, 148 samples of at least 36 species were collected, including amaranth (18 samples), squash (18), yardlong bean (10), eggplant (9), leaf mustard (9), and others.

The most diverse collection, in terms of number of species, was from Thailand, followed by Bangladesh, and Vietnam. Germplasm of 32 species was collected from at least two of the countries. Germplasm of 10 species was collected only from Bangladesh, 23 species only from Thailand, and 8 species only from Vietnam.

- ***Amaranthus***. At least five species of *Amaranthus* were collected from the three countries, namely *A. gangeticus, A. gracilis* (syn. *A. viridis*), *A. lividus*, *A. spinosus*, and *A. tricolor*. Species is still uncertain for most of the material. The farmers' cultivars and landraces were used for their stem, leaf, or whole plant. Varietal mixtures, either natural or deliberate, were observed in Bangladesh and Vietnam. In the former case, it is uncertain whether the mixture in the natural stand was due to several distinct genotypes being present in one varietal mixture, or whether there is segregation and continuous variation for several morphological characters in one population. In the latter case, consumer preference for combinations of green and red was the reason given for deliberate mixing of two varieties.
- ***Basella alba***. Two distinct stem and leaf colors, green and reddish purple, were observed in the Indian spinach cultivars from the three countries. There was a definite preference in the three countries for green, highly succulent varieties with long internodes. The cultivars with reddish purple stems and leaves were grown only for home consumption.
- ***Benincasa hispida***. Variation in fruit size, shape (degree of elongation), fruit skin color (from light to dark green), and degree of speckling were the more obvious variations observed in fruit characters among the different farmers' varieties and landraces of wax gourd.
- ***Capsicum***. Wide variation was observed in chili pepper fruit color, shape, and size. In addition, samples of *C. chinense* were collected from two districts in Bangladesh.
- ***Clitoria ternatea***. Plants of butterfly pea were seen being grown in the three countries, but as ornamentals. A distinct form with double corolla was observed in Thailand.

Table 83. *Species of indigenous vegetables collected from Bangladesh, Thailand, and Vietnam*

Scientific name	Number of samples collected			
	Bangladesh	Thailand	Vietnam	Total
Abelmoschus esculentus	30	-	-	30
Allium cepa	1	-	-	1
Amaranthus spp.	68	15	18	101
Anethum graveolens	-	1	-	1
Basella alba	24	3	4	31
Benincasa hispida	28	4	3	35
Brassica juncea	8	-	9	17
Brassica rapa cvg. Caisin	2	1	1	4
Brassica spp.	-	3	5	*8*
Cajanus cajan	1	-	-	1
Canavalia gladiata	-	1	-	1
Capsicum spp.	21	4	6	31
Celosia argentea	-	1	-	1
Centella asiatica	-	3	-	3
Crysanthemum coronarium	-	-	1	1
Citrullus lanatus	-	-	1	1
Clitoria ternatea	1	7	-	8
Coccinia grandis	-	10	-	10
Corchorus olitorius	25	1	3	29
Coriandrum sativum	3	1	1	5
Crataeva religiosa	-	1	-	1
Cucumis melo	1	-	2	3
Cucumis sativus	44	1	5	50
Cucumis sp.	-	1	-	1
Cucurbita moschata	44	1	18	63
Diplazium sp.	-	1	-	1
Emilia sonchifolia	-	1	-	1
Eryngium foetidum	3	1	2	6
Gynandropsis gynandra	3	4	-	7
Hibiscus sabdariffa	3	1	1	5
Houttuynia cordata	-	-	1	1
Ipomoea aquatica	4	2	-	6
Lablab purpureus	44	1	-	45
Lactuca sativa	-	-	1	1
Lagenaria siceraria	41	1	2	44
Luffa acutangula	58	1	2	61
Luffa aegyptiaca	25	1	3	29
Luffa sp.	-	-	2	2
Lycopersicon esculentum	2	2	4	8
Momordica charantia	33	15	5	53
Momordica dioica	2	-	-	2
Morinda citrifolia	-	2	-	2
Moringa oleifera	-	4	-	4
Ocimum basilicum	-	4	4	8
Ocimum sanctum	1	1	-	2
Ocimum sp.	-	5	-	5
Pachyrhizus erosus	1	1	-	2
Passiflora foetida	-	4	-	4
Petroselinum crispum	-	1	-	1
Phaseolus lunatus	2	--	-	2
Phaseolus vulgaris	9	-	6	15

Contd. Table 83.

Scientific name	Number of samples collected			
	Bangladesh	Thailand	Vietnam	Total
Physalis angulata	-	1	-	1
Pisum sativum	1	-	-	1
Plantago asiatica	-	-	4	4
Psophocarpus tetragonolobus	2	2	2	6
Raphanus sativus	8	-	1	9
Raphistelma hooperianum	-	1	-	1
Sesamum indicum	-	-	1	1
Sesbania grandiflora	3	10	-	13
Solanum indicum	-	1	-	1
Solanum melongena	31	5	9	45
Solanum nigrum	-	-	2	2
Solanum sanitwongsei	-	1	-	1
Solanum sisymbrifolium	1	-	-	1
Solanum sp.	-	4	2	6
Solanum torvum	-	7	-	7
Solanum trilobatum	-	1	-	1
Solanum xanthocarpum	-	4	-	4
Spinacia oleracea	4	-	-	4
Talinum triangulare	-	2	2	4
Trichosanthes anguina	24	-	-	24
Trichosanthes dioica	1	-	-	1
Trichosanthes sp.	-	1	-	1
Vigna radiata	-	-	2	2
V. unguiculata ssp. *sesquipedalis*	75	-	3	78
V. unguiculata ssp. *unguiculata*	-	-	10	10
Total	682	152	148	982
No. of species	at least 40	at least 50	at least 36	at least 73 73

- ***Corchorus***. Two species of jute mallow were found being used as a vegetable in Bangladesh and Thailand, *C. capsularis* and *C. olitorius*. Wide variation in leaf tenderness, stem succulence, and leaf and stem color was observed.
- ***Cucumis sativus***. Interesting variation was noted in fruit characters of cucumber, especially in Bangladesh, where farmers' varieties were observed with varying fruit lengths (from short and blocky to very long) and fruit color (light green, dark green, yellow, orange).
- ***Cucurbita moschata***. Wide diversity was noted in the fruit characters of farmers' varieties and landraces of squash in the three countries. Variation in fruit size, shape, carpellation, fruit skin and flesh color, flesh texture, seed size, and seed shape was observed by the farmers.
- ***Eryngium foetidum***. False coriander was found in home gardens in Thailand and Vietnam, in contrast to large-scale cultivation in Bangladesh. Variation was noted in leaf characters, especially length and width.
- ***Lablab purpureus***. Lablab bean is an extremely important vegetable in Bangladesh, which accounts for the tremendous diversity in farmers' varieties. Variation was noted in pod shape, size, color and length, seed size, and seed color. Some varieties showed continuous variation in the pod characters.
- ***Lagenaria siceraria***. Bottle gourd is an important vegetable in the three countries. Farmer selection and consumer preference might partly account for the great diversity in farmers' cultivars, especially in terms of fruit size (from short and blocky to

very long), fruit shape (ovate, pyriform, squash-shaped, oblong, elongate), fruit color (light green to dark green), and fruit markings.

- ***Luffa***. Ridged gourd (*Luffa acutangula*) and sponge gourd (*L. aegyptiaca*), are equally important in the three countries. Wide variation in fruit length, width, color, and mottling was observed, and differences in taste and aroma were reported. In Bangladesh, three unique ridged gourd varieties were found, one with short, blocky fruits with pronounced ridges, another with extremely short fruits and shallow ridges, and another extremely short with pronounced ridges. The last two were reported to bear fruit in clusters, and to be sweet, with a pleasing aroma.
- ***Momordica charantia***. Wide variation was observed in fruit size, shape, and prominence of tubercles in farmers' cultivars of bitter gourd in the three countries. Variation was also observed in leaf characters, such as size, shape, and lobing.
- ***Momordica dioica***. This species was observed only in Bangladesh, where it is called *kakrol*. The plants are dioecious, so farmers plant cuttings to ensure a desirable proportion of male and female plants. Collecting seeds proved extremely difficult as farmers never allowed the fruits to ripen they were not interested in the seeds. Variation in plants and fruits was not evident, perhaps due to the asexual method of propagation.
- ***Sesbania grandiflora***. White- and red-flowered sesbania were found in Thailand: The white-flower type is grown on a large scale and the flowers consumed as a vegetable, while the red-flowered type is reported to be used solely as an ornamental.
- ***Solanum***. In addition to eggplant, several species of Asiatic Solanum were observed to be used as vegetables, including *S. indicum, S. sanitwongsei, S. sisymbirifolium, S. torvum*, and *S. trilobatum*. Intraspecific variation was greatest in *S. melongena*.
- ***Trichosanthes anguina***. Snakegourd is a very popular vegetable in Bangladesh. Variation in fruit size, shape, color, and pattern was observed.
- ***Trichosanthes dioica***. Pointed gourd, known in Bangladesh as *potol*, is dioecious and propagated by cuttings. Therefore, it was also extremely difficult to obtain seeds as the farmers never allowed the fruits to mature on the vine. Variation in fruit length and pattern was observed.
- ***Talinum triangulare***. Populations of *Talinum* were observed in the three countries, but the species is not cultivated in Bangladesh and Vietnam. Some households in Thailand cultivate *Talinum* in kitchen gardens. In Thailand and Bangladesh, populations of the species are allowed or encouraged to grow near households for a ready source of pot herbs.

Thirty-three percent of the collected materials are named as a priority by at least four of the five countries; 10% belong to the genus *Amaranthus*, 7% are species of *Solanum*, 4% are wax gourds; 3% are jute used as vegetable, and 9% are sponge gourds. Some indigenous species not on the priority list, but which are consumed as vegetables in the collecting site or in other countries, were also collected. Species excluded mainly because of method of propagation, from the priority list but which were deemed important by the local members of the collecting expedition were also collected to become part of the NARS germplasm collection.

Other samples were divided into two: one part for storage at AVRDC and the other to remain in the country of origin. Before each expedition, import permits were obtained from the Council of Agriculture, Taiwan. Phytosanitary certificates were also obtained before the materials were brought to Taiwan. All samples brought to AVRDC were given registration numbers and placed in medium-term storage. All information gathered was duplicated: one set for AVRDC and the other for the country of origin.

A research fellow was appointed to gather information on names and uses of indigenous vegetables in Bangladesh, Indonesia, Philippines, Thailand, and Vietnam. This information will serve as a guide in collection, conservation, and utilization.

Seed storage practices and maintenance of genetic diversity. Some of the practices observed during the expedition included:

a) A farmer in Vietnam uses a classification system based on seed characters, such as seed length and width ratio and seed size, in conjunction with fruit characters.
b) Farmers, in general, store seeds of vegetable varieties wrapped individually by variety, suggesting the practice of maintaining varietal

purity, even during seed storage. One farmer labels packets of seeds with the variety name.

c) In tribal communities in Vietnam, seeds are stored over the fireplace (a common practice among farmers in other countries) to prevent insect infestation. In Bangladesh, seeds are stored under the eaves or ceiling.
d) Some farmers in Vietnam add ash to stored seeds to control storage pests.
e) Farmers practicing shifting cultivation in the hill tracts of southern Bangladesh mix cultivars and species during storage. The seeds are sown together in the same hill (by dibbling) as a mixture of 5–10 species and varieties.
f) Farmers in Bangladesh maintain and plant varieties of amaranth showing a continuous range of stem and leaf colors from green to red. In Bangladesh and Vietnam, distinct varieties of amaranth are grown for the market and for home consumption. Those that fetch low prices or those that have no market at all, are given minimal care and are harvested for home use.
g) Farmers in the three countries use quality traits (e.g., taste, aroma, tenderness, succulence, color) as criteria for selecting vegetable varieties to grow and maintain.
h) In Bangladesh and Vietnam, seeds and varieties are regularly exchanged with relatives and other farmers, even from different provinces.
i) Seed traders in village markets are a regular source of farmers' varieties and commercial cultivars in Bangladesh and Vietnam.

Contact: LM Engle

Regeneration of vegetable accessions for preservation and exchange

GRSU regularly regenerates germplasm accessions for preservation and exchange. A total of 2416 accessions, including at least 35 species, were regenerated.

Regeneration during the summer months

Ten species were sown in April and May 2000. All crops were grown on 25-cm-high raised beds. Kangkong and Ceylon spinach were sown directly into the field (germination in 3–7 days), the rest were transplanted three weeks after sowing in the nursery. The plants were supported on bamboo and iron pipe trellises 1.5 m high. Gourd fruits were allowed to hang above the soil to prevent damage. Bitter gourd fruits were covered with polyethylene bags to protect them from insects. Fruit were harvested after maturity and put in labeled net bags.

- ***Basella alba***. Flowering started in July, 88 days after sowing. Shoot elongation continued even after flowering commenced. Harvesting of seeds started in the middle of September. There were few signs of pests and diseases throughout the growing period. Ceylon spinach sets about 20 fruit per cluster. Harvesting was done when fruit color fully changed to dark purple. After harvest, the fruit were put inside a net bag and crushed until the seeds were pushed out of the fruit and the thick flesh around them. This was followed by washing in water to clean the seeds of debris.
- ***Cajanus cajan***. Pigeon pea, a short-day plant, took 208 days after sowing to flower. Fruit set was high and little damage was caused by insects or pests. It took approximately one month for the fruit to reach maturity. Harvesting was best done in the morning, when pods were still moist. Pods and seeds harvested late in the morning were too dry and easily damaged during threshing. Pods were air dried to facilitate seed extraction. The planting time could be moved to late summer.
- ***Canavalia gladiata***. Sword bean, also a short-day plant, started to bloom in mid August and continued until termination of the experiment in January of the following year. Green pods suffered insect damage. Fruit matured starting in mid October. Harvesting should commence when the entire branch on which the pods are attached has turned brown. When pods are harvested

earlier, i.e., when just the pods have turned brown, seed extraction is difficult. Drying the pods at 15°C and 15% RH for 2–3 days facilitated seed extraction.

- ***Coccinia grandis***. Female plants flowered in July, one week later than male plants. Due to high temperature, only a few fruits were formed in July. Profuse fruit setting started in September, or four months after sowing. Unprotected fruits were severely damaged by insects. The fruit were harvested as soon as they changed from green to red, and put in net bags to ripen. And they were crushed until the seeds were exposed, and gathered in the nets and put together in a plastic container. The crushed fruit were allowed to ferment for two days (to help remove the mucilagenous coating on the seeds) before seeds were extracted by washing with water.
- ***Corchorus olitorius***. Flowering started on 17 August, and pods matured after two months. Harvesting for seed started in November. Some plants exhibited virus-like symptoms. Seeds were easily extracted from the mature, dark brown pods.
- ***Ipomoea aquatica***. Kangkong, a short-day plant, began to flower in late September. Shoot elongation continued after flowering. There were signs of pests and diseases. Harvest began in mid November, when capsules turned brown. After drying, capsules were placed in net bags and threshed by hitting with a bamboo stick. Each pod yielded 3–4 seeds.
- ***Lagenaria siceraria***. Female flowers started to appear in the beginning of August and continued throughout the growing period. Fruit set started two weeks after flowering, but was not satisfactory. To obtain enough fruit, supplementary pollination might be necessary. It took 2–3 months for the fruit and seeds to mature. Fruit maturity is signaled by a change to brown, but at this stage the seeds are not ripe, so fruit harvest should be delayed until the peduncle has turned brown. About 50 g of seed was extracted per fruit.
- ***Momordica charantia***. Male flowers started to appear in the beginning of July, one week after female flowers appeared. Fruit set was satisfactory even without supplementary pollination. Fruit skin broke a few days after maturity. Fruit were harvested and the seeds extracted just after fruit breaking.
- ***Trichosanthes cucumerina***. Male flowers appear in mid July and female flowers two weeks later. When more than 80% of the fruit skin changed to red, the fruit was harvested and seeds extracted from the broken fruit. About 30 seeds could be extracted per fruit.
- ***Vigna umbellata.*** Rice bean is a short-day plant. Most of the flowers were damaged by insects, which reduced the number of pods, which suggests the need for pest control measures soon after flowering. Mature pods broke easily, resulting in seed loss. Harvesting should, therefore, be done early in the morning and before the pods are too dry. After extraction all seeds were put in the drying room for two weeks to reduce seed moisture content to 4–7%.

Equilibrium seed moisture content

Studies were conducted to determine the behavior of seeds under different conditions of temperature and relative humidity (RH).

Newly extracted seeds of seven species were obtained. They were cleaned and left on a bench in open containers to dry for five days at ambient temperature (28ºC, 65% RH). Each experiment was conducted in completely randomized design with two replications each. For each replication, at least 15 g of seeds of the species was left in open containers under different conditions of temperature and humidity. After two days, about 1 g of seeds in each treatment was sampled for moisture content. The determinations were repeated every two days for 14 days. The high constant temperature oven method was used for *Cucurbita, Luffa,* and *Momordica,* and the low constant temperature oven method was used for *Arachis, Capsicum, Citrullus*, and *Solanum* (ISTA, 1985). Data on seed moisture content (SMC) in percentages were transformed to arcsin values before statistical analysis. The seeds were said to have reached equilibrium moisture content (EMC) when two to three consecutive readings showed no significant differences at 5% level of probability using Duncan's multiple range test.

In the drying room (15ºC, 15% RH), seeds of four species reached EMC of 3.9–5.1% after 10 days (Table 84). In the short-term room (15ºC, 45% RH),

Table 84. *Equilibrium seed moisture content of some vegetable seeds, peanut and watermelon*

Temperature (ºC)	15	15	20	25
Relative humidity (%)	15	45	45	50
Arachis hypogaea				
Days to reach equilibrium	10.0	10.0		
SMC at equilibrium (%)	3.9	4.9		
Capsicum annuum				
Days to reach equilibrium	10.0	12.0		
SMC at equilibrium (%)	4.8	6.3		
Citrullus lanatus				
Days to reach equilibrium	10.0	12.0		
SMC at equilibrium (%)	4.9	6.4		
Cucurbita moschata				
Days to reach equilibrium	10.0	10.0	10.0	10.0
SMC at equilibrium (%)	5.1	6.3	7.2	7.6
Momordica charantia				
Days to reach equilibrium		8.0	10.0	8.0
SMC at equilibrium (%)		6.8	7.2	7.6
Luffa aegyptiaca				
Days to reach equilibrium		12.0	10.0	10.0
SMC at equilibrium (%)		7.1	8.5	8.6
Solanum melongena				
Days to reach equilibrium		10.0	10.0	12.0
SMC at equilibrium (%)		7.0	7.6	8.0

seeds of all seven species reached EMC of 4.9–7.1% in 8–12 days. In the packing room (20ºC, 45% RH), the seeds of four species reached EMC of 7.2–8.5% in 10 days. In the seed processing room (25°C, 50% RH), the seeds reached EMC of 7.6–8.6% in 10–12 days.

For preservation, seeds are dried at 15ºC, 15% RH for two weeks. For all species studied, seeds reached a moisture content of less than 7%, meeting the standard for long-term conservation. Even in an efficiently air conditioned room the seeds can be maintained at moisture contents of less than 9%, which is adequate for short-term storage.

Previous study showed that in the short-term store, mungbean seeds kept in paper bags for 10 years had moisture content of 10% while in the medium-term store, seeds of the same age stored in plastic jars had moisture content of 9.4%. Seeds packed in aluminum foil bags maintained a low moisture content of 7.2%.

Contact: LM Engle

Enhancing vegetable germplasm utilization through widespread distribution

More than 18,000 samples, including breeding lines, were sent from headquarters in 2000. About 97% went to 77 countries, and about 3% went to AVRDC regional offices. A total of 2939 samples (16% of the samples sent) came from the AVRDC genebank . The recipients were another genebank for duplicate storage, government organizations, international projects in developing countries, private companies, individuals, and universities. The samples were used for research, demonstration, and home gardens.

A total of 350 samples from the genebank were given to other AVRDC units for research.

Evaluation and pre-breeding activities on selected newly introduced indigenous vegetable species

Characterization and evaluation of indigenous leafy vegetables from South and Southeast Asia

Characterization were carried out in the AVRDC field using 101 accessions of *Amaranthus* spp. (amaranth,), 24 accessions of *Basella* spp. (Ceylon spinach,), 9 accessions of *Chrysanthemum coronarium* (garland chrysanthemum), 7 accessions of *Corchorus* spp. (white jute,), 18 accessions of *Gynandropsis pentaphylla* (syn. *Cleome gynandra*, spider flower), and 24 accessions of *Ipomoea aquatica* (kangkong,) from fall 2000 to spring 2001.

Growth analysis and changes in nutritive value in Amaranthus *spp.*

Transition in plant height and fresh weight of leafy and stem types of *Amaranthus* spp. at various stages are shown in Figure 23. Twenty days after seeding, plant height of the stem types (TOT1793 from Indonesia and TOT2355 or Ames 2084 from the collection at the US Department of Agriculture) was double that of the leafy types (TOT2222 from Malaysia and TOT2272 from Taiwan). Thirty-two days after seeding (3 October 2000), there were wide differences in plant height among accessions, but fresh weight was almost at the same level. The typical leafy type, TOT2222, had the lowest plant height and fresh weight. The stem types grew taller and had higher fresh weight compared to the leafy types. However, differences in stem width and number of expanded leaves were not detected between leafy and stem types. Aside from their longer stems, the stem types had narrow leaves.

Seedlings, three weeks after seeding, showed no significant differences in ß–carotene, vitamin C, sugar, iron, calcium, and fiber content. However ß-carotene content of the leaves of the stem types (TOT1793 and TOT2355) was usually higher than the leafy types (TOT2222 and TOT2272) (Figure 24) when harvested in the later growth stage. The leaves of stem type TOT1793 had the highest vitamin C content (Figure 25). There was no difference in the sugar content of the leaves, but the sugar content in the stem of stem type TOT1793 was similar to that of one leafy type (TOT2272) and higher than the other (TOT2222) (Figure 26).

The four accessions used in these experiments were green. TOT2222 is paler than the others. However, *Amaranthus* spp. possess wide genetic diversity in size, shape, and color. There are many purple stem types, especially in Bangladesh. Nutrient content assessment of the different stem and leafy types of *Amaranthus* spp. is, therefore, a very attractive research area, and much remains to be done.

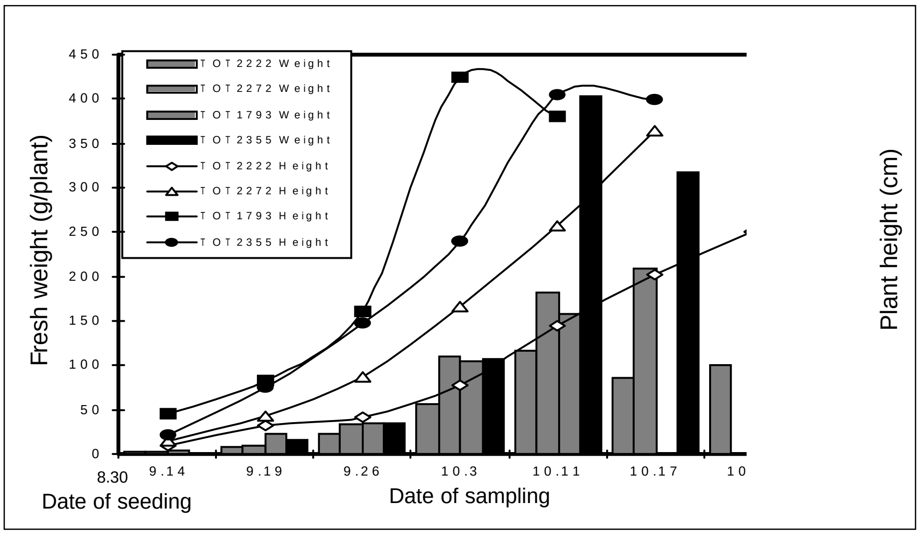

Figure 23. *Transition in plant height and fresh weight of* Amaranthus *at various stages, 2000.*

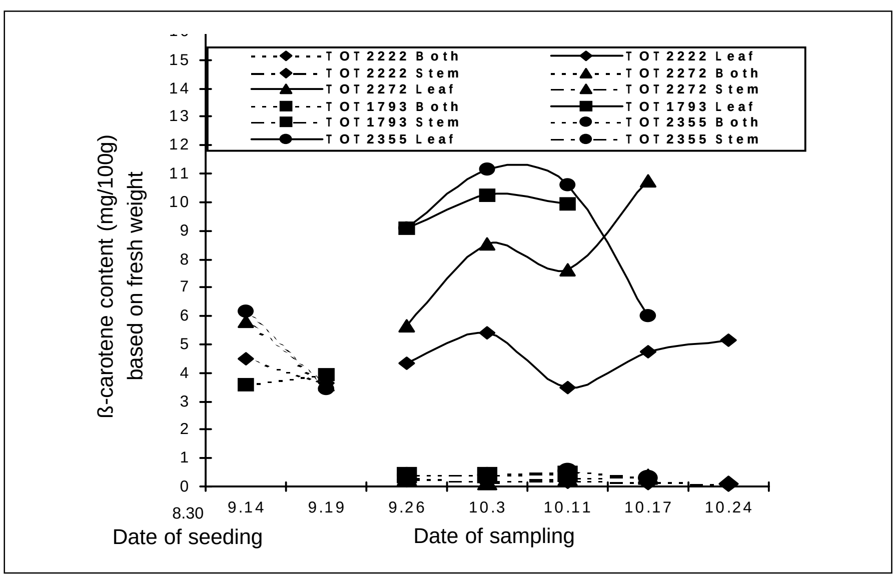

Figure 24. *Transition in carotene content of* Amaranthus *at various growth stages , 2000.*

Characterization of Amaranthus *spp. as sprouting seeds*

Sprouted seeds in their most vigorous growth stage are rich in vitamins A and C and various minerals. And sprouts can provide vegetables year round. *Amaranthus* spp. are rich in diverse colors and they produce many small seeds. This study was undertaken to assess the coloration, seed productivity, and sprout productivity of *Amaranthus* spp.

Based on the results of observations in the greenhouse and field, mainly regarding color, 16 accessions of *Amaranthus* spp. were chosen for this experiment. Characteristics of the sprouted seeds are described in Table 85. One thousand-seed weight was different among accessions, as sprout yield. Sprout productivity was measured one week after seeding using 1 g seeds.

Sprouting seeds in the dark produced white or yellow sprouts, which then turned gree/pale green, or purple/pale purple after at two days under light. Based on seed productivity, sprouting productivity, and color of sprouts, TOT0521 (Bangladesh), TOT4058 (Vietnam), TOT4510 (Bangladesh), and TOT4661 (Bangladesh) stood out.

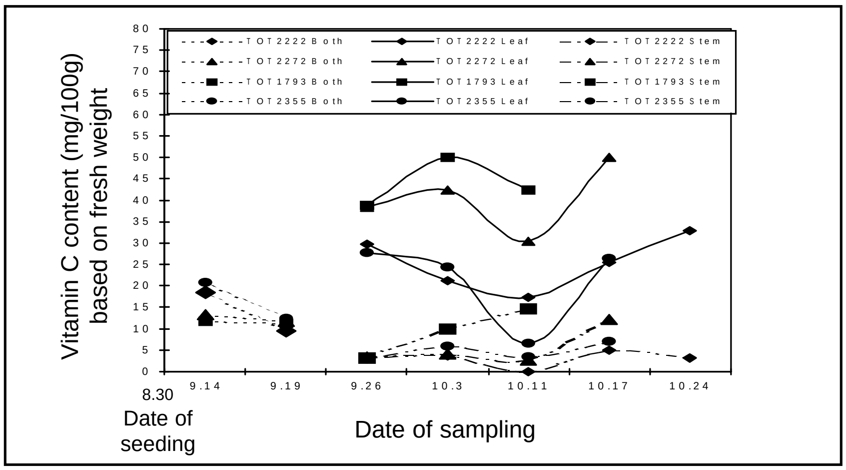

Figure 25. *Transition in vitamin C content of* Amaranthus *at various growth stages, 2000.*

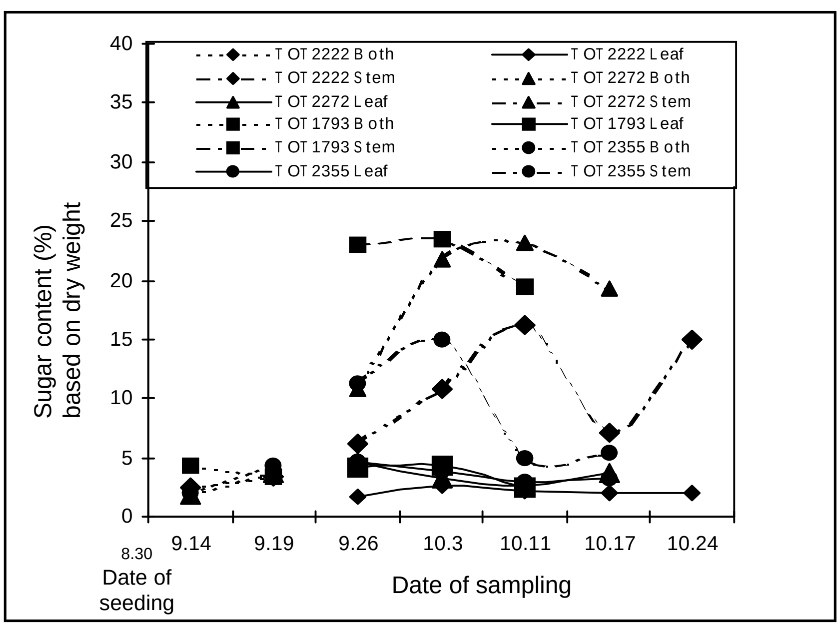

Figure 26. *Transition in sugar content of* Amaranthus *at various growth stages, 2000.*

Table 85. *Characteristics of sprouting seeds of* Amaranthus *spp.*

Entry number	Origin	Color of true leaf	Seed[1] yield (g)	1000-seed weight (g)	Color of hypocotyl[2] upper	middle	lower	Color of cotyledon[2] front	back	Sprout[3] yield (g)	Remarks
TOT0512	Bangladesh	Green	190	0.70	PP	H	H	G	G	8.04	
TOT0521	Bangladesh	Dark Purple	540	1.77	P	H	H	G	PP	9.95	
TOT1793	Indonesia	Green	496	1.23	H	H	H	G	G	8.22	
TOT1818	Indonesia	Green	575	1.50	H	H	H	G	G	8.31	
TOT2222	Malaysia	Green	200	1.20	H	H	H	G	G	8.16	
TOT2272	Taiwan	Green	745	1.27	H	H	H	G	G	8.70	
TOT3524	Vietnam	Greenish Purple	278	1.43	PP	PP	PP	G	PP	4.52	
TOT3573	Vietnam	Green	415	0.53	H	H	H	G	G	9.55	Small seed
TO3919	Vietnam	Pale Purple	366	0.50	H	H	H	PG	PG	7.95	Small seed
TOT4058	Vietnam	Green	740	1.20	H	H	H	G	G	9.52	Mixture
TOT4250	Bangladesh	Pale Purple	465	1.10	PP	PP	H	G	G	9.05	Mixture
TOT4326	Bangladesh	Purple	350	1.50	PP	PP	H	G	G	8.14	Mixture
TOT4349	Bangladesh	Pale Purple	426	0.93	P	P	H	P	P	9.42	
TOT4510	Bangladesh	Pale Purple	455	0.30	H	H	H	PG	PG	12.02	Small seed
TOT4582	Bangladesh	Pale Purple	550	1.67	PP	PP	H	G	G	6.88	
TOT4661	Bangladesh	G. (Purple in vein)	1025	1.40	PP	PP	H	G	G	9.87	

1 Total yield of seeds (g) by direct seeding (4 g seeds) at a bed size of 1 m width and 2 m length.
2 H : White, PP : Pale purple, P : Purple, PG : Pale Green, G : Green.
3 Total yield of sprouting seeds (g) were measured 1 week after of sowing derived from 1 g seeds. Mean value of 3 replications.

Selection of day-neutral accessions of Amaranthus *spp. for bolting*

For a leafy vegetable to be useful for year-round production it must able to produce vegetatively regardless of daylight periods, and not bolt. In order to evaluate the earliness of flower bud formation, 337 accessions of *Amaranthus* spp. were grown in the greenhouse from September to November in 2000. Day length during the experiment was 12 hours 29 minutes at 0 day or date of seeding (6 September 2000) and 10 hours 46 minutes at 94 days after seeding, or the final day of flowering (9 December 2000). Ten plants of each accession were observed. The day when half of the plants formed buds was recorded as the day of bud formation, and the first day when half of the plants were in flower was recorded as the day of flowering.

The earliest maturing accessions flowered 24 days after seeding (DAS) and the latest (one accession) flowered at 94 DAS (Figure 27). The earliest maturing accessions formed buds 16 DAS and the latest (one accession) formed buds 94 DAS. (r = 0.95) Most accessions formed buds 22–40 DAS and flowered 26–50 DAS (Figure 27).

There was high correlation (r = 0.95) between day of bud formation and day of flowering. Correlation coefficient between number of expanded leaves and plant height at bud formation was 0.74. The correlation between plant height and day of bud formation, and between number of expanded leaves and bud formation was 0.73 and 0.75, respectively.

Leafy accessions that do not flower within one month after seeding and stem types that do not flower within one and half month after seeding are acceptable for summer cultivation. For winter cultivation, leafy accessions that do not flower within one and half month after seeding and stem types that do not flower within two months after seeding would be acceptable. Selection for day-neutral accessions would allow year-round production of the crop. Unwanted flowering, which can result in a weed problem due to the uncontrolled scattering of seeds, would be avoided. The relationship between the day-neutral trait and other agriculturally useful traits must next be clarified.

Organoleptic evaluation of Amaranthus *spp.*

Organoleptic evaluation is an important method for evaluating taste objectively. However, taste varies from place to place, so location-specific tests are needed prior to the introduction of a variety.

Organoleptic evaluations of leafy (TOT2222 and TOT2272) and stem type (TOT1793 and TOT2355) *Amaranthus* spp. were carried out at AVRDC headquarters. Young leaves and stems were cut into five cm lengths and cooked 30–60 seconds in boiling water with salt added. The cooked leaves were served with soy sauce and chili pepper. About three-fourths of the 35 taste panel members were Taiwanese and the rest were of other nationalities. The panel preferred the leafy types over the stem types (Figure 28).

Contact: T Sato

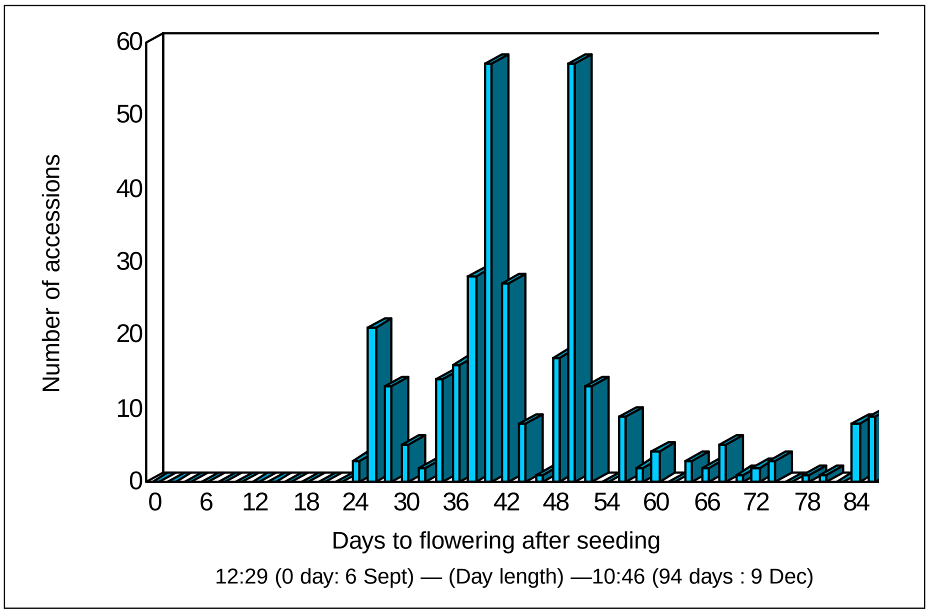

Figure 27. *Days to flowering in* Amaranthus *in 2000.*

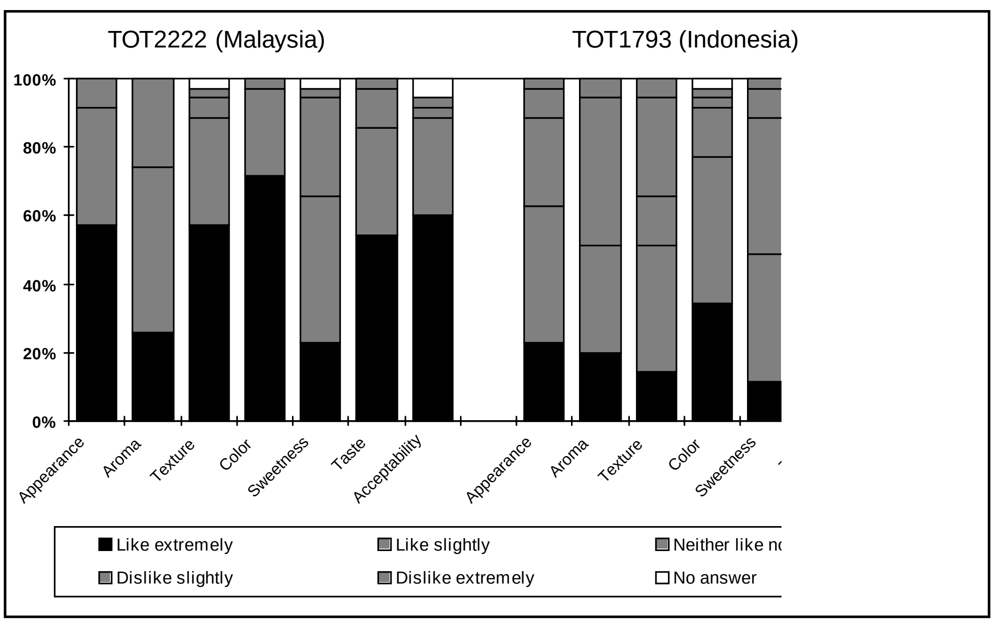

Figure 28. *Organoleptic evaluation of* Amaranthus *at AVRDC in 2000.*

Project 9. Collaborative research and networks for vegetable production

The objective of project 9 is to increase the capacity of national agricultural research systems (NARS) to perform regional collaborative research, and to enhance the adoption and impact of research innovations. To this end, AVRDC fosters and supports effective regional and inter-regional research collaboration. In particular, the Center facilitates this collaboration using participatory research planning methods, and engages directly in collaborative research with NARS partners and advanced laboratories. The following reports summarize the work of AVRDC's collaborative programs with its various partners.

AVRDC-USAID Bangladesh project

With the assistance of Grant No. LAG-G-00-93-00040-00 Modification # 3, the United States Agency for International Development (USAID) supported AVRDC to work with Bangladesh NARS under the leadership of the Bureau of Agricultural Research Center (BARC) to strengthen vegetable research and development programs in the country.

Efforts have been made to boost vegetable production for domestic markets and export through technological improvement, development of need-based infrastructure, transfer of valuable varieties and technologies to farmers, enhancing capacities of scientists through specialized trainings overseas, organizing in-country trainings, and involving AVRDC and its regional centres/networks for research and other support.

In collaboration with BARC and the Bangladesh of Agricultural Research Institute (BARI), the first phase ofthe project was to: 1) identify the problems of the vegetable growers, scientists and extension workers in Bangladesh; and 2) to support BARI and other NARS institutes by providing useful germplasm and assisting in identifying promising lines/varieties/technologies suitable for the country.

In the second phase, technologies suitable for various regions were introduced and identified. An active collaboration existed in strengthening the research infrastructure; training of researchers and extension workers at AVRDC; and technology transfer through BARI regional stations, Department of Agriculture and Extension (DAE) and NGOs.

The period of May 1997 to October 2000 may be considered the time of real consolidation of activities - more backstop research on identified issues at AVRDC headquarters, more output in generations/ release of varieties, taking up the transfer of technology through a network of NGOs who were associated at the grass root in verifying the results, training of trainers, training of farmers, exposure to more policy makers, researchers, and making relevant impact analyses. It enhanced the capacities of the researchers to generate better varieties and other technologies.

In the last year of this phase the USAID provided additional resources (funds/staff) to carry out the massive transfer of available technologies. A network of 23 NGOs was thus established that covered 49 sub-districts of Bangladesh to conduct large number of on-farm demonstrations, pilot production demonstrations, adaptive trials, hands-on nutrition awareness training to women farmers, and conducting more field days in different regions of Bangladesh.

Brief accomplishments

Backstopping research

AVRDC headquarters provided strategic backstop research support to Bangladesh throughout the tenure of the project. Some of such activities covered an array of multidisciplinary research activities related to micronutrient studies, developing IPM strategy, developing genotypes resistant to high temperature, virus (MYMV, TYLCV), bacterial wilt, and late blight, while being rich in vitamins A and C.

Germplasm introduction

Since 1993, AVRDC provided 2997 more germplasm to BARI, other NARS institutions, private seed companies, and NGOs making a total of 3454 genotypes of 59 different vegetable crops. The new genotypes had useful traits specific to different vegetables (e.g. earliness, high beta-carotene, high vitamin C, resistance to diseases and high temperature). The project also supported in collecting indigenous germplasm of pointed gourd and drumstick at Ishurdi. Varieties of newer crops such as longmelon, muskmelon, round melon, asparagus, and baby corn were also introduced in Bangladesh to bring diversity and sustainability in vegetable production.

Such a broad genetic base is important in developing suitable varieties.

Varietal and technological development

The period 1993-2000 was very satisfying in which 42 more varieties were released by BARI (34), BINA (7) and BSMRAU (1). Generating and supplying useful germplasm, better appreciation of knowledge of the scientists through overseas specialized training and participation in international workshops/ symposia, and sustained rigorous backstopping research at AVRDC, have resulted in accelerating the scientific output. Now dozens of promising lines of several crops are in the pipeline.

All 13 varieties of tomato released by BARI and BINA during the last 7 years have been developed from AVRDC material. These include varieties rich in beta-carotene. Promising lines resistant to TYLCV, bacterial wilt, and having high nutritive value are in the pipeline. The yield level of most of these varieties ranges 80-90 t/ha in main season and 20-45 t/ha during summer. Now, tomato is grown round-the-year in Bangladesh. They are planted in raised beds and greenhouses, and are applied with growth regulators. AVRDC genotypes made summer tomato cultivation possible.

Almost 100 percent contribution of AVRDC generated/supplied material go to tomato, peas, cabbage, Chinese cabbage, cauliflower, red amaranth, okra, and kangkong. Yellow vein mosaic virus (YVMV) resistant okra variety has revolutioned okra cultivation in Bangladesh by replacing all other popular varieties in about 80-85 % of the area. Bold seeded, MYMV resistant and short-duration mungbean varieties have developed from AVRDC material. Mungbean cultivation is also spreading very fast in north and northwest districts of Bangladesh replacing rice, tobacco crops and fitting well into wheat-rice cropping systems. It is hoped that such short duration mungbean varieties may occupy about 400,000 hectares of land (50% area of wheat) within next two to three years if the efforts are aggressively pursued. Similarly, tomato cultivation has spread to south-west region, a non-traditional tomato growing area.

The grafting technology in tomato and watermelon has been popularized to a good extent to combat bacterial wilt and fusarium wilt diseases. It still requires sustained efforts for the technology to expand on a commercial scale by young entrepreneurs.

Protein-rich yardlong bean, vitamin-A-rich leafy vegetables (kangkong, red amaranth, batisak, chinasak), and tomato have been popularized in larger areas of Bangladesh. Many of such varieties have been included in the homesteads so that nutrient-rich vegetables are consumed by household family members.

Logistic support

The project strengthened BARI and its regional stations as well as the Bangabandhu Sheik Mujibur Rahman Agricultural University (BSMRAU) through the provision of need-based essential laboratory/ office equipment, audio visual aides, polytunnels, brick-lined pucca nursery beds, and polyhouses where research on raising seedlings was conducted.

Manpower development

Twenty-five scientists of BARI were trained on specialized topics for four weeks to seven months each at AVRDC to upgrade their skill in conducting research.Three BSMRAU students conducted part of their PhD research work at AVRDC for five to seven months each. It will go a long-way to develop critical mass of capable vegetable scientists in Bangladesh.

About 64 scientists, extension workers, NGO officials, seed and nurserymen, and relevant young entrepreneurs were encouraged to participate in international workshops, symposia, conference, and study tours to widen their knowledge in their own fields to exchange ideas with scientists of other countries. The policy makers and research managers were also provided opportunities to witness the modern trend of research and development at AVRDC, its Asian Regional Centre in Bangkok, as well as outreach stations in the Philippines so as to equip them with the knowledge on setting the priorities and directing policies.

In-country training

The project organized 10 in-country training courses on relevant modern topics to train 400 participants drawn from BARI and other NARS institutes, and extension workers of NGOs. In most of the trainings scientists from AVRDC headquarters served as resource persons along with local senior scientists.

National workshops/symposia

During the past seven years, seven national-level workshops/symposia were organized enabling 467 participants from BARC, BARI, AVRDC, USAID, BADC, DAE, BSMRAU, BAU, Hortex Foundation, ATDP, NGOs, seed companies, private entrepreneurs and farmers' representatives to attend discussion and in formulating useful recommendations.

Short term local consultants

Nine senior and experienced Bangladeshi vegetable scientists worked as short term local consultants for four to six months each on identified subjects: homestead, crop agribusiness, IPM, vegetable research, seed production, post harvest technology and technology transfer. They made several useful suggestions to improve the research and development system in Bangladesh.

Interaction with Government Organizations (GOs), NARS institutions, and USAID

The project maintained communication with the officials of BARC/BARI, BSMRAU and USAID in the planning and implementation of the workplan. Senior officials from these organizations periodically reviewed the progress of the project and visited the project sites regularly to give encouragement to the project staff, NGO staff, as well as the farmers. The Bangladesh newspaper media published articles in their national and local newspapers about the significant achievements of the project, reaction of the NGOs and their beneficiary farmers.

Interaction with partner NGOs

AVRDC projects were associated with several NGOs almost from its inception. In the year 1999-2000, a network of 23 NGOs was established to associate with on-farm demonstrations, pilot production demonstrations, training of women farmers on nutrition awareness, organizing field days in 35 districts of the country. Their trainers were trained on various aspects of vegetable cultivation in different seasons including off-season cultivation, and grafting technology. They presented their results and took an active part in the review workshop.

Linkage with other AVRDC projects

The AVRDC staff made regular visit to overview the project activities, and participated as resource persons in various in-country trainings, and monitoredthe performance ofvariousvarieties/ technologies developed. The project also assisted and overviewed the activities of other related projects including SAVERNET, IPM projects, indigenous germplasm projects, and mungbean sub-network activities being coordinated by AVRDC.

Technology transfer

Inspite of the fact that several vegetable production technologies including improved varieties have been evolved by BARI, BINA and IPSA (BSMRAU), their adoption in the farmers' fields needs improvement. Hence this project undertook this challenge and over the years about 28,171 on-farm demonstrations and 272,000 homesteads were laid out.

To achieve the desired activities, 2159 trainers from NARS, NGOs, DAE, private entrepreneurs and seed companies were trained through 74 courses organized on specific topics of vegetable cultivation and seed production.

About 1493 courses were conducted in collaboration with various NGOs to train 46,371 farmers. Through 101 field days organized by the project, 8929 farmers were given the opportunity to participate formally. In 2000, the farmers' exchange visit component was introduced through respective NGOs.

During the year 1999-2000, large number of on-farm demonstrations (11,008) and homesteads (91,400) were carried out through NGOs. A 27-NGO network (now 23) was established to conduct on-farm demonstrations, adaptive trials and homesteads activities in about 49 upazilas of 35 districts covering almost all agro-ecological zones of the country.

About 20 technologies were selected for demonstrations during four seasons starting from kharif-I (1999) to kharif-I (2000). The trainers and the farmers were provided the cultivation manuals, leaflets and guidelines for conducting demonstrations, procedure of collecting sample data and writing reports. The reports were presented and discussed in review workshops after each season. The monitoring team regularly visited to monitor and guide the farmers on the spot about their problems. The important feedback was obtained on each technology from all NGOs. The researchers were informed about the major researchable issues.

The massive on-farm demonstrations, adaptive research trials, and homestead activities over the years helped in identifying and popularizing the varieties/technologies in different regions. The results may be summarized as follows:

- helped in identifying the suitability of several genotypes/technologies in different agro-ecological zones (AEZs) faster.
- helped in identifying the constraints on the farmers' fields and giving feedback to the researchers.
- helped in popularizing the cultivation of promising varieties in newer areas.
- established that BARI Tomato-4 and 5 are superior for summer tomato cultivation, however the high cost of protected structure, use of growth regulator, high risk (due to bacterial wilt and climate) are limiting off-season production
- the issue of local preference for specific color (amaranth, gourd), shape (bottle gourd, eggplant) also brought the suggestion to be made to the researchers for developing varieties to meet their specific requirements.
- established that BARI Dherosh-I has high yield, resistance to YVMV, and acceptable quality. The appearance of a few susceptible plants reveals the need of developing some more varieties from different sources of resistance to YVMV.
- indicated that okra can successfully be grown in off season (winter) especially in the coastal districts where the winter is mild. It is a potential year-round crop.
- proved that regular training to NGO trainers and farmers, and organizing field days are beneficial to get the desired results in increased production, productivity, consumption, income generation.

Nutrition awareness training

About 70 trainers of 23 partner NGOs were trained on basic nutrition and post harvest management of vegetables. About 48,000 women farmers were imparted hands-on training on nutrition awareness and processing of vegetables for home consumption during the last two years.

During the year 2000, 10,020 women farmers of 345 villages were trained on this aspect. It brought very encouraging results in developing low cost high nutritive diets for the poor families.

Post-flood rehabilitation

Bangladesh experienced many typhoons and floods in 1998. At times, 60-70 per cent area of the country was under water. The prompt and timely gesture of AVRDC in sparing USD 200,000 (Tk. 9.38 m) for the above purpose was highly appreciated by USAID. As a result of the assistance to three NGOs (BRAC, PROSHIKA, GKT) about 887,104 farmers and landless workers of 282 sub-districts belonging to 56 districts were benefited from the assistance.

BARI was also supported to supply over 100,000 seedlings of different vegetables to remedy the shortage of vegetables.

Socioeconomic/impact studies

The impact analyses of the AVRDC-USAID Bangladesh Project intervention were conducted by different NGOs, BARI and AVRDC headquarters. The notable findings were:

In collaboration with NGOs

Vegetable growers in Manikgonj areas consumed 25.2% of their vegetables. Thus, growers both improved their diets and generated income. By selling the rest 74.8 per cent extra income was generated (GKT, 1995-96).

- Grameen Krishi Foundation (GKF) in a study conducted in 1997-98 said that in six northern districts found that as a result of organized farmer field days. It resulted in increases in area planted to vegetables (up to 40%), farmers' income (5-50%) and adoption of new varieties in these areas (5-50%).

In collaboration with BARI

- During 1998-99, BARI conducted a study in four districts viz. Manikgonj, Jessore, Rangpur and Chittagong to assess the impact of virus resistant okra and summer tomato cultivation. It was found that under cultivation of these varieties increased and that 71-77% of the produce were s old by the sampled farmers to generate extra income (23-29% was consumed by the families). The gross marginal returns was US$790/ha for okra and US$4600/ha for summer tomato, respectively. The return to labor per day was US$4.40 and US$13.20, respectively for okra and summer tomato against a daily wage of US$1.00 per day.
- Five tribal communities in five regions were targeted for another study on their food habit involving 900 respondents in three seasons during 1998-99. The study revealed:

- respondents consumed 70 per cent of their own produce and rest was sold.
- average vegetable consumption during the peak period was 81 g/day/person and 45 g in the lean period.
- Garo tribe in Sherpur consumed the maximum (132 g/person/day) and the lowest by Rakhain tribe in Cox's Bazar (59 g/person/day).
- The average yield was very low due to non-availability of high yielding varieties, high price of inputs, and lack of relevant knowledge.

AVRDC headquarters made an elaborate survey at Savar, Jessore, Rangpur and Noakhali in 2000 to study farm production and household consumption. A brief summary is given below:

Production and price trends

While vegetable production (including onion, garlic, and chili), increased by only 1.99% during 1972-94, it increased more than 10% just within three years from 1.42 MT in 1995 to 1.59 MT in 1998. The area under production increased during the corresponding period by about 8%. The analysis of nominal farmgate vegetable prices suggests that they became almost stagnant during the last four years, compared to upward drift in the pre-innovation time.

Costs and profits

Due to the adoption of new technologies, per unit cost of vegetable production has decreased in all cases. Yields of adopters are about 24% higher compared to non-adopters, and 34% higher compared to before adoption. Hence, the net return on vegetables is about 22% and 34% highe, respectively. The mean farm cash income of adopting farmers is Tk. 1743 per month, which is about 8% higher than the farm cash income of non-adopters and 32% higher than that of non-vegetable farmers. Adopting farmers also earn higher off-farm income: Tk. 670 compared to Tk. 577 for non-adopters and Tk. 569 for non-vegetable farmers. Vegetables generate Tk. 673 and Tk. 425 per month cash income to adopter and non-adopter families, which constitutes about 39% and 26% of the total farm cash income, respectively.

Consumption

On the average, the daily per capita consumption of vegetables in Bangladesh is only 126 g, which is less than the minimum recommendation. Consumption is not only low, but there is also little diversity in vegetable consumption. Main vegetables consumed are fruit types, which are low in vitamin A and iron. Leafy vegetables, rich in vitamin A and iron, have a small share in total vegetable consumption.

Adopting families consume 67.3% more vegetables than non-vegetable farmers, and 26.2% and 53.5% more than non-adopting farmers and urban dwellers, respectively. Moreover, vegetable farmers have, on the average, larger and more diversified home gardens.

Economic surplus

It is estimated that the technological innovations in vegetable production generated about US$ 32 million economic surplus in Bangladesh. The producers benefited in terms of higher productivity and reduced costs of production, while consumers benefited from lower vegetable prices as a result of increased supply. The consumers' surplus is about US$18 million compared to the producers' surplus of US$ 14 million. The USAID investment on the project was US$ 3.67 million. Adding an estimate of US$ 6.33 million as contribution from the government of Bangladesh and other donor agencies during the project period, it is estimated that the internal rate of return on vegetable research may have been as high as 200% or more. Thus investment made on vegetables research is highly profitable and an excellent way to improve the lot of poor farmers and urban dwellers.

The estimated demand elasticities of vegetables are relatively low. The price elasticity for vegetables is only 0.20 and income elasticity of 0.22, implying that increasing vegetable supplies through technological innovation or increasing incomes will not be enough to enhance vegetable consumption unless such moves are supported by a nutritional awareness program highlighting the role of vegetables in supplying micronutrients. About 48,000 women (during 1998-2000) imparted training on the importance of micronutrients in health, and the role of vegetables in supplying these micronutrients at cheaper rates.

Additional findings

- The adoption of some crops has spread into non-traditional areas, enhancing the availability of such vegetables over the extended period. For example, the cultivation of tomato in Barisal-Patuakhali region (southwest region), mungbean in north and northwestern districts, and okra during winter in coastal areas of Bangladesh are helping in increased availability of vegetables throughout the year. Mungbean alone has, potential to fit into wheat-rice systems covering about 50% of the area planted to wheat (0.8 m ha).
- The seed production of the released varieties has been taken up by a few NGOs, private contract farmers and seed companies.
- As a result of participating with a team of 5-6 members in a seminar on 'Hi-tech Hort' one young entrepreneur has taken up the challenge of introducing the polyhouse fabrication and drip irrigation in Bangladesh for the first time. Another entrepreneur has improved and streamlined the vegetable seedling supply system in Bangladesh after undertaking the above short study visit to India.

In summary, the project was able to improve the compatibility of vegetable production with other crops by enhancing per hectare yields and reducing per unit cost of production. The promotion of new technologies improved the growth rates in vegetable supplies, halted the increase in vegetable prices, and reduced seasonality. It improved farmers cash income, generated US$32 million surplus to consumers and producers in just four years time, and the pay-off on the investment in the project was more than 200%. The promotion of new technologies along with the nutritional awareness program was able to increase expenditure on food as well as vegetable consumption, and reduced micronutrient deficiency. However, area under vegetable constitutes only 1.42%, and vegetable consumption is still far below the recommended level. Efforts to enhance vegetable supplies coupled with nutritional awareness on the role of vegetables in supplying micronutrients need to be continued.

Contact: DP Singh

AVRDC-ROC cooperative program

Bilateral vegetable research and development in Taiwan

The goal of this program is to increase the capacity of the national agricultural research system (NARS) in Taiwan, to stabilize summer vegetable production, and to reduce seasonality of vegetable supply. The project continued to conduct adaptive research in cooperation with the NARS of the host country. The Republic of China (ROC) Council of Agriculture (COA) supports the project. Promising AVRDC developed vegetable varieties/lines are evaluated in the field in different seasons and locations in Taiwan in cooperation with various district agricultural improvement stations (DAIS). The research and trials aim to complement the NARS and identify promising vegetable varieties and improved cultural practices for release in Taiwan. To date, 16 AVRDC improved varieties of various crops, including mungbean, soybean, vegetable soybean, Chinese cabbage, processing tomato, fresh market tomato, and cherry tomato, have been released to farmers. Most of these varieties now make major contributions to vegetable production in Taiwan (Table 86).

Table 86. *Planted area, estimated production, and value of AVRDC improved vegetable varieties in Taiwan, 1999*

Crop and varieties	Area planted (ha)	Production (t)	Value (US$)
Fresh market tomato	741	48,890	45,834,375
Taichung ASVEG #4			
Hualien ASVEG #5			
Taoyuan ASVEG #9			
Cherry tomato	1,080	53,784	58,826,250
Tainan ASVEG #6			
Kaoshiung # 1	1,469	11,755	8,816,563
Total	3,290	114,429	113,477,188

Regional yield trials

In 1999–2000, a total of 39 regional yield trials were conducted, in cooperation with Tauyuan, Taichung, Tainan, and Kaohsiung DAIS, to evaluate AVRDC's improved varieties/lines of vegetable soybean, mungbean, fresh market and cherry tomato, and lettuce, along with locally developed varieties, at different locations and in different seasons (spring, summer, and autumn).

Vegetable soybean

In the vegetable soybean trials, nine lines, including two AVRDC lines, were evaluated in 12 trials against three check varieties. The lines showed significant differences in pod yield in different seasons and locations. In the spring crop, an AVRDC line, GC89023-7-1, gave a high average pod yield (8.7 t/ha) across the five locations, but its performance in summer was unsatisfactory (Figure 29). KVS836, a Kaohsiung DAIS developed line, produced the best yield (6.4 t/ha) in summer trials. Another AVRDC line, GC89008-17-1-1, had the highest protein content (44%, mean of three locations), comparable to TS82-02V-03 (43.5%).

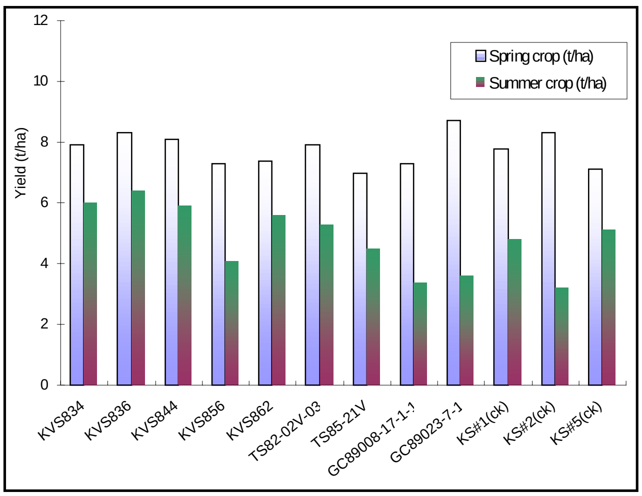

Figure 29. *Average pod yields of vegetable soybean lines in regional yield trial across five locations.*

Mungbean

The mungbean regional yield trials conducted by AVRDC and Tainan DAIS identified three lines, VC6040A, NS81-55, and NS85-03, that out yielded the check variety Tainan #5. Their yields were in the range 1.61–1.81 t/ha. These lines have large, dull seeds that are preferred by local consumers.

Fresh market tomato

In summer 2000, five hybrids were evaluated against the check, Taichung ASVEG #4, at three locations in the Taichung area. FMTT593, a large-fruited variety with dark green shoulders, gave high yields consistently in the three locations (Table 87). It had an average yield of 72.6 t/ha compared to 70.4 t/ha for Taichung ASVEG #4.

Table 87. *Yields (t/ha) of fresh market tomato lines in trials at various locations in Taiwan, summer 2000*

Entry	Location			Mean
	Renai	Hsinyi	Puli	
FMTT552	71.0	65.3	62.4	66.2
FMTT553	63.5	67.7	66.9	66.0
FMTT556	68.6	63.8	65.1	65.8
FMTT591	68.9	74.6	69.5	71.0
FMTT593	73.0	73.6	71.2	72.6
Taichung ASVEG #4	71.1	71.8	68.3	70.4
Mean	69.4	69.5	67.2	68.7
CV (%)2.10	2.32	2.71		
LSD (0.05)	2.19	2.43	2.75	

Cherry tomato

Three new cherry tomato hybrids, CHT1126, CHT1127, and CHT1130, were tested in three regional yield trials in 1999–2000 against check variety Tainan ASVEG #6. CHT1127 and CHT1130 out-yielded the check by 37% and 35%, respectively. Their average yields were in the range 39.9–40.6 t/ha (Table 88). These hybrids have long oval fruit of 13–15 g.

Table 88. *Yields of cherry tomato lines in trials in Taiwan, 1999–2000*

Entry	AVRDC		TNDAIS[1]	Mean
	Summer 1999	Spring 2000	Summer 2000	
CHT1126	61.2	17.7	24.1	34.3
CHT1127	66.0	22.3	33.4	40.6
CHT1130	60.3	20.2	39.3	39.9
Tainan ASVEG #6	56.0	13.0	19.7	29.6
Santa	44.3	11.5	-	27.9
Mean	60.9	18.3	29.1	36.1
LSD (0.05)	7.31	2.38	8.64	

[1] TNDAIS = Tainan District Agricultural Improvement Station

Lettuce

Four lettuce varieties, LT40, LT45, LT86, and TOT423, were continuously evaluated in regional yield trials conducted by AVRDC and Taoyuan DAIS (Table 89). The four varieties out yielded the two checks by 12–50%. One of the most promising varieties, LT45, yielded an average 31.4 t/ha across the three seasons and three locations. It is a Batavia

Table 89. *Yields (t/ha) of lettuce lines in trials in Taiwan, 1999-2000*

Entry	Autumn 1999		Spring 2000		Summer 2000		Mean
	AVRDC	Taoyuan DAIS & Pingjenn[1]	AVRDC	Taoyuan DAIS & Pingjenn[1]	AVRDC	Taoyuan DAIS & Pingjenn[1]	
LT86	45.2	39.2	21.1	27.6	5.45	13.2	25.3
LT45	53.7	29.1	33.8	34.6	12.72	24.6	31.4
LT40	52.2	37.9	35.6	35.1	9.58	16.2	31.1
TOT423	41.6	41.9	35.3	19.6	5.02	23.9	27.9
French salad	33.2	34.0	13.0	28.8	1.56	16.3	21.0
Min fun # 3	26.3	34.2	25.3	26.8	1.18	21.2	22.5
Mean	4.59	-	9.09	-	3.68	-	
LSD (0.05)							

[1] Mean of two locations.

type of lettuce which is new to Taiwan. In general, lettuce grows well in autumn in Taiwan, but high temperatures in summer cause low yields due to incomplete development of leaves, early stem elongation, and bolting.

Variety evaluation trials

AVRDC continued to identify vegetables for recommendation to the host country NARS, to diversify the production and consumption of vegetables. In 1999–2000, snap bean, yardlong bean, and various leafy vegetables were included in the trials. Results and lists of promising accessions are presented in Table 90.

Nutrient contents of leafy vegetables

Samples of leafy vegetables were analyzed for nutrient content (Table 91). Nutrient content of leafy vegetables varied with species and variety. Kale varieties were rich in vitamin C. Amaranth entries were high in calcium. Seasonal effect on nutrient contents of leafy vegetables was also observed.

Technology transfer

A fresh market tomato hybrid, FMTT33, developed by AVRDC in the early 1990s, was named by the Taoyuan DAIS and officially released as Taoyuan ASVEG #9 on 13 November 2000. It has high yield potential, is resistant to tobacco mosaic virus and moderately resistant to bacterial wilt (BW), suffers less fruit cracking, and produces large fruit of excellent quality. Its characteristics are similar to the so-called red-point variety, with dark green shouldered fruit preferred by Taiwanese consumers.

Two field days coordinated by Tainan DAIS were held in farmers' fields in the Chiayi–Tainan area to demonstrate grafting for summer tomato production (cherry and fresh market). More than 100 farmers and nursery operators attended. Nursery operators are using the technology, which involves grafting tomato scions on BW resistant and flood tolerant eggplant rootstocks. In 2000, 330,000 grafted tomato seedlings were produced by three nurseries (Shan-Seng, Yu-Jia, and Yu-Ching) in the Chiayi area. The seedlings were priced at NT$4 compared to NT$1 for nongrafted tomato seedlings. Farmers are using the grafted seedlings to overcome problems associated with the disease and flooding encountered in summer production.

Seed production and distribution

With COA's support, AVRDC produced stock seeds of released vegetable varieties for NARS in 1999–2000 (Table 92).

Increasing public awareness

AVRDC received 2156 visitors, including 1735 local visitors, 209 international visitors, and 212 from Mainland China. AVRDC also helped arrange side-trips to introduce international visitors to small-scale farming and intensive crop production systems in Taiwan.

Contact: NC Chen

Table 90. *Promising accessions of vegetables identified in variety evaluation trials*

Crop	No. of entries	Maturity range (days)	Yield range (t/ha)	Promising accessions
Bush snap bean	49 (au)	59-77 (au)	2.2 - 7.1 (Au)	
	17 (sp)	50-61 (sp)	5.1 - 9.1 (Sp)	BN4, BN39, BN47, BN2, BN23
Pole snap bean	38 (Au)	62-91 (Au)	0.2 - 8.8 (Au)	BN308, BN323, BN322, BN321
	12 (Sp)	64-74 (Sp)	5.8 - 19.2 (Sp)	
Yardlong bean	22 (Au)	80-90 (Au)	1.3 - 3.9 (Au)	BN184, BN229, BN167, TUN205,, TUN210
	15 (Sp)	66-73 (Sp)	10.9 - 18.7 (Sp)	
Amaranth	6 (Su)	19-32 (Su)	1.2 - 2.9 (Su)	TOT2263, TOT2353
	6 (Sp)	26-32 (Sp)	4.4 - 12.2 (Sp)	
Kale	4 (Su)	32-51 (Su)	1.9 - 16.0 (Su)	LV19, LV21
	5 (Sp)	27-31 (Sp)	5.8 - 12.0 (Sp)	
Mustard	3 (Su)	40-59 (Su)	2.6 - 4.6 (Su)	LV8,CN78, TB559
	6 (Sp)	24-27 (Sp)	4.1 - 17.9 (Sp)	
Bai-tsai	3 (Su)	29-39 (Su)	3.1 - 5.0 (Su)	CN89, CN88
	6 (Sp)	25-26 (Sp)	12.8 - 21.5 (Sp)	
Rape	5 (Su)	22-34 (Su)	1.6 - 5.4 (Su)	TB473, TB570
	6 (Sp)	21-26 (Sp)	4.9 - 15.6 (Sp)	
Ceylon spinach	5 (Su)	52-55 (Su)	5.6 - 29.9 (Su)	MS6, MS9

Sp = spring crop; Su = summer crop; Au = autumn crop.

Table 91. *Nutrient contents of leafy vegetables*[1]

Crop	No. of accessions	Dry matter (%)	Sugar (%)	Fiber (%)	Vitamin C (mg/100g fm)	Calcium (mg/100g dm)	Iron (mg/100g dm)	Nitrate (ppm)
Amaranth	12	9.8	3.9	10.8	32	1927	25	3675
Kale	9	7.2	6.7	12.0	70	1673	23	4090
Mustard	9	6.1	12.6	11.9	61	1114	20	3754
Pai-tsai	9	5.3	11.2	11.9	48	1651	24	4165
Rape	11	5.9	9.4	12.3	59	1546	25	4168
Lettuce	6	3.8	16.3	13.6	8	1019	21	982

[1] Data represent the mean of two crop seasons (spring and summer) except for lettuce, for which data were taken from the samples of the regional yield trial in autumn season.

Table 92. *Seed production and production area of AVRDC released varieties in Taiwan, 1999-2000*[1]

Crop	Variety	1999		2000	
		Seeds (kg)	Area (ha)[2]	Seeds (kg)	Area (ha)[2]
Cherry tomato	Tainan ASVEG #6	54.2	1080	56.2	1123.0
Fresh market tomato	Taichung ASVEG #4				
	Hualien ASVEG #5	67.3	673	33.8	338.0
	Taoyuan ASVEG #9	6.8	68	10.2	102.0
Vegetable soybean	Kaohsiung #5[3]	1313.0	11	1900.0	15.8
Mungbean	Tainan #5	200.0	5	200.0	5.0

[1]AVRDC and Taiwan Seed Improvement and Propagation Station (TSIPS) produced seeds. TSIPS distributed the seeds to farmers.
[2] Estimated planting areas.
[3] Kaohsiung #5 was not an AVRDC released variety, but its seeds were produced by AVRDC.

South Asia Vegetable Research Network SAVERNET – II

The South Asia Vegetable Research Network–II (SAVERNET-II) was approved by the Asian Development Bank on 10 January 1997 and the technical agreement RETA No. 5719 was signed on 4 April 1997. Work is divided between subnetwork I, "Translating Research into Farmers' Applications," and subnetwork II, "Integrated Disease and Pest Management," which include the following activities: 1) bacterial wilt (BW) resistance in tomato and eggplant, 2) leaf curl and other virus resistance in tomato and chilies, 3) integrated pest management of fruit and shoot borer in eggplant and fruitworm in tomato, and 4) off-season vegetable production of tomato and chili.

Subnetwork I – Translating research into farmers' applications

- **Bangladesh** – Eggplant cultivar Pant Rituraj, from India, was released as Nayantara and is gaining popularity with farmers. Another eggplant cultivar from India, Pusa Kranti, produced 3.97 ± 0.4 kg/plant compared to local check Uttara's 3.3 ± 0.2 kg/ha. A chili cultivar introduced from Sri Lanka, MI-2, can be harvested two weeks earlier (109 ± 2.2 days) compared to the local cultivar reaching maturity (green) at 122 ± 5.3 days. Chili pepper, MI-2 (dry), gave a yield of 11 ± 0.5 t/ha and 2.5 ± 0.1 t/ha, compared to 4.2 ± 1.9 t/ha and 1.2 ± 0.1 t/ha (dry) for the local check. MI-2 will be released as Bangla-Lanka in April 2001. An onion cultivar from India, Agrifound Dark Red, matured in 129 days and gave 14.2 t/ha compared to BARI-PIAR's 9.1 t/ha in 141 days. A new seed-producing open pollinated cabbage, Agradoot, has been released.About 20 kg of seed of Agradoot has been harvested for distribution to farmers.
- **Bhutan** – From 100 g of seed, 3.2 kg of seed of AVRDC's Chinese kale cultivar, CK 24, has been produced for distribution to farmers.
- **India** – Farmers and consumers in southern India prefer the newly introduced chili cultivars from Sri Lanka, KA-2 and MI-2. Seeds have been distributed to 25 farmers in 11 districts in six states. Multiple disease resistant, seed-producing cabbage has been selected from Probati from Bangladesh.
- **Nepal** – AVRDC tomato varieties, CLN 2026C and CLN 2026D, were free from disease and have the medium size of fruit that is preferred by farmers and consumers.
- **Pakistan** – AVRDC tomato variety, CLN 2026C, produced 4 kg/plant compared to Moneymaker 2.7 kg/plant.
- **Sri Lanka** – AVRDC tomato line, BL 355, produced 15.3 ± 2.4 t/ha compared to 14.2 ± 1.4 t/ha for the local check T-245.

Subnetwork II – Integrated disease and pest management

Bacterial wilt resistance in tomato and eggplant

- **Bangladesh** – Susceptible tomato variety MH-1 suffered 20% due to bacterial wilt but yielded 84.6 t/ha, while AVRDC tomato line TC, which suffered no wilt, yielded 73.4 t/ha. Tomato lines L-85, Arka Alok, and KWR had less than 20% wilt. Out of 19 eggplant varieties evaluated, grafting tomato onto BW resistant eggplant rootstock gave the lowest wilt, 11%. MIX, EG 195, EG 203, TS 90, EG 193, TS 47A, and EG 191 had less than 30% wilt.
- **India** – Out of 18 tomato varieties from AVRDC evaluated for BW resistance/tolerance, BL 994, BL 989, BL 985, BL 986, BL 1009, L-285, and KWR had 100% survival. SUN 7610 (35 t/ha) and King Kong-2 (32 t/ha) were the highest yielders. In another screening, CLN 1465, Hawaii 7997, CRA 66, and L-180-1 had higher percent survival against BW. Among the eggplant entries, S 90, EG 203, EG 195, and S 47A had more than 75% survival against BW, while susceptible lines suffered 100% infection. Intercropping tomato with sorghum, marigold, and garlic was found to minimize BW. Application of *Glomus mossae*also reduced BW incidence.
- **Nepal** – AVRDC tomato lines CLN 2116, CLN 1466P, and CLN2026C suffered less than 15% wilt, while the local check, Lapsigade, suffered 100% wilt.

Leaf curl virus and other disease resistance in tomato and chili

- **Bangladesh** – Six AVRDC tomato accessions were highly resistant to tomato yellow leaf curl virus (TYLCV). Of these accessions, ATY 14, 17 and 23 were negative for DNA hybridization. Despite 9% infection with TYLCV, Avinash 2 produced 96.4 t/ha, while CLN 1466J and CLN 1466P, which did not have TYLCV, produced 81.6 t/ha.

- **Bhutan** – Phytophthora late blight of pepper is a serious problem in Bhutan, and AVRDC is breeding for resistance to the disease.
- **India** – Tomato accessions ATY 1, ATY 16, and ATY 17 showed no TYLCV symptoms, while ATY 14, ATY 15, ATY 18, and ATY21 had only 5% infection by TYLCV. In an on-farm trial, Avinash 2 and SR 7725 gave 48 and 45 t/ha, respectively. Pepper lines C-2, C-6, C-7, and C-9 were resistant to cucumber mosaic virus (CMV). Pepper lines CV-1, CV-2, CV-5, CV-6, CV-7, and CV-9 were resistant to chili veinal mottle virus (ChiVMV).
- **Nepal** – Tomato accessions ATY 1, ATY 5, ATY 16, ATY 18, ATY 20, ATY 21, ATY 23, CLN 1314G, and LA 1777 were resistant to TYLCV. Pepper lines CV-2, CV-10, and CV-22 were resistant to ChiVMV.
- **Pakistan** – Tomato lines CLN 2116 and SR 7725 were free from TYLCV at the National Agricultural Research Centre, Islamabad, but had 27 to 33% infection , respectively, in Khatta Sughral in Khusab. Avinash 2 and SR 7725 were the highest yielders in both locations. Pepper lines C-5 and C-21 were resistant to CMV.
- **Sri Lanka –** In a field screening, CLN 2123D and SR7725 had no TYLCV infection.

IPM of eggplant fruit and shoot borer *Leucinodes orbonalis*

The results are summarized in Table 93.

Off-season vegetable production

- **Bangladesh** – Using BARI F_1 tomato Anupama or BARI Tomato 4 and 5, with growth regulator (Tomatotone®) to promote fruit set, profitable yields of 20–27 t/ha and 14–25 t/ha, respectively, were obtained in the summer season.
- **Bhutan** – Tomato variety Ratan is successful in the low hills in September.
- **India** – When applied with growth regulator, Avinash 2, Pusa Ruby, and RockyGood had good fruit set, even at 42/36°C (day/night temperature).
- **Sri Lanka**— The cooperative bank gives credit to farmers for off-season tomato cultivation using polytunnels. Use of growth regulator doubled fruit numbers and increased fruit weight by 130–157% compared to the control.

Contact: S Shanmugasundaram

Table 93. *Summary of eggplant fruit and shoot borer* (Leucinodes orbonalis) *research in five countries*

Treatment	Response to eggplant fruit and shoot borer (EFSB) infestation				
	Bangladesh	India	Nepal	Pakistan	Sri Lanka
Net barrier with or without clipping affected shoots	Lowers infested, 25-33 t/ha (CK 14 t/ha)	Reduces infestation by 21%	Lowers infestation, 14 kg/plot (CK 6 kg/plot)	Effective in reducing infestation	120-132% more yield than control
EG 058	Lower EFSB; susceptible to leaf hopper	Susceptible to EFSB and leaf hopper	-	-	More susceptible than local variety, susceptible to bacterial wilt
EG 075	Susceptible to leaf hopper and EFSB	Susceptible to EFSB and leaf hopper	-	-	More susceptible to EFSB than loca variety, susceptible to bacterial wilt
Trichogramma chilonis	Effective parasite for *L. orbonalis*				

Collaborative Vegetable Research and Development Network for Central America, Panama, and Dominican Republic (REDCAHOR)

The "Collaborative Vegetable Research and Development Network for Central America, Panama, and Dominican Republic (REDCAHOR)" project was executed from 1997 to 2000 with the financial support of the International Cooperation and Development Fund (ICDF), the Central American Bank for Economic Integration (CABEI) and the Inter-American Development Bank (ADB).

The general objective of REDCAHOR is to develop a regional network of national and regional institutions, for the discussion of ideas, the prioritization of agenda and the establishment of cooperation mechanisms, with a view to maximizing impact in the use of available resources in Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, Panama, and the Dominican Republic. As regards its technical objectives, priority was attached to improving the adaptation of commercial crops, developing high-quality seeds, reducing the use of pesticides and improving postharvest technologies.

The Asian Vegetable Research and Development Center (AVRDC) and the Inter-American Institute for Cooperation on Agriculture (IICA) acted as executing agencies and, like the other participating institutions, provided in-kind support.

The project executed activities through four components: 1) Collection, evaluation and conservation of germplasm; 2) Improvement and evaluation of germplasm; 3) Integrated pest management (IPM); and 4) Analyses of vegetable production, consumption and marketing.

REDCAHOR is a coordinated effort aimed at evaluating genetic resources, validating varieties suited to growers' needs, and studying alternative methods for combatting pests. The purpose of REDCAHOR is to generate technological options, strengthen national plant breeding programs and foster teamwork in the vegetable sector.

Research was conducted by the participating institutions, by means of regional and national cooperation. A leader was assigned to each research project and common protocols were defined, so that results could be shared by all the people involved.

Between June 1998 and June 1999, REDCAHOR conducted 54 research projects involving 66 researchers from 23 national institutions (1998-1999 Research Report). Between 1999 and 2000, the Network conducted 90 experiments, of which some are still in the analysis or information gathering stages. In the validation of commercial cultivars, seed companies and national agricultural research institutes collaborated with REDCAHOR.

The most important accomplishments of REDCAHOR are:

- For the first time, a regional vegetable research and development network has been established. As a result, researchers, extension agents and technical personnel from national institutions and the private sector can now interact with one another.
- Researchers are coordinating their actions at the regional level.
- Different institutions and disciplines have been integrated at the national and regional levels, making it possible to draw on the capabilities of different entities and adopt common objectives and priorities.
- The main obstacles to vegetable production and marketing have been identified, with a view to designing a real strategy for developing the sector.
- The critical mass for vegetable research and development has increased in quality and quantity.
- Germplasm, scientific and economic information has been distributed to researchers in the region, which provides valuable inputs for planning actions.
- More than 3000 people have been trained in the region.
- It has been possible to identify varieties that are much more promising than those usually used by farmers. In the case of onions, production has increased by almost 200%; for tomatoes, from 80% to 150%.
- The use of molecular markers to identify genetic variability in the region has proven to be a useful tool for geneticists.
- Other organizations of the agricultural sector have

joined the system, making the network much more aware of the context in which the farmer actually works.

- Biological control, using *Plutella parasitoids* in cabbage, is available. This would mean a reduction of 75% in the application of pesticides per growing cycle.
- Vegetable research in national institutions has increased by more than 80%.
- Research aimed at identifying better options for integrated pest management has produced new alternatives for combating the pepper weevil and the larvae of tomatoes and onions.
- The need to have access to economic and trade information in order to plan actions in the vegetable sector has been recognized. SIRCAHOR is a new regional information system that will link the documentation centers in the region which possess or generate information on human resources, services and institutions related to vegetable production.
- The importance and potential of vegetables have been recognized throughout the agrifood chain (including political levels). Vegetables are now a priority in the national research programs.

Contact: J Carls

Project 10. Information exchange on tropical vegetables

Project 10 is about gathering, packaging, and sharing information critical to the progress of vegetable research and development. The work is divided into two subprojects, the first dedicated to packaging information and the second dedicated to making that information available to AVRDC scientists and cooperators.

Multimedia, electronic, and print publications

Some of the publications produced in 2000 include *AVRDC Report 1999*; *Collection conservation and utilization of indigenous vegetables: Proceedings of a workshop held at AVRDC, 16–18 August 1999*; *Vegetable research in South Asia: Proceedings of the South Asian Vegetable Research Network mid-term review meeting, held at AVRDC, 5–9 February 1999*; *Dynamics of vegetable production, distribution and consumption in Asia; Indigenous treasures: Healthy diversity through indigenous vegetables*, produced for International Centers Week; four issues of *Centerpoint* newsletter (the newsletter was increased to quarterly in 2000); and two technology pamphlets in the *International Cooperators' Guide* series.

As in 1999, AVRDC's annual report was made available on the Center's WWW site in PDF format. And work is well along in updating and converting AVRDC's many training materials for presentation on the Center's website. (See Project 11.) The website had more than 21,000 visitors from 110 countries in 2000. This represents a 50% increase in the number of visitors to the site, and a 10% increase in the number of countries accessing the site. The Center is always looking for ways to make better use of this important, expanding medium.

The Office of Publications and Communications mailed more than 19,360 publications in 2000. The Center's mailing list now contains 2998 entries, including 637 libraries in 161 countries. The office printed more than a quarter of a million pages and handled more than 215 art requests from Center scientists. About 10,000 photos were shot and processed.

Collecting and sharing tropical vegetable information

This subproject is handled by the Center's library. In 2000, the library delivered more than 1420 documents, loaned more than 4420 titles, and collected and catalogued hundreds of new acquisitions. The library also subscribes to 1700 electronic journals that are made available to AVRDC scientists through the Center's website. As usual, literature of use to vegetable researchers was searched and the findings were added to the library's collection databases, which can also be searched by Center scientists via the website. Library staff conducted 45 searches of CD-ROM databases and 56 searches of the library collection on behalf of Center scientists and cooperators in 2000.

The library conducts regular searches of literature of interest to vegetable researchers. The results of these searches are published as Selective Dissemination of Information bulletins. In 1998, the Center began publishing these on its website, and in 1999 a listserver was set up to allow people to sign up to receive these SDI bulletins regularly by email. Membership of these lists grew throughout 2000, which means that each topic-specific list is becoming more useful for Center scientists to reach out to people working in their specific areas of interest.

Contact: D Abbass

Project 11. Training for research and development

The main goal of this project is to increase skills among vegetable researchers throughout the world, and especially in developing countries. In 2000, 100 scholars from 34 countries received training at AVRDC headquarters in Taiwan.

Research development skills

Seventeen researchers from 10 Asian countries completed internships. In these 1 to 6-month training programs, researchers developed skills within the fields of entomology, mycology, plant physiology, tomato breeding, legume breeding, allium breeding, and genetic resource management.

Research fellows from development institutions in the Philippines and Vietnam received training on genetic resource management and socio-economics, respectively. A research scholar from Japan undertook extensive training on vegetable breeding for developing countries. Other visiting scientists received training on biological pest control and the production of leafy vegetables.

Five scholars from Vietnam, Cambodia and Myanmar were offered internships by the Government of Japan through ASEAN. Three of these 5 scholars began their training in 2000. These scholars are developing skills in entomology, pathology, biotechnology, off-season production, and the English language.

Special-purpose training

Vegetable cultivation and seed production course

The International Cooperation and Development Fund (ICDF) of the Republic of China continued to support AVRDC's training activities in 2000. ICDF funded a course on vegetable cultivation and seed production for 19 participants from 17 developing countries. The three-week course trained the students in innovative crop management practices and seed production technologies. The students also visited several agricultural research organizations and farmers' associations in Taiwan.

An evaluation of the course showed that it was a valuable experience for the students. All (100%) participants stated that the course was "stimulating and useful" for their professional careers. A self-assessment tool showed that knowledge levels among the participants increased by an average of 61%. The students rated the course at an extremely high score of 4.90, using a scale of 1 = poor and 5 = excellent.

Allium virus workshop

Fifteern participants from nine countries (Argentina, Indonesia, Japan, Korea, Mauritius, New Zealand, Philippines, Taiwan, and Thailand) attended a workshop on virus elimination and indexing of garlic and shallot. The workshop was funded by the German Agency for Technical Cooperation. Scholars shared experiences and discussed strategies to develop highly sensitive tools for improving the diagnosis and indexing of allium viruses.

English language training

Twenty international trainees, 16 AVRDC staff, and 14 Taiwanese university students developed greater fluency in the English language through weekly classes. These persons demonstrated improved communication skills that assisted them in their work at AVRDC.

Graduate degree-oriented training

AVRDC collaborated with National Pingtung University of Science and Technology (NPUST) in Taiwan and the Bangladesh Sheikh Mujibur Rahman Agricultural University (BSMRAU) to make its facilities and expertise available to graduate students conducting thesis research on tropical vegetables.

In 2000, seven graduate students studied at AVRDC under this program. Among the NPUST scholars, one person from the Solomon Islands studied the biology of DBM parasitoid *Microplitis plutellae*; another from the Republic of Macedonia studied the identification of tomato fruitworm (*Helicoverpa armigera*) attraction factors in *Solanum viarum*; a student from Liberia evaluated the use of fishbean (*Tephrosia vogellii*) foliage for the control of storage insect pests; and a student from Gambia evaluated the effect of mycorrhizal colonization and grafting on off-season tomato production.

Bangladeshi students from BSMRAU studied the genetics of heat tolerance in tomato, the management of nutrients in vegetable soybean, and the physiology of heat stress and seed quality in bell pepper.

Summer internships

For the 26th consecutive year, AVRDC hosted undergraduate students from universities in Taiwan. Sixteen students from 7 universities were trained in 2000. The students developed skills in experimental design, implementation, data collection and analysis, technical report writing, and the English language. This training provided a valuable experience to students who are deciding their futures in agricultural science.

Three undergraduate students from Japan conducted research at AVRDC during the summer. These students studied allium viruses, and the accumulation and partitioning of biomass in selected indigenous vegetables.

Development of training materials

International Cooperators' Guides were developed on: *Suggested Cultural Practices for Tomato*; *Pepper Seed Multiplication*; *Grafting Tomatoes for Summer Production in the Hot, Wet Season*; *Use of Growth Regulator for Increased Fruit Set in Tomato*; and *Suggested Cultural Practices for Vegetable Amaranth*.

A model of a computer based, educational "Learning Center" was developed. Over 40 fact sheets, focusing on cultural practices and pest management, were written in 2000. The Learning Center will be launched in 2001 with a goal of expanding the educational outreach programs at AVRDC via the internet.

MS PowerPoint® presentations on suggested cultural practices for alliums, crucifers, eggplant, peppers, and tomatoes were prepared. Additional PowerPoint presentations are scheduled to be added in 2001.

A survey of the national coordinators of AVRDC networks was conducted to identify their needs of training materials. Priority topics identified for future training were integrated pest management, protective cultivation strategies, disease management, and seed production. Priority crops were tomato, chili pepper, and alliums.

Evaluation and dissemination of training materials

All slide sets were evaluated for accuracy and, when needed, updated. Computer-based training modules on tomato production (developed by AVRDC Africa Regional Program) and tomato disease diagnosis (developed by AVRDC Project 7) were evaluated.

AVRDC's *Vegetable Production Manual* was evaluated by AVRDC trainers and Taiwanese university teachers for accuracy and usefulness. Evaluators considered it to be a useful tool for higher level education. Plans have been made to update the manual with new information and emerging issues in vegetable production.

Ninety-five slide sets, 11 videos, and 200 *Vegetable Production Training Manuals* were sold and disseminated upon request.

Contact: T Kalb

Project 12. Technical services

The objectives of this project are to:

- enhance the capacity of local agribusinesses and public corporations to better serve vegetable producers;
- create employment; and
- spur socioeconomic development

AVRDC conducts research to better understand the functions and constraints of vegetable related agribusinesses, and the Center continues to refine mechanisms by which its expertise and infrastructure are made available to the private sector.

Constraints of vegetable seed companies in Southeast and South Asia

A questionnaire was distributed to 28 vegetable seed companies in India, Philippines, Thailand, Indonesia, Vietnam, and Malaysia in October 2000. By the end of the year, 12 (43%) completed questionnaires had been returned from India (4), Philippines (1), Thailand (2), Indonesia (2), and Vietnam (3). Survey results are summarized below.

Major products

About 25% of respondents sell products, such as pesticides and fertilizers. Respondents reported that cucurbitaceous crops are the most important in terms of sales in the regions surveyed, following by solanaceous and root vegetables.

Research and development in the seed industry

Some 92% of seed companies have established research and development (R&D) departments, and the rest of the companies plan to do so. About 36% of the companies have R&D budgets below 5% of their total budget, 55% of the companies are in the range 5–20%, and only one company has an R&D budget above 20%. The money is mostly spent on developing new varieties and local and international markets. Some 33% of the companies have substations or branches in foreign countries.

Major constraints

The seed companies reported that weakness in R&D (in developing new varieties/products) and opening up new markets are important constraints (Table 94). Training of professionals, quality control, and application of new technology were also cited as important constraints. Cost of seed production and labor were not cited as serious constraints.

Table 94. *Relative importance of constraints faced by seed companies, as perceived by survey respondents in Southeast and South Asia*

Constraint	No. of companies that responded
New variety/product development	11
Opening new markets	10
Training of professionals	8
Quality control	7
Application of new technology	6
Quality authentication	5
Shortage of manpower	5
High cost of seed production	4
Funding and credit	3
High cpost of laborers	3
Other (availability of germplasm)	1

Technical services needed by vegetable seed companies

The questionnaire listed several technical services that AVRDC could offer to the private sector, and respondents were asked to make choices based on their needs. The results are given in Table 95. Most of the respondents chose evaluation of disease

Table 95. *Relative importance of technical services required by seed companies as perceived by survey respondents*

Service	No. of companies that responded
Evaluation of disease resistance	10
Special seed production	8
Disease identification	8
Evaluation of insect resistance	8
Molecular tools	7
Identification of vegetable varieties	7
Purity tests of vegetable varieties	6
Plant nutrient analysis	6
Others[1]	4

[1] Supply of germplasm, screening and improving cucurbit germplasm, and genebank development.

resistance as their most required technical service. Special seed production, disease identification, and evaluation of insect resistance were also cited as important technical services required by the seed industry.

Technical service procedures on disease resistance screening

AVRDC plant pathologists occasionally receive requests for help in disease screening. Based on a questionnaire survey conducted in 1999, evaluation of disease resistance is the most important service required by seed companies in Taiwan. With a special project supported by the Council of Agriculture, ROC has provided plant pathology units the opportunity to renovate their facilities to train more personnel and to develop procedures for offering disease screening services to Taiwan's private sector.

A total of 27 important diseases of tomato, pepper, onion, and brassicas can be screened for.

Offering of technical services

AVRDC provided 15 technical services to three private companies and seven public corporations in 2000. The basic service has been set up for resistance screening of 10 diseases: bacterial wilt (BW), cucumber mosaic virus (CMV), chili veinal mottle virus (ChiVMV), pepper mild mottle virus (PMMV), potato virus Y (PVY), radish mosaic virus (RaMV), tobacco mosaic virus (TMV), tomato mosaic virus (ToMV), tomato yellow leaf curl virus (TYLCV), and turnip mosaic virus (TuMV). Protocols are those routinely used, as described previously. Rating for all viruses is by visual symptom observation, followed by ELISA or nucleic acid hybridization in the case of TYLCV.

The services included:

- Screening of tomato lines for BW, ToMV, TYLCV, and PVY resistance
- Screening pepper lines for BW and PVY
- Evaluation of breeding lines of eggplant for BW resistance
- Production of seed of cherry tomato Tainan ASVEG #6 for Taiwan Seed Improvement and Propagation Station
- Virus elimination and indexing of three garlic lines from Mauritius
- Chemical evaluation of 2.5% Mefenoxan G (Ridomil–Gold) for control of pythium root rot of tomato
- Supply of isolates of *Alternaria porri-1, Pseudocercospora fuligena, Phytophthora paratica, P. infestans, P. capsici*, and *Alternaria solani*
- Near-infrared reflectance spectroscopy analysis of vegetable soybean samples for nutrient and quality factors
- Disease identification

Contract research projects

In 1999–2000, AVRDC was granted 22 contract research projects from COA and one from the National Science Council, ROC. In addition, AVRDC pepper and tomato units conducted three contract research and development projects under agreements with Seminis Vegetable Seeds, Kagome Company, and Taiwan Sugar Research Institute (TSRI). Under the contract agreements, the CMS pepper materials developed at AVRDC were turned over to Seminis; 6 hybrids of processing tomato were given to Kagome for further evaluation; and 70,000 seeds of ornamental pepper were provided to Taiwan Sugar Research Institute.

Contact: NC Chen

AVRDC Asian Regional Center

The Asian Regional Center (AVRDC–ARC is AVRDC's link to national partners in Asia. Established in 1992 in Thailand, the Center is situated to gauge the needs and capabilities of the region and to address the immediate and long-term needs of partner national agricultural research systems (NARS).

The Center conducts applied and adaptive research on AVRDC crops, conducts training and dissemination activities, and coordinates subregional networks and collaborative programs.

AVRDC–ARC activities remained forcused on AVRDC's major crops and important regional crops. Many studies on various vegetables important to the region are being carried by participants in the Center's training program. On-farm trials of promising lines are continuously being carried out in advance of official release. Furthermore, collaborative projects are being forged with various scientists in the region.

Resistance to tomato yellow leaf curl in Thailand and Southeast Asia

Twenty-four cultivated and wild tomatoes reported as resistant to tomato yellow leaf curl virus (TYLCV) (Table 96) and 14 inbred lines developed by AVRDC using H24 as the TYLCV resistance source (Table 97) were screened at AVRDC's Asian Regional Center (AVRDC-ARC), Kamphaengsaen, during the dry season 2000. Resistance assessment was based on visible symptom and virus detection by DNA hybridization with a Thai TYLCV strain probe on leaves collected from 10 symptomless plants per entry. A second trial was undertaken in collaboration with Limagrain and East-West Seed companies, in Thailand and the Philippines, respectively. Ten lines (Table 98) were screened during dry season 2000 and resistance was assessed according to visual symptoms 60 days after transplanting.

Out of the 24 resistance sources tested at AVRDC-ARC, only seven entries showed highly to moderate resistance (Table 96). None of the commercial inbred lines resistant to TYLCV strains from India or Middle-East/Mediterranean areas was resistant to the virus strain inducing yellow leaf curl symptom prevalent at AVRDC-ARC. Among the three

Table 96. *Twenty-four lines, reported as resistant to tomato yellow leaf curl virus (TYLCV), screened for resistance at AVRDC-ARC*

Entry	Origin / Resistance source	Resistance to TYLCV	
		Visual symptom[1]	Virus detection[2]
LA1932 (*L. chilense*)		HR	0%
TLCV(271/1x26)-1	IIHR, India / H24	HR	0%
FL505	JW Scott, UFL[3] / *L. chilense* (LA1969), Tyking, Fiona	R	0%
LA1777 (*L. hirsutum*)		MR	0%
H24	*L. hirsutum* f. sp. *glabratum*	MR	20%
FL619	JW Scott, UFL / *L. chilense* (LA1932, LA2779)	MR	50%
FL699sp	JW Scott, UFL / *L. chilense* (LA1938)	MR	80%
LA1969 (*L. chilense*)		MS	0%
H36	*L. hirsutum* f. sp. *glabratum*	MS	0%
TY-8487	Hazera Seed	MS	0%
TY-King	Royal Sluis	MS	0%
FL699sp+	JW Scott, UFL / LA1938	MS	20%
FL776	JW Scott, UFL / LA1969	MS	20%
FL744-6-9	JW Scott, UFL	MS	40%
CLX3709	Limagrain	MS	60%
FL438-17	John Scott, UFL	MS	100%
CLX3752	Limagrain	MS	100%
CLX3748	Limagrain	MS	100%
FL805	JW Scott, UFL / LA2779	S	50%
FL456-17	JW Scott, UFL / TY-King, LA2779	S	60%
Avinash #2	Novartis Seed	S	80%
FL582-17	JW Scott, UFL	S	100%
Fiona F_1		S	100%
FL763	JW Scott, UFL / LA1938	S	100%
CLN2026D	AVRDC / susceptible check	HS	–
FMTT260	AVRDC / susceptible check	HS	–

[1] TYLCV resistance based on percentage of symptomless plants: HR = highly resistant (100% symptomless plants), R = resistant (99-90% symptomless plants), MR = moderately resistant (89-75% symptomless plants), MS = moderately susceptible (74-50% symptomless plants), S = susceptible (49-25% symptomless plants), HS = highly susceptible (24-0% symptomless plants).

[2] Percentage for 10 symptomless plants tested by DNA hybridization with a Thai TYLCV strain probe.

[3] University of Florida, USA.

resistant inbred lines from Florida, FL505 appeared to be the most promising line, combining both low number of plants with symptoms and low number of plants testing for TYLCV. In contrast, 50% and 80% of the symptomless plants of lines FL619 and FL699sp (both moderately resistant) tested positive. Resistance source H24 and AVRDC inbred lines (with H24 as resistance source) showed high to moderate resistance (Tables 96 and 97). However, the percentage of symptomless plants carrying the virus varied widely from line to line. Nevertheless, nine among the 14 tested lines had similar or better resistance than the resistant parent H24 at AVRDC-ARC.

Multilocation screening, however, showed that lines identified as resistant at AVRDC-ARC might not be suitable in other areas. This screening confirmed the high level of location-specificity of TYLCV resistance (Table 98). Five lines were identified as resistant at the East-West Seed station in the Philippines, whereas at Limagrain's station in Thailand, all lines were moderately to highly susceptible. The three lines identified as resistant and moderate resistant at AVRDC-ARC showed unstable resistance, varying from highly susceptible to resistant in other locations.. Among them, H24 was highly susceptible in the Philippines and at the Limagrain's station in Thailand. TY52, Gempride, and FLA505 displayed similar resistance instability.

It can be concluded that TYLCV resistance is highly complex in the Philippines and Thailand; and that all the resistance sources we tested were unstable. Location-specificity has to be considered in developing a resistance breeding strategy. H24 is highly resistant to TYLCV in Taiwan and southern India, and was identified as a resistance donor for AVRDC inbred lines, but it has been shown to be moderately resistant to highly susceptible in Thailand and the Philippines. Thus, new resistant sources must be identified.

Lines from the University of Florida might be good candidates, but wider range multilocation testing is needed to assess their stability. Genetic analysis of these lines must be done to determine whether resistance pyramiding would be a suitable approach to circumvent location-specificity.

Table 97. *Fourteen AVRDC inbred lines, carrying tomato yellow leaf curl virus (TYLCV) resistance from H24, screened for resistance at AVRDC-ARC*

Line	Resistance to TYLCV	
	Visual symptom[1]	Virus detection[2]
CLN2114DCF1-2-16-8-2-17-0	HR	0%
CLN2116DC1F1-180-50-15-8-5	HR	0%
CLN2116DC1F1-180-50-15-8	HR	20%
CLN2114DC1F1-2-42-4-1-12	HR	30%
CLN2114DC1F1-2-16-8-2-17-0	HR	40%
CLN2116DC1F1-180-31-10-25-23	R	0%
CLN2123DC1F1-14-3-5-11-12	R	20%
CLN2116DCF1-180-31-10-25-8-0	R	30%
CLN2116DCF1-180-31-9-24-4-0	R	60%
CLN2117DCF11-26-19-15	MR	20%
CLN2114DCF1-2-29-20-23-14-0	MR	20%
CLN2116DCF1-180-31-10-25-16-0	MR	20%
CLN2116DCF1-180-31-10-25-22-0	MR	20%
CLN2116DCF1-180-31-9-11-12-0	MR	100%
H24	MR	20%
CLN2026D	HS	–

[1] TYLCV resistance based on percentage of symptomless plants: HR = highly resistant (100% symptomless plants), R = resistant (99-90 % symptomless plants), MR = moderately resistant (89-75% symptomless plants), MS = moderately susceptible (74-50% symptomless plants), S = susceptible (49-25% symptomless plants), HS = highly susceptible (24-0% symptomless plants).

[2] Percentage for 10 symptomless plants tested by DNA hybridization with a Thai TYLCV strain probe.

Table 98. *Ten lines, reported as resistant to tomato yellow leaf curl virus, screened for resistance in the Philippines and Thailand by visual symptom observation*

Entry	Resistance source	Resistance[1]		
		Philippines	Thailand	
			LG	ARC
FL456-4	Tyking, LA2779	HR[2]	MS	Nd[3]
TY52	TY-1 from LA1969	HR	HS	Nd
Gempride	Unknown	HR	HS	Nd
FL505	LA1969, Tyking, Fiona	R	S	R
FL591-15	LA1969, Tyking, Fiona	R	S	Nd
FL699sp	LA1938, *L. pimpinellifolium* (PI211840)	MS	MS	MR
H24	*L. hirsutum* f. sp. *glabratum*	HS	HS	MR
BL83-3B-1/4	Unknown	HS	HS	Nd
Avinash#2	Unknown	HS	HS	S
CLN2116D	H24	HS	HS	Nd
CLN2026D	Susceptible check	HS	HS	HS

[1] Trial carried out at East-West Seed company station in the Philippines, Limagrain (LG), and AVRDC-ARC in Thailand.
[2] TYLCV resistance based on percentage of symptomless plants: HR = highly resistant (100% symptomless plants), R = resistant (99-90 % symptomless plants), MR = moderately resistant (89-75% symptomless plants), MS = moderately susceptible (74-50% symptomless plants), S = susceptible (49-25% symptomless plants), HS = highly susceptible (24-0% symptomless plants).
[3] Nd: not done.

Management of TYLCV by cultural practices

Several cultural practices, which have been successful in controlling TYLCV in other areas, were evaluated at AVRDC-ARC in the dry season 2000.

Mulching materials, weeding, inter-cropping, and use of net barrier were assessed for their ability to control the TYLCV vector, whitefly (*Bemisia tabaci*), as measured by TYLCV incidence in susceptible tomato variety FMTT260.

Whitefly has been reported to be affected by mulch color and weed population, so mulches of various color (black, blue, yellow, aluminum, transparent) or material (organic or plastic), with or without weed management, were tested. The whitefly population was monitored (by use of four yellow traps) in each weeded and non-weeded main plot every 10 days.

Mulch material had a significant effect on final TYLCV incidence (Table 99). Aluminum color plastic mulch reduced disease incidence by 50% compared to the control. Similarly, use of yellow mulch resulted in significantly lower disease incidence, whereas other materials and colors had no significant effect. No significant effect on TYLCV final incidence was observed between weeded and non-weeded plots, even though the adult whitefly population was significantly lower in the weeded plot compared to the non-weeded plot, 67 and 88 whiteflies per trap for 80 days, respectively. The movement of whiteflies between plots might explain this result.

Table 99. *Effect of mulch and weeding on final incidence of TYLCV on susceptible tomato variety FMTT260, December-March. 1999-2000*

Mulch material	Weeding	No weeding (%)	Average
Aluminum color plastic	50.3	43.1	46.7 b
Yellow color plastic	56.3	66.6	61.4 b
Transparent plastic	90.0	70.5	80.3 a
Black color plastic	82.5	81.0	81.7 a
Rice straw	92.4	82.6	87.5 a
Dried grass	89.5	86.4	88.0 a
Blue color plastic	87.2	95.1	91.2 a
No mulch	87.7	96.3	92.0 a
Average	79.5 a[1]	77.7 a	

[1] Values followed by a same letter are not significantly different at P<0.05 by Duncan's multiple range test.

The effect of vector host preference was studied by inter-cropping tomato with whitefly host (cucumber, okra, vegetable soybean, and sweet potato) and non-host (corn) crops. Six leaves of the inter-crop were collected every 10 days and the whitefly larvae were counted. The adult population was monitored every 10 days by use of nine yellow traps randomly distributed throughout the field. Larvae monitoring revealed a significant difference between inter-crops, with cucumber and vegetable soybean as the most preferred hosts; whereas no larva was found on corn (Table 100). Despite this clear preference, there was no significant effect on final TYLCV incidence, which can be explained by the high heterogeneity between replications, related to the complex environmental pattern created by the multiple crops grown within the field.

Table 100. *Effect of inter-crop on TYLCV incidence on susceptible tomato variety FMTT260 and virus vector host preference, December-March, 1999-2000*

Inter-crop	Final TYLCV incidence on tomato	Whitefly larvae on inter-crop[2]
None	38.1 a [1]	0 d
Corn	36.2 a	0 d
Okra	30.0 a	28 c
Sweet potato	31.7 a	39 d
Vegetable Soybean	25.1 a	49 a
Cucumber	42.1 a	52 a

[1] Values followed by a same letter are not significantly different at P<0.05 by Duncan's multiple range test.
[2] Total number of larvae for 80 days recorded on six leaves.

The third study was conducted to confirm the efficacy of physical barrier to reduce TYLCV incidence, as found in a study in 1999. TYLCV incidence and whitefly population in two 40 m^2 fields surrounded by a 2.5-m-high, 40-mesh net barrier were compared to that in two open fields. The barrier controlled the adult whitefly population size throughout the tomato crop duration (Figure 30), although whiteflies were found inside the barrier. The vector population was 67% lower inside the barrier compared to the open field, and final TYLCV incidence was significantly lower within the barrier (20%) compared to the open field (43%). This result confirms the effectiveness of physical barriers to reduce TYLCV incidence through control of its vector.

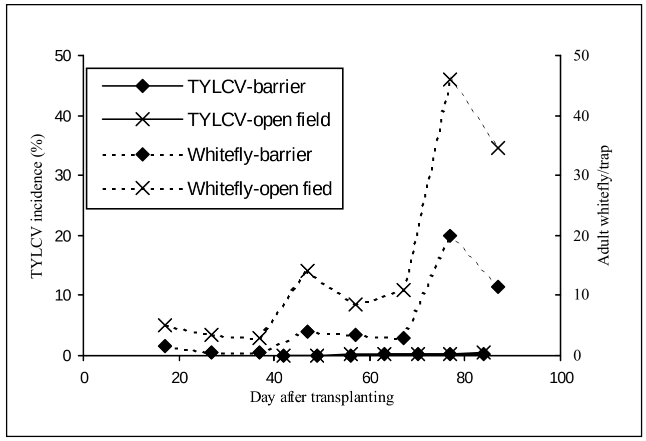

Figure 30. Dynamics of TYLCV incidence on susceptible variety FMTT260 and whitefly adult population in open field and field protected with a 40-mesh, 2.5-m-high net barrier.

Utilization of *Solanum viarum* as a trap crop for controlling tomato fruitworm

Solanum viarum has be shown to be an effective trap crop reducing damage caused by tomato fruitworm (*Helicoverpa armigera*) in Taiwan. A study was undertaken to determine effectiveness of *S. viarum* at AVRDC-ARC in Kamphaengsaen.

Four 100 m^2 plots planted with cherry tomato Season Red 385 were surrounded by one row of *S. viarum*. Four other plots were planted solely with tomato. *S. viarum* was sown one month ahead of tomato in order to ensure that its flowering period and bud production coincided with those of tomato.

Results revealed that *H. armigera* preferred to lay eggs on *S. viarum* rather than tomato (Table 101). This host preference led to a lower number of eggs found on tomato planted with *S. viarum* compared with tomato grown alone. Consequently, the percentage of tomato fruit damaged by fruitworm was lower in plots surrounded by *S. viarum* (Table 101). Although total yield did not differ significantly between tomato planted with *S. viarum* and grown alone, marketable yield was significantly higher at 9 t/ha compared to the former, due to a lower yield loss caused by fruitworm. In conclusion, by *S. viarum* is an effective trap crop for *H. armigera* in Thailand.

Table 101. Effect of *Solanum viarum* on the tomato fruitworm *Helicoverpa armigera* and its damage to tomato variety Season Red 385, December-March, 1999-2000

	With *S. viarum*	Without *S. viarum*
Fruitworm eggs per plant on		
Tomato	11	27
S. viarum	40	-
Total yield (t/ha)	68.8 a[1]	64.4 a
Marketable yield (t/ha)	55.2 a	46.1 b
Yield loss (t/ha)		
Fruitworm infected	9.8 b (14.2%)	14.8 a (23.0%)
Cracking fruits	3.8 a (5.5%)	3.5 a (5.4%)

[1] Yield data with and without *S. viarum* were compared by using t-test of Student; ns, * and ** = non-significant difference, significant difference at 0.05 and 0.01, resepctively.

Identification and control of pathological constraints of mungbean in a rice-based cropping system

Three land preparation and sowing methods were compared on two dates after rice harvest for their effect on mungbean diseases caused by soil borne fungi. VC1973A was sown 7 and 66 days after rice harvest with the following methods: in row in raised bed, in row with no tilling, by broadcasting after plowing. Presence of *Pythium* sp*, Fusarium* sp, *Sclerotium rolfsii, Macrophomina phaseolina,* and *Rhizoctonia solani* in the soil was determined at each sowing date by using selective media or direct counting on 27 soil samples randomly collected at a depth of 0 to 10 cm. Percent germination, damping-off/root rot incidence, yield, and agronomic characters were recorded. Causal agents of post-emergence damping-off and root rot diseases were determined by collecting infected plants at 15, 21, and 43 days after sowing.

Fusarium sp and *R. solani* were found in all soil samples at both dates, whereas the *S. rolfsii* and *M. phaseolina* decreased between 7 and 66 days after rice harvest (Table 102). In contrast, *Pythium* sp was not isolated from any sample at both dates. Post-emergence damping-off and root rot diseases were mainly caused at both dates by *R. solani* and *S. rolfsii*, representing 42% and 37% of infected plants, respectively (Table 102). Sampling at different dates after mungbean sowing revealed that *S. rolfsii* occurred mainly in the seedling stages (7 to 20 days after sowing), while *R. solani* was the main cause of root/stem rot at later stages (from 30 days after sowing). Occurrence of *S. rolfsii* and *R. solani* on mungbean grown after rice was predictable, since these fungal species are pathogenic to rice too, causing damping-off and sheath blight, respectively.

Epidemics of damping-off and root rot caused by these pathogens were influenced by both land preparation and date of sowing in relation to rainfall pattern (Figure 31). At the first date of sowing, seven days after rice harvest, heavy rainfall was recorded and final damping-off/root rot incidence varied from 21% to 69% for sowing in raised bed and with no tilling, respectively (Table 103). At this date, sowing by broadcasting showed an intermediate incidence. In contrast, at the second date of sowing, 66 days after rice harvest, only 5 mm of rainfall was recorded, and no significant difference in damping-off/root rot incidence was observed between the three sowing methods, with an average final incidence of 24%. In comparing sowing method for damping off/root rot incidence, only sowing in raised beds did not show significant difference for incidence between the two

Table 102. *Soilborne fungal species isolated from soil and infected plant, for mungbean sown at 7 and 66 days after rice harvest*

	Soil [1]		Infected Plant [2]	
Species	7 days	66 days	7 days	66 days
Pythium sp.	0%	0%	0%	0%
Fusarium sp.	100%	100%	2%	0%
Sclerotium rolfsii	41%	7%	29%	44%
Macrophomina phaseolina	89%	67%	10%	18%
Rhizoctonia solani	100%	100%	45%	38%

[1] Percentage of 27 samples collected before mungbean sowing.
[2] Percentage of 36 samples collected 15, 21, and 43 days after sowing.

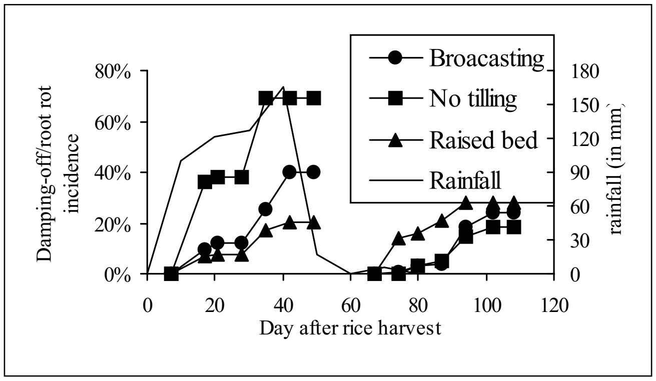

Figure 31. *Dynamics of damping-off/root rot incidence on mungbean variety VC1973A sown according to three methods of tillage in rice fields 7 and 66 days after rice harvest.*

dates. While late sowing after rice harvest reduced incidence of damping-off/root rot, when mungbean was sown with no tillage or by broadcasting.

Agronomic characters and yield were also affected by sowing method and date of sowing. However, contrary to damping-off/root rot incidence, germination rate was significantly higher when mungbean was sown early after rice in raised beds and by broadcasting (Table 103). This could be partly explained by the higher soil moisture content (17%) 7 days after rice harvest, compared with 66 days after rice harvest (10%). Yield per plant showed a similar variation as damping-off/root rot incidence between sowing methods and dates. Yield difference was found between the three sowing methods at the first date, with the highest yield for raised beds and the lowest for no tillage. On the contrary, no difference in yield was found at the second date of sowing. Furthermore, late sowing improved significantly the yield per plant sown by broadcasting and with no tillage, whereas yield in raised beds did not differ at both dates. Difference in yield per plant could be related to difference in root weight, as well as pod number per plant and seed number per pod (Table 103).

Analyses of yield per hectare at each date for the different treatments pointed out similar ranking of the sowing methods as the one found on yield per plant basis. Comparison of each sowing method for the two date of sowing showed that delaying sowing date from 7 to 66 days after rice improved the yield per hectare by 900 kg when no tilling method was used. No significant change in yield per hectare at different sowing dates was found when broadcasting method was used, whereas a reduction of 600 kg was shown with sowing in raised bed. The difference in result between yield per plant and yield per hectare is explained by the effect of germination and damping-off on plant stand, which directly affects yield per hectare. Although yield per plant significantly increased and damping-off incidence decreased between the two dates of sowing when using broadcasting method, more than 20% decrease in germination led to an unchanged yield per hectare between the two dates of sowing.

Control of bacterial spot of tomato and various diseases of pepper during off-season

Effectiveness of copper and mancozeb to control bacterial spot (BS) on tomato and to control several pepper diseases was studied on five tomato varieties and nine pepper lines during the 2000 rainy season. Copper hydroxide (Kocide101, 2.5 kg/ha) was applied three times in the nursery starting seven days after emergence, and at a 10-day interval until 30 days after transplanting (DAT) followed by a weekly application from 30 DAT until harvest. The second treatment was the same as the first except that mancozeb (Dithane M-45, 2.3 kg/ha) was mixed with copper hydroxide every two weeks starting from 30 DAT until harvest. Bacterial spot of tomato and pepper (*Xanthomonas axonopodis* pv. *vesicatoria)* was evaluated every two weeks for severity (0–4 scale, with 4 being the most severe) based on estimations of percentage of infected leaves per plant. Pepper anthracnose (*Colletotrichum* sp.) was assessed based on estimation of the percentage of infected fruit at harvest. Severity (0–5 scale, with 5 being the most severe) of choanephora blight (ChB) *(Choanephora cucurbitarum)* was assessed based on estimation of the percentage of infected shoots per plant. To determine the *Colletotrichum* species present at AVRDC-ARC, spores isolated from 50 infected fruit, collected randomly, from each variety PBC416 and PBC602, were observed under a microscope.

Neither chemical treatment was effective in controlling any of the three targeted diseases in pepper. Anthracnose was the most damaging disease, affecting on average 68% of the fruit in the control treatment (Table 104). The ineffectiveness of copper and mancozeb to control anthracnose and choanephora blight in pepper highlights the need to

Table 103. *Effect of sowing method and date of sowing after rice harvest on damping-off/root rot incidence, yield and agronomic characters of mungbean variety VC1973A*

Variable [1]	Sowing method	Date of sowing [2] 7 days after rice harvest	66 days after rice harvest	Difference [3]
DO/RR	Broadcasting	40.0% b	24.4% a	-15.6% *
	No tilling	69.4% a	18.4% a	-51.0% **
	Raised bed	20.6% b	28.0% a	7.4% ns
G	Broadcasting	67.8% a	43.2% a	-24.7% **
	No tilling	33.8% b	45.2% a	11.3% ns
	Raised bed	67.0% a	45.8% a	-21.2% **
PH	Broadcasting	54.5 a	52.3 a	-2.1 ns
	No tilling	41.2 a	51.1 a	9.9 **
	Raised bed	60.8 a	48.6 a	-12.2 ns
RW	Broadcasting	0.7 a	1.0 a	0.3 *
	No tilling	0.4 b	0.7 a	0.3 **
	Raised bed	0.7 a	0.9 a	0.2 ns
YP	Broadcasting	3.8 b	5.4 a	1.7 *
	No tilling	2.9 c	6.0 a	3.1 *
	Raised bed	5.5 a	5.1 a	-0.4 ns
PN	Broadcasting	6.6 b	10.3 a	3.7 *
	No tilling	5.6 b	10.0 a	4.4 *
	Raised bed	8.3 a	9.0 a	0.7 ns
SP	Broadcasting	10.9 ab	11.1 a	0.2 ns
	No tilling	10.8 b	10.4 a	-0.4 ns
	Raised bed	11.8 a	11.0 a	-0.7 ns
SW	Broadcasting	12.8 a	13.8 a	0.9 ns
	No tilling	13.2 a	13.6 a	0.4 ns
	Raised bed	13.2 a	14.3 a	1.1 ns
Yha	Broadcasting	0.8 b	0.9 a	0.1 ns
	No tilling	0.2 c	1.1 a	0.9 **
	Raised bed	1.5 a	0.9 a	-0.6 *

[1] Variables are: final damping-off/root rot incidence DO/RR (%), germination G (%), plant height PH (cm), dry root weight at harvest RW (g), yield per plant YP (g), number of pod per plant PN, number of seed per pod SP, 200-seed weight SW (g), yield per hectare (Yha) (t/ha).

[2] Sowing methods were compared by analysis of variance for each variable at sowing date. Values followed by a same letter were not significantly different at P (0.05) with Duncan's multiple range test.

[3] Date of sowing were compared for each sowing method by using t-test of Student. Ns, * and ** = non significant difference, significant difference at 0.05 and 0.01 levels, respectively.

find an effective fungicide and other control methods, especially resistant varieties. This study revealed that AVRDC-ARC offers a favorable environment for both diseases, which makes the site suitable for screening resistance sources and inbred lines. PBC602 was the most susceptible line, with 89% incidence, while PBC125 was the most resistant line, with moderate incidence of 44% (Table 104).

C. gloeosporioides was isolated from 98% of the collected infected fruit, and *C. capsici* was present in the remaining 2%. No difference in the ratio of Colletotrichum species was found between the varieties PBC416 and PBC602.

Choanephora blight was found to be an important constraint on pepper, with an average severity of 2.7. Pepper lines were homogeneous for their reaction to *C. cucurbitarum,* with only PBC602 showing a lower severity, at 1.4 (Table 104). In contrast to the

Table 104. *Reaction of nine pepper lines to three diseases under field conditions, rainy season 2000, AVRDC-ARC*

Line	Disease [1]		
	BS	Anthracnose	ChB
PBC275	1.0 a [2]	64% a-c	2.7 a
PBC274	0.0 b	72% ab	2.7 a
PBC273	0.0 b	70% a-c	2.7 a
PBC276	0.0 b	61% bc	2.6 a
PBC124	0.0 b	53% bc	3.2 a
PBC125	0.0 b	44% c	2.9 a
PBC137	0.0 b	52% bc	3.1 a
PBC602	1.5 a	89% a	1.4 b
PBC416	1.2 a	67% a-c	2.8 a

[1] BW = bacterial wilt, F-1 = Fusarium wilt race 1, F-2 = Fusarium wilt race 2, GLS = gray leaf spot, BS = bacterial spot.
[2] Values followed by the same letter are not significantly different at P<0.05 by Duncan's multiple range test.

other two diseases, infection by BS was light at AVRDC-ARC, with a low severity of 0.4 on average for the control treatment. Only the lines reported to be susceptible, PBC275, PBC602, and PBC416 were infected (Table 104). It is possible that *X. axonopodis* pv. *vesicatoria*, prevalent at AVRDC-ARC, belonged to pepper race P0 and/or P1, with low aggressiveness. BS infection on tomato was high, 4 on the severity scale (Table 105). Although use of copper and mancozeb did not reduce the final severity, chemical treatments did significantly affect BS progress, in time leading to a reduction in the area under the disease progress curve (AUDPC). However, adding mancozeb to copper hydroxide did not improve BS control. Analysis of previous epidemics revealed that both treatments mainly delay disease progress of by more than three weeks compared with the control treatment. Although chemical treatment was effective on all five tested tomato varieties, significant differences were observed between treatments (Table 106). CLN5915 had the lowest AUDPC for all treatments, while variety CLN2026D had the highest.

Table 106. *Effect of copper and mancozeb on bacterial spot AUDPC[1] on five tomato lines, rainy season 2000, AVRDC-ARC*

Variety	Treatment		
	Control	Copper	Copper/ mancozeb
CLN2026D	44.5 a [2]	35.3 a	32.8 a
CLN2116B	41.1 b	27.3 b	28.0 ab
CLN5915	35.0 c	19.8 c	19.5 c
Bonny Best	36.3 c	26.6 b	25.3 b
FMTT260	41.2 b	25.8 b	23.2 bc

[1] Area under disease progress curve.
[2] Values followed by the same letter are not significantly different at P<0.05 by Duncan's multiple range test.

Although the effect of chemical control differed from variety to variety, the five varieties tested were shown to be susceptible to BS. In order to develop off-season tomato production, BS resistance should be incorporated in new inbred lines. For instance, although CLN2026D has been recommended for off-season production given its good yield performance, its susceptibility to BS, as shown in this study, could

Table 105. *Average effect over five tomato varieties of copper and mancozeb on bacterial spot, rainy season 2000, AVRDC-ARC*

		Treatment		
		Control	Copper	Copper/mancozeb
Final severity index [1]		4.0 a [4]	4.0 a	4.0 a
AUDPC [2]		39.6 a	27.0 b	25.8 b
Epidemics parameters [3]	Logit-Slope	0.6 +/- 0.5	0.5 +/- 0.2	0.5 +/- 0.3
	Logit-Intercept	-2.7 +/- 4.2	-3.8 +/- 1.5	-4.2 +/- 2.7
	R square	0.85	0.97	0.91
	Delay with Control	–	3.2 weeks	3.6 weeks

[1] BW = bacterial wilt, F-1 = Fusarium wilt race 1, F-2 = Fusarium wilt race 2, GLS = gray leaf spot, BS = bacterial spot.
[2] Area under disease progress curve (AUDPC) of severity index recorded from 2 to 14 weeks after transplanting.
[3] BS progress curve was linearized by using Logit transformation and further analyzed by linear regression.
[4] Values followed by the same letter are not significantly different at P<0.05 by Duncan's multiple range test.

reduce its usefulness. *X. axonopodis* pv. *vesicatoria* strains in the area appear to be moderately aggressive on pepper. Several strains have been isolated and races will be determined. Inoculation might be necessary in further studies on pepper BS.

Quantitative analysis of capsaicin and oleoresin content in pepper

Pepper is a very important vegetable in Thailand. However, pepper capsaicin content varies widely. Four extraction methods (Soxhlet, shaking, stirring, and soaking). (1, 3, 5, and 7 hours), and four extraction solutions (acetone, ethylacetate, acetone:ethylacetate [1:1], and dichloromethane) were tested for extracting capsaicin and oleoresin from 10 hot pepper accessions. The optimal extraction was achieved by soaking the samples in acetone for seven hours.

After extraction, the 10 pepper accessions were compared for capsaicin and oleoresin content in fruit by using high performance liquid chromatography (HPLC). CA 250 had the highest capsaicin content and CA 397 had the highest oleoresin content (Table 107).

Table 107. *Capsaicin and oleoresin content in 10 accessions of pepper, AVRDC-ARC*

Accession	Capsaicin (%)	Oleoresin (%)
CA 364	0.10	17.3
CA 363	0.08	16.2
CA 303	0.13	20.3
CA 459	0.11	23.8
CA 848	0.07	17.1
CA 397	0.09	28.9
CA 250	0.17	21.6
CA 262	0.09	22.3
CA 257	0.10	21.6
CA 115	0.16	19.6

Training

Regional training course

Twenty-eight participants attended the 18th Regional Training Course on Vegetable Production, Research, and Extension held from 26 October 1999 to 25 March 2000 at AVRDC-ARC, on the Kamphaengsaen campus of Kasetsart University. They were from Bangladesh, Bhutan, Cambodia, China, Laos, Myanmar, Philippines, Thailand, and Vietnam. Nineteen participants were supported by the Swiss Agency for Development and Cooperation (SDC) through the Mekong Region Human Resource Development Project.

The 19th course opened on 26 October 2000 and includes 28 participants from Bhutan, Cambodia, China, Laos, Myanmar, Philippines, Thailand, and Vietnam. Fourteen participants are supported by SDC. Another eight participants from Cambodia, Laos, Myanmar, and Vietnam are supported by the ASEAN Foundation through the Japan-ASEAN Solidarity Fund.

In-country training

Two in-country courses were offered in 1999–2000 in Vietnam. The courses focused on two topics: diagnostics and management of major vegetable diseases; and research, development, and extension linkages for effective transfer of vegetable production technologies. A total of 58 people completed the two courses.

Germplasm collection, multiplication and exchange

AVRDC-ARC distributed 1579 seed samples of tomato, pepper, mungbean (including the International Mungbean Nursery and the series of materials resistant/tolerant to mungbean yellow mosaic virus), soybean, eggplant, and other vegetables in 2000. About 37% went to project collaborators in China and the Mekong Region. AVRDC-ARC and its local counterpart, Thailand Vegetable Research Center (TVRC), also provided seed samples to farmers in the Kamphaengsaen area.

AVRDC-ARC's new seed storage facility, built with funds from the government of Switzerland (through SDC) is now preserving important vegetable germplasm (more than 6500 accessions) from the Mekong region. In 2000, TVRC collected

744 samples of 74 Thai indigenous vegetable species and characterized 471 accessions of six genera for horticultural traits, disease resistance, and yielding ability. The collection will provide the genetic bases for vegetable improvement programs that will serve the needs of vegetable farmers and

consumers in the region.

Information development and dissemination

AVRDC-ARC distributed 805 publications on various topics to 18 countries in Asia and Africa (61% of the publications went to collaborators in China and the Mekong region). Translations of various technical publications were initiated with cooperators in Laos and Vietnam. Meanwhile, the Center's cooperators in Laos and Vietnam continued to disseminate technical materials translated in previous years, such as *Field Guide: Insect Pests of Selected Vegetables in the Tropical and Subtropical Asia* (Vietnamese and Lao), and *Pepper Diseases: A Field Guide* (Vietnamese).

China program

The collaborative research with 11 agricultural institutes in China continued in 2000 with SDC support. The progress of various studies conducted by Chinese collaborators is summarized below.

Training and exchange of germplasm and information also continued.

Institute of Crop Genetic Resources—Chinese Academy of Agricultural Sciences (CAAS)

The 22nd International Mungbean Nursery trial in China

The 22nd International Mungbean Nursery (IMN) trial was conducted in Shijiazhuang in Hebei, Taiyuan in Shanxi province, Daqing in Heilongjiang, Nanjing in Jiangsu, Mingguang in Anhui, Weifang in Shandong, Zhengzhou and Nanyang in Henan, Guilin in Guangxi, and Yangling in Shaanxi in 2000.

There were significant differences in the performance among the 20 entries. Among the new lines, VC6153B-22, VC6379-23-11, VC6379-23-11G, VC6370-92, VC6459-3-1-35, VC6370-21-3A, and VC6370-21-3A out-yielded VC1973, and VC6371-94, VC6368-46-40, VC6371-20-7A, VC3960-88, and VC6375-41-13-6 matured earlier than VC1973A. Most of the new lines have smaller seeds than VC1973A, the exception being VC6173B-15.

Enhancement of mungbean genetic resources

Breeding for high yield, good qualities, and disease resistance

The superior mungbean line I-176 was developed by ^{60}Co radiation using VC2917A as parent. The new variety gave an average yield of 1827–2337 kg/ha, which was higher (by 10.8% to 32.1%) than VC2917A in mungbean trials in Shanxi province in 1998–2000.

Breeding for bruchid resistance

One hundred and fifty bruchid-resistant breeding progeny lines were evaluated in 2000. VC6089A was found to have superior agronomic characteristics, was resistant to bruchids, and yielded 2835 kg/ha, 23% higher than VC1973A, in the Beijing municipal mungbean trial.

Collection and characterization of mungbean germplasm

The agronomic characters of 70 mungbean accessions collected from the Three Gorges region were evaluated. The collection has been preserved at the national gene bank.

Adoption and extension of new mungbean varieties and production techniques

- VC2917A and VC2719A were awarded first and second prize, respectively in the national germplasm resources excellence contest in 2000.
- Zhong Lu # 2 (VC2917A), with its superior inter-cropping ability, continued to be distributed throughout China.
- The publication *New Crossbreeding Techniques in Food Legumes* was awarded third prize in the scientific advancement contest of the Science and Technology Department, Hebei province, in 2000.

Institute of Vegetables and Flowers—CAAS

More than 300 samples of late blight-infected tomato from major production regions in China were collected and an integrated technique for isolation, purification, and maintenance of the pure culture of the pathogen was developed. Of the samples collected, 109 are being maintained in pure culture: 27 from the north; 8 from the northeast; 16 from the northwest; 22 from the southwest; 7 from central China; 2 from the east; and 9 from the south.

These pure isolates have been used to monitor the late blight pathogen's resistance to the commonly used fungicide metalaxyl. The highest proportion of resistance in the culture was found in the isolates from the southwest (70%), followed by south and central China with 40% and 36% resistant culture, respectively. There are slight indications of resistance development in the north and east.

Institute of Vegetable and Flowers, Shaanxi, AAS

Work focused on evaluation and utilization of AVRDC elite tomato lines, selected and improved since 1998, and evaluation of mungbean varieties entered in the 22nd IMN.

The following were evaluated in 2000: 23 AVRDC tomato lines improved and selected since 1998; fresh market tomato lines and varieties from various parts of China; and F_1s derived from the hybrid combinations of selected AVRDC-ARC and Chinese tomato lines.

In general, the introduced lines from AVRDC showed higher resistance to disease, more tolerance to heat, and better transportability than the Chinese lines. The yield of the AVRDC lines was influenced mainly by fruit number and fruit-setting ability, which are much higher than in the Chinese lines.

Fruits of the F_1s tended to be soft and their storability was lower than that of the AVRDC parents.

Institute for Vegetable Research, Shandong AAS

Sixty-six garlic and 25 onion lines were tested for onion yellow dwarf virus, leek yellow stripe virus, onion mite-borne filamentous virus, garlic common latent virus, and shallot latent virus by enzyme-linked immunosorbent assay and immunoelectron microscopy. The occurrence and distribution of the major viruses infecting garlic and onion in the major production areas of China have now been worked out and will be reported in 2001 after completion of analyses. In the same studies, some lines of garlic showed resistant to the viruses have been obtained.

The technology and system for *in-vitro* conservation and virus-free preservation of garlic in the genebank have been developed. The *in-vitro* storage of garlic germplasm has been proven to be genetically stable. A database of bio-information, including *in-vitro* conservation technique and molecular profile of the plant materials, has been improved and is now available.

Newly collected germplasm and older collections of garlic and onion were evaluated for agronomic characters and yield performance. Twelve garlic and eight onion entries were selected as promising for commercial production and were propagated. Twenty-six papers have been written, of which 22 have been published in journals and magazines.

Vegetable Research Institute, Tianjin AAS

An inoculation trial of 40 pepper lines was conducted to select phytopthora resistant lines and to determine the important virus diseases of pepper in the major production areas of Tianjin. Cucumber mosaic virus (CMV) (98% incidence in 43 samples) and potato virus Y (PVY) (83%) were the two most important viruses. Two other viruses were also present in high frequency: potato virus X (62%) and tobacco mosaic virus (50%). No phytopthora resistant lines were identified.

One-hundred and nine cross combinations of tomatoes were tested for heat tolerance in summer 2000. Five new combinations outyielded the three local checks by 20–30. One tomato line (S-05) was selected as a TMV- and CMV-resistant parent line for the breeding program.

Twenty heat-tolerant combinations of Chinese cabbage were tested in summer 2000 against three local checks. Two combinations were selected as most promising, outyielding the checks by 12–25% and 5–28%.

Institute of Vegetable Crops, Jiangsu AAS

Twelve accessions of gourd, Chinese cabbage, and radish were added to the vegetable germplasm collection in 2000.

Using artificial inoculation, 1346 accessions of non-heading Chinese cabbage were evaluated for resistance to turnip mosaic virus (TuMV), downy mildew, and alternaria leafspot. Two accessions, R14 and R15, showed high levels of resistance to all three diseases. The result has been confirmed in two other tests.

The transfer of Bt gene into heading and non-heading Chinese cabbage progressed well in 2000.

Nine accessions, identified as heat tolerant in previous tests, were confirmed as heat tolerant in a growth chamber study where temperature was maintained at 32.5ºC.

Fifteen new varieties of hot pepper, tomato, sponge gourd, eggplant, yardlong bean, watermelon, and non-heading Chinese cabbage were submitted by the Institute for commercial testing.

Hunan Plant Protection Institute, Hunan AAS

The Institute reported on its studies on the biological and molecular characteristics of TMV-B and CMV-P1, and the successful cloning of the coat protein (CP) genes of TMV and CMV, the transformation of these genes into pepper, and the successful establishment of a transgenic pepper line resistant to TMV and CMV.

Oil Crops Research Institute — CAAS

The Institute collected 30 accessions of vegetable soybean from different sources. Eleven were evaluated for agronomic performance and quality (as vegetable soybean) in 2000, following seed multiplication. Tai75, Yinmao 8, and Yinmao 4 showed superior traits, such as earliness, short plants with few branches, compact plant type (suitable for machine harvest), and good flavor (relatively high sugar content). However, the varieties were very susceptible to anthracnose and purple seed stain.

Seed and Seedling Center, Guangdong AAS

The Seed and Seedling Center (SSC) continues to introduce new breeding lines, especially tomatoes from AVRDC, for evaluation and selection. The best lines have been used as parents in the local breeding program. Previously, 56 tomato lines and 3 pepper lines were collected. Local tomato variety Dong Fang Hong No. 1 and pepper variety Guang Jiao No. 2 were bred from AVRDC materials. Dong Fang Hong No. 1 is resistant to bacterial wilt and tolerant to CMV, TMV, and heat, and has now become a popular variety. SSC introduced seven cherry tomato lines from AVRDC for evaluation. The best line, CLN1555B, yielded up to 53 t/ha, but its fruit are not ideal for local consumption. Although CH 154 yielded less, its fruit quality was found to be acceptable (elliptical fruit with a mean weight of 9.5 g, and soluble solids content of 6.1%).

Institute of Horticulture, Zhejiang AAS

In 2000, 25 cross combinations among lines introduced from AVRDC were studied for horticultural characteristics and heat tolerance under a plastic structure. In this study, six crosses yielded at least 80 t/ha and had firm fruits. The highest yield of the best combination was 105 t/ha. In general, most of the crosses showed prolific fruit set under high temperatures. During early summer, fruit setting of most lines was good, even when the temperature reached 35ºC.

Institute of Horticulture, Xinjiang AAS

The following tomato research was done in 2000:

- Regional trial of 9 lines
- Observational trial of 12 processing varieties
- 22 early maturing cross combinations evaluated
- 27 late maturing combinations evaluated
- 8 long shelf-life varieties evaluated
- 62 cross combinations tested in preliminary yield trial
- 16 breeding lines tested in preliminary yield trial
- Observational trial of 155 lines/accessions (collected from various sources)

In the regional trial, two new high yielding varieties, Xin Fan No. 12 and Xin Fan No. 13, were confirmed by the Xinjiang Crop Review Committee as useful for local processing tomato production. However, both varieties registered soluble solids below 5%.

Two foreign varieties, HyPeel 303 and NDM 843, were selected for promotion into commercial production based on their good yield and good solids content, fruit weight, and wall thickness.

Of 22 early maturing combinations, two were selected for demonstration and extension in 2001 based on their yield, earliness, and fruit firmness. Similarly, in the trial of 27 late maturing combinations, two were selected for demonstration and further extension in 2001.

Collaborative vegetable research and development in the Mekong region

AVRDC-ARC implemented two special projects that involved collaborative vegetable research and development (R&D) in the Mekong Region, particularly in Cambodia, Laos, and Vietnam, in 2000: the Cambodia, Laos, and Vietnam Vegetable Research Network (CLVNET), funded by the Asian

Development Bank, and the SDC-ARC Human Resource Development Project for the Mekong Region, which included collaboration with Myanmar and China.

Vegetable R&D under CLVNET

The first phase of the CLVNET project ended in July 2000 after four years. A summary of accomplishments is given below.

Human resource development

A total of 25 NARS personnel were trained , the total expected to be trained under project's three-year budget.

Adaptive trials and selection of promising germplasm

Lines identified by NARS as promising in adaptive trials in 1996–1999 were tested on-farm to verify performance and were multiplied. Promising entries yielded as much as 80% more than local checks. Other promising lines were chosen for their quality.

In Cambodia, promising entries of the following crops were identified: tomato, eggplant, hot pepper, yardlong bean, mungbean, vegetable and grain soybean, onion, kangkong, and Chinese cabbage.

In Laos, promising entries of the following crops were identified: tomato, yardlong bean, mungbean, vegetable and grain soybean, onion, and Chinese cabbage.

In Vietnam, promising entries of the following crops were identified: tomato, eggplant, hot pepper, yardlong bean, mungbean, vegetable and grain soybean, onion, cucumber, and broccoli.

The Ministry of Agriculture and Rural Development, Vietnam, approved the release of pepper variety PVR9 (PBC 495), cherry tomato VR2 (CHT 152), and vegetable soybean AGS 346. They were recommended by CLVNET's lead agency in that country, Research Institute for Fruit and Vegetable.

Integrated pest management of diamondback moth on crucifers

Facilities, including screenhouses to rear biological parasites of diamondback moth (DBM) were constructed and equipped in Cambodia and Laos. In Vietnam an old facility was renovated.

In 1997, DBM parasites *Cotesia plutellae* and *Microplitis plutellae* were reared in Cambodia. The parasitism rate of DBM larvae in the mass-rearing facility by *C. plutellae* was 74.5%, while that of *M. plutellae* was 74.7%. Several releases of the parasites in farmers' fields led, however, to disappointing results, with the mean parasitism rate in the dry season averaging 10%. In the rainy months, parasitism rate was practically nil. It is believed that heavy use of pesticide by farmers contributed to high mortality of parasites, and, thus, the low parasitism of DBM.

On the other hand, results of the integrated pest management (IPM) sub-network activities in Laos were encouraging. Parasites *C. plutellae*, *Diadegma semiclausum*, *M. plutellae*, and *Oomyzus sokolowski* were successfully reared and released in four areas where crucifers are widely grown: Paksong district, Champasak province; Luang Prabang and Xieng Ngeune districts, Luang Prabang province; Vangviang district, Vientiane Province; and Sisattanak and Hatxayfong districts, Vientiane municipality.

The rate of parasitism by *D. semiclausum* was 60% in the first release and 80% in the second release. In a follow-up monitoring, *D. semiclausum* inflicted 82% parasitism after the first release, 88% after the second, and 92% after the third. *D. semiclausum* and *M. plutellae* appear to have successfully established in the highlands of Champasak province. Frequency of pesticide spraying by farmers declined from eight times per season to almost nil. It has been estimated that poor vegetable farmers in the area saved as much as $10,000 as a result. More importantly, the cabbage crops produced in the area are relatively free of pesticides. At a lowland site, Hatxayfong, promising results were recorded with *C. plutellae*, which is more heat tolerant. Parasitism ranged from 60% to 80% over two evaluation periods.

In Vietnam, *M. plutellae* and *D. semiclausum* were also successfully reared. Releases in farmers' fields in Sapa (highland), Gialam, and Nhuquynh, Hungyen province, indicated results as promising as those in Laos, during the cropping season, especially when combined with *Bacillus thuringiensis* spray.

Contact: RT Opeña

AVRDC Africa Regional Program

AVRDC's Africa Regional Program (AVRDC-ARP) conducts vegetable research, training, and generates information for the benefit of national research and extension systems in Africa. The research and training facilities in Arusha, Tanzania, were officially opened on 15 July 1997.

Through the years, AVRDC-ARP has distributed germplasm and trained a lot of vegetable researchers, extensionisits, and NARS personnel in the region covering Angola, Botswana, Lesotho, Kenya, Malawi, Mauritius, Mozambique, Namibia, Swaziland, Tanzania, Zambia, and Zimbabwe.

Research focuses on tomato and African indigenous vegetables. Tomato breeding lines with high level of resistance to late blight are continuously being tested, so as with crop management studies on cultivar description, plant nutritional requirements, population, etc.

Development of late blight resistant tomato lines

Late blight caused by *Phytophthora infestans* remains the most important fungal disease of tomato in the African highlands during wet and cold seasons. Through a shuttle breeding program between AVRDC headquarters and AVRDC-ARP, F_5 selections with a good level of late blight resistance were selected (*AVRDC Report 1999*). During July and November 1999, these F_5 selections were evaluated for horticultural traits in two separate trials (Tables 108 and 109) and 114 new single selections were made. A few seeds of each F_6 selection were screened at AVRDC headquarters for resistance under controlled conditions using isolates T1 and T2. At AVRDC-ARP, the remaining seeds of these F_6 selections were sown on 17 February 2000. The plants were transplanted on 24 March 2000 and evaluated for field resistance.

Screening at headquarters indicated that 90 may be resistant. Of the 90 lines tested again under field conditions at AVRDC-ARP, 26 were resistant. All single selections found resistant at AVRDC-ARP were also resistant under controlled conditions at headquarters. Thirty-eight new selections were made and will be evaluated for horticultural traits and resistance to tomato mosaic virus, fusarium wilt, and root-knot nematodes.

Screening tomato breeding lines for resistance to tomato mosaic virus and root-knot nematodes

A major objective of the tomato germplasm improvement program for the African highlands is to develop multiple disease resistant tomato lines with good horticultural traits. In order to achieve the above objective, late blight resistant breeding lines selected in previous experiments were screened for both tomato mosaic virus (ToMV) and root-knot nematodes under controlled conditions. Seeds of 30 late blight resistant tomato lines were sown on 1 August 2000 in a nematode (*Meloidogyne javanica*) – infested nursery. The selections were arranged in a randomized complete block design (RCBD) with three replications. Two weeks after sowing, seedlings were mechanically inoculated with an isolate of ToMV pathotype 0, which was maintained on tomato cv. Moneymaker in the screen house. Four weeks after inoculation, ToMV presence in inoculated plants was ascertained by enzyme-linked immunosorbent assay (ELISA) using reagents from Agdia Inc., USA. Two weeks later, seedlings were uprooted and evaluated for severity of root galling or egg mass production. The root galling severity was assessed on a 0–5 scale by estimating the number of galls or egg masses: 0 = no galls or egg masses, 1 = 1–2 galls or egg masses, 2 = 3–10 galls or egg

Table 108. *Yield and other characteristics of late blight resistant lines (Trial 1)*

Line code	Yield (t/ha)	Fruit no. per plant	Days to 50% flowering	Fruit shape
LBR 3-1	54. 3 ab[1]	31 ab	23 e	round blocky
LBR 3-3	55.1 ab	42 a	17 f	globe oblate
LBR 32-2	40.5 bc	43 ab	29 a-d	oblate
LBR 28-1	47.2 bc	31 ab	31 ab	oblate
LBR 28-2	45.8 bc	31 ab	28 cd	globe oblate
LBR 28-3	49.1 bc	30 ab	31 ab	oblate
LBR 28-4	40.4 bc	22 b	27 d	oblate
LBR 1-6	53.6 ab	35 ab	17 f	oblate
LBR 29-1	33.7 c	26 b	31 ab	oblate
LBR 29-2	42.0 bc	28 b	30 a-d	globe oblate
LBR 29-3	42.8 bc	24 b	27 d	oblate
LBR 29-4	47.5 bc	24 b	24 e	oblate
LBR 29-6	45.4 bc	27 b	28 b-d	globe oblate
LBR 30-1	42.3 bc	26 b	29 a-d	oblate/nippled
LBR 30-2	45.6 bc	24 b	29 a-d	oblate/nippled
LBR 30-3	40.5 bc	26 b	31 a-c	globe oblate
Tengeru 97	66.9 a	33 ab	23 e	globe oblate

[1] Means within the same column followed by the same letter are not significantly different at P<0.05 by Duncan’s multiple range test.

Table 109. *Yield and other characteristics of late blight resistant lines (Trial 2)*

Line code	Yield (t/ha)	Fruit no. per plant	Days to 50 % 50% flowering	Fruit shape
LBR 8-2	47 ab [1]	34 b-f	23 cd	oblate
LBR 9-1	42 a-c	40 b-d	23 cd	flat round
LBR 9-3	55 a	61 a	24 b-d	globe
LBR 10-1	47 ab	40 b-d	23 cd	oblate
LBR 10-2	42 a-c	43 bc	24 b-d	flat round
LBR 10-3	46 ab	44 ab	23 cd	flat round
LBR 10-6	43 a-c	46 b	21 d	round
LBR 20-5	33 b-d	36 b-e	25 bc	oblate
LBR 26-2	30 b-d	28 d-f	23 cd	oblate
LBR 26-3	36 b-d	27 d-f	26 bc	oblate
LBR 35-3	22 d	23 ef	23 cd	oblate
LBR 38-1	35 b-d	30 c-f	26 bc	oblate
LBR 42-1	29 b-d	21 ef	30 a	flat round
LBR 45-3	28 cd	10 f	27 ab	oblate
Marglobe	48 ab	22 ef	30 a	globe

[1] Means within the same column followed by the same letter(s) are not significantly different at P<0.05 by Duncan's multiple range test.

masses, 3 = 11–30 galls or egg masses, 4 = 31–100 galls or egg masses, and 5 = more than 100 galls or egg masses.

The late blight resistant lines were heterogeneous in their response to ToMV and nematode inoculations (Table 110). For each pathogen, a few lines were resistant and the others were segregating or susceptible. There was no line that expressed resistance to both root-knot nematode and ToMV. However, a few plants from different selections were found resistant to root-knot nematodes and ToMV.

Adaptation trial of multi-disease resistant sweet pepper lines

In sub-Saharan Africa, the major pepper diseases are anthracnose, phytophthora blight, bacterial spot, cucumber mosaic virus (CMV), pepper veinal mottle virus (PVMV), potato virus Y (PVY), and tobacco mosaic virus (TMV). The use of genetic resistance remains the best control strategy. Sources of resistance was identified and incorporated into some bell pepper cultivars. In 1997, collaborative work has been initiated with the vegetable breeding unit of Institut National de la Recherche Agronomique (INRA), Avignon, France, to test multi-disease resistant sweet pepper populations for in Tanzania. Following adaptation trials, seeds of the best plants in each family were harvested and sent to INRA for further virus (CMV, PVMV, PVY, and TMV) screening under controlled conditions. Resistant plants from each subpopulation were intercrossed with the resistant plants from the neighboring subpopulations.

In December 1999, seeds of 35 progenies from intercrosses of the best subpopulations evaluated in 1998 (*AVRDC Report 1998*) were received. These seeds were sown on 11 January and transplanted on 17 February. Cultivars California Wonder and Yolo Wonder were used as controls. In each family, 25 plants were evaluated for adaptability and agronomic traits. Seeds of the best plant of each family were harvested and sent to INRA for further screening under controlled conditions. Based on yield, adaptability and other agronomic characteristics, have been Tz-5, Tz-8, and Tz-19 are selected for selfing (Table 111).

Preliminary evaluation of 12 garlic lines for yield adaptation

Selected lines of garlic (*Allium sativum*) were evaluated for yield adaptation at AVRDC-ARP from June to November 2000. The experiment was laid out in a RCBD with three replications. Cloves were planted on 0.45-m-wide, 3-m-long beds. Ten AVRDC lines and two local checks were sown. The plants were watered regularly and were fertilized with 100 kg/ha of NPK (20-10-10) four weeks after planting. Weeding and pest control were carried out

Table 110. *Evaluation of late blight resistant tomato breeding lines for resistance to root-knot nematodes and tomato mosaic virus*

Line code	Gall index [1]	ToMV incidence
3 LBR 32-2 (Pl.1)R2’	0.00 e [2]	58.30 a
14 LBR 45-1 (Pl.10)R1	4.30 a	16.30 c
15 LBR 30-2 (Pl. 3) R1’	4.60 a	39.70 b
122	4.40 a	11.30 c-g
13 LBR 42-1 (Pl.4) R3	0.00 e	6.70 d-g
5 LBR 28-2 (Pl. 1) R1’	4.60 a	4.30 f-h
119	4.50 a	0.00 h
5 LBR 28-2 (Pl. 1) R2’	5.00 a	0.00 h
10 LBR 29-2 (Pl. 7) R2’	5.00 a	0.00 h
4 LBR 28-1 (Pl. 5) R2	0.00 e	3.30 gh
15 LBR 30-2 (Pl. 1) R1	0.00 e	5.00 e-g
13 LBR 42-1 (Pl. 3) R2’	4.50 a	13.30 c-e
6 LBR 28-3 (Pl. 3) R2	0.30 de	4.30 f-h
8 LBR 10-3 (Pl. 4) R2’	0.50 c-e	4.30 f-h
6 LBR 28-3 (pi.4) R1’	0.70 c-e	13.70 c-e
7 LBR 28-4 (Pl. 2) R2	0.40 c-e	0.66 h
7 LBR 10-2 (Pl. 4) R1	0.00 e	1.30 h
14 LBR 30-1 (Pl.6) R1	2.90 b	1.70 h
15 LBR 30-2 (Pl.6) R1	5.00 a	3.70 gh
6 LBR 28-3 (Pl. 5) R1	0.98 cd	14.30 cd
13 LBR 42-1 (Pl. 2) R3’	0.00 e	1.70 h
6 LBR 28-3 (Pl. 4) R2	0.00 e	1.70 h
120	4.80 a	2.00 h
15 LBR 42-2 (Pl. 1) R1’	0.81 cd	13.00 c-f
6 LBR 28-3 (Pl. 4) R2	0.97 cd	0.00 h
16 LBR 30-3 (Pl. 3) R1	1.00 cd	0.00 h
130	4.50 a	5.00 e-h
11 LBR 29-3 (Pl. 5) R3’	4.80 a	0.00 h
9 LBR 29-1 (Pl. 1) R3’	1.90 c	5.70 h
13 LBR 29-6 (Pl.1) R2	5.00 a	0.00 h

[1] Gall index was made on a scale of 0 to 5 with 0 = no gall or egg mass and 5 = over 100 galls or egg masses.

[2] Means followed by the same letter within column do not differ significantly at P<0.05 by Duncan’s multiple range test.

as needed. Bulbs were harvested from 129 days (on average) after planting. They were cured for a week prior to data collection. VFG 180, VFG 34, VFG 176, and Kenya 2 achieved the best yields. VFG 180, VFG 34, VFG 173 had the highest number of cloves, while VFTA 275 was the earliest to reach maturity, at 107 days (Table 112).

Onion performance trial

Seventeen cultivars of onion were evaluated for their yield characteristics. The experiment was laid out in RCBD with three replications. The seeds were sown in sterilized seedbeds on 2 June 1999. Seedlings were transplanted 15 cm apart in a plot 0.75 × 6 m on 19 July 1999. There were 150 plants per plot. Ringer Grano (improved) gave the highest bulb yield, 38.2 t/ha, followed by E 515 (H), Contessa, Gladalar Brown, Texas Grano 438, Valeouro IPA-II, and Pyramid, which yielded 28.8, 27.7, 26.8, 25.3, 25.2, and 25.0 t/ha, respectively.

Preliminary evaluation of 12 mungbean lines for yield adaptation

Mungbean (*Vigna radiata*) is popular in tropical Africa. In 1998, preliminary evaluation identified a few promising lines, although yields were low (0.9–1.44 t/ha). Twelve promising lines were further evaluated from September to December 1999. The trial was laid out in RCBD with three replications in 0.45-m-wide and 6-m-long beds. Seeds were drilled and two weeks after germination, the seedlings were thinned to a spacing of 15 cm. Furrow irrigation was applied once a week initially and twice a week during flowering and pod formation. Weeds and pests were controlled as necessary. The plants were sprayed in October with Selectron® to control aphids.

NM-92, VC6173 (B-33), VC6379(23-2-1), and VC6175(41-13-6) flowered earliest, while Kanti (check variety) gave the highest number of pods per plant. VC6148(50-12) and VC6173(B-10b) had the highest 1000-seed weight. VC6153 (B-20P), Kanti, and VC6148(5012) gave the highest seed yields, although there were no significant difference among the lines (Table 113).

Table 111. *Yield and other agronomic traits of the best sweet pepper populations evaluated in Tanzania in 2000*

Line code	Yield (kg/plant)	Fruit no./plant	Characteristics
Tz-5	1.5	10.8	blocky, good fruits, good canopy
Tz-8	1.3	10.8	blocky, good fruits, uniform
Tz-19	1.7	13.0	good fruits, good canopy
California Wonder	1.0	7.8	susceptible to phytophthora blight
Yolo Wonder	1.0	8.0	susceptible to phytophthora blight

Table 112. *Yield and horticultural characteristics of 12 garlic accessions evaluated at AVRDC-ARP, June–November 2000*

Variety	Yield (t/ha)	Yield (g/plant)	Ave. no. of cloves/bulb	Bulb diameter (cm) (equatorial)	Bulb diameter (cm) (neck)	Bulb length (cm)	Leaves/ plant	Days to maturity
VFG 180	17.5 a	44.1 a	11.7 f	4.7 ab	1.4 b	3.8 bc	8.3 a-d	135 b
VFG 34	14.7 ab	40.6 ab	11.7 f	5.0 a	1.4 b	3.9 ab	7.9 b-e	133 bc
VFG 176	14.1 ab	40.0 ab	10.7 f	4.7 b	1.2 bc	3.5 b-e	8.0 b-e	128 d-f
KENYA 2	13.5 ab	32.5 b-d	10.7 f	4.4 b-d	1.1 d	3.6 b-d	8.9 a	127 ef
G98-6-1-1	13.1 b	31.8 b-d	17.3 de	4.3 cd	1.2 cd	3.5 c-f	7.6 c-e	132 c
KENYA 1	12.7 b	23.1 d-f	1.0 g	3.2 g	1.9 a	4.2 a	8.1 a-e	156 a
VFG 173	11.8 bc	35.1 a-c	24.0 ab	4.5 bc	1.1 cd	3.7 c-f	8.5 a-c	126 ef
G98-9	11.5 b-d	30.0 c-e	20.3 cd	4.5 bc	1.1 cd	3.7 c-f	8.0 b-e	131 cd
VFTA 325	10.4 b-d	35.1 a-c	16.0 e	4.5 bc	1.3 b	3.2 d-g	8.7 ab	125 f
G50-1-1-2	8.2 cd	28.5 c-f	19.3 cd	4.2 cd	1.0 d	3.1 e-g	7.5 de	129 de
VFTA 275	7.5 cd	19.1 f	26.3 a	3.8 f	1.0 d	2.9 gh	7.3 e	107 h
VFTA 158	7.3 d	20.8 ef	22.0 bc	3.8 ef	1.2 cd	2.7 h	8.1 a-e	115 g

[1] Means within the column followed by the same letter are not significantly different at P<0.05 by Duncan's multiple range test.

Table 113. *Evaluation of selected mungbean lines for seed yield and agronomic characteristics*

Accessions	Days to 50% flowering	Days to 50% pod formation	Pod no./ plant	Seed no./ pod	1000-seed wt. (g)	Seed yield (g/plant)
NM 92	43 d[1]	53 d	17 b	9.7 a	51.3 ab	8.4
Kanti	61 b	68 a	46 a	9.3 ab	43.2 b	12.9
VC6173(B-10b)	47 bc	61 b	17 b	8.0 bc	63.8 a	9.1
VC6173(B-6)	48 bc	57 b-d	14 b	8.4 a-c	51.2 ab	5.9
VC6148(50-12)	48 bc	57 b-d	19 b	9.7 a	64.7 a	12.2
VC6173(B-33)	43 d	56 b-d	15 b	8.8 ab	61.2 ab	8.6
VC6379(23-2-1)	43 d	58 b-d	17 b	9.2 ab	51.1 ab	8.0
VC6367(44-5-2)	50 b	56 b-d	18 b	9.8 a	54.9 ab	10.3
VC6173(B-14)	45 cd	56 b-d	17 b	6.9 c	58.3 ab	7.3
VC6175(41-13-6)	43 d	56 b-d	19 b	8.6 ab	60.4 ab	10.2
VC6173(45-8)	46 cd	54 cd	20 b	9.5 ab	55.1 ab	10.2
VC6153(B-20P)	45 cd	53 d	24 b	8.3 a-c	60.3 ab	12.9

[1] Means followed by the same letter within the column are not significantly different at P<0.05 by Duncan's multiple range test.

Evaluation of soybean accessions for yield adaptation under highland conditions

Thirteen soybean (*Glycine max*) accessions were evaluated for adaptability from August to November 1999. The experiment was laid out in RCBD with three replications. Seeds were sown 10 cm apart in plots 6.0 × 0.7 m. Weeds, pests, and diseases were controlled as necessary. GC 00138-29 flowered earliest at 32 days, while GC 84058-21-4 and G 10428 gave the highest fresh pod yields and most pods per plant (Table 114). GC 60020-8-7-7-18 produced a significantly higher percentage of one-seeded pods, while G 8587 and GC 00138-29 had the largest pods.

Evaluation of cabbage varieties for black rot resistance

Black rot, caused by *Xanthomonas campestris* pv. *campestris*, occurs in all countries where cabbage is grown. Typical symptoms include V-shaped lesions and chlorotic blotches on leaf margins, and

Table 114. *Yield and growth characteristics of soybean lines evaluated at AVRDC-ARP, Arusha, August–November 1999.*

Accession	Days to 50% flowering	Biological (t/ha)	Fresh pod yield (t/ha)	Pod no./ plant	One-seeded pods (%)	Pod length (cm)	Pod width (cm)
GC 84040-27-1	43.7 b	16.6 c	7.1 f	8.2 e	72.2 b	5.4 a-c	1.5 b-e
GC 86017-170-1N	39.0 b	19.4 c	10.4 de	12.2 de	57.3 c-e	5.6 a-c	1.6 a-c
GC 86018-427-3	44.3 b	31.0 b	14.5 c	21.6 b	56.2 c-e	5.4 a-c	1.5 b-e
GC 60020-8-7-7-18	118.8 a	40.3 a	15.4 bc	22.9 b	94.2 a	5.4 a-c	1.5 de
GC00138-29	31.6 b	29.8 b	10.5 de	14.9 cd	57.6 c-e	5.7 a-c	1.6 a
GC84058-21-4	43.7 b	45.7 a	21.4 a	34.0 a	51.7 ef	5.6 a-c	1.5 c-e
GC86049-35-2-1-1-8-1N	44.3 b	29.2 b	22.3 f	18.2 bc	62.0 cd	5.3 a-c	1.6 ab
GC84040-7-1	39.0 b	28.3 b	13.8 c	20.3 b	46.7 f	5.2 c	1.5 a-e
GS86045-23-2	43.3 b	17.7 c	9.1 ef	11.4 de	60.0 cd	5.4 a-c	1.5 de
G 8586	43.3 b	18.4 c	9.3 ef	10.9 de	63.3 c	5.3 a-c	1.5 a-d
G 8587	43.7 b	29.5 b	17.8 b	23.0 b	44.9 f	5.9 a	1.5 a-d
G 10427	43.7 b	18.9 c	9.7 ef	11.2 de	55.9 de	5.2 bc	1.6 a-c
G 10428	39.3 b	42.7 a	21.6 a	35.4 a	46.6 f	5.8 ab	1.4 e

Means with the same letter within the column are not significantly different at P<0.05 by Duncan's multiple range test.

blackened veins associated with systemic movement of the pathogen. The pathogen is primarily disseminated through infected seeds. The disease has reemerged as one of the most economically significant problems affecting cabbage crops in Tanzania, where popular varieties, such as Drumhead and Glory of Enkhuisen, are very susceptible. Currently, disease control relies on frequent applications of copper fungicides. The objective of this study was to evaluate cabbage varieties for black rot resistance.

Seeds of Amigo, Amukosi F_1, Conquisidor, Drumhead, Gloria F_1, Glory of Enkhuisen, Hercules, and Rinda F_1 were sown in the nursery on 4 April 2000, and seedlings were transplanted to the field on 11 May. The experimental was laid out in RCBD with three replications, 24 plants of each variety in each replication. On 12 June, a pure isolate of black rot was injected in two leaf petioles of each plant. Plants were monitored weekly for disease severity, which was rated on a scale from 0 to 9 where 0 = no lesions; 1 = small necrotic lesions on leaf margins; 3 = V-shaped necrotic lesions about 0.5 cm long along leaf margins; 5 = small to medium size V-shaped lesions and blackened veins; 7 = progressing marginal lesions, often reaching mid-rib, prominent vein blackening; 9 = severe stunting of plants, soft rot, dead plant.

The disease progressed quickly in Drumhead, Amukosi, and Amigo F_1. These varieties exhibited the highest severity two weeks after inoculation. At harvest, plants of all varieties expressed disease symptoms. Based on disease severity, Conquistador, and Hercules expressed a high level of resistance to black rot. With Amigo, the incidence remained and produced the highest yields only in the outer leaves and did not progress to the main stem, allowing for high marketable yields. (Table 115).

Effect of nitrogen fertilizer type and application levels on seed yield of *Amaranthus cruentus*

Amaranth is a popular vegetable in most of sub-Saharan Africa. It is commonly grown in the tropical lowlands, mostly for its leaves but also for its grain. *Amaranthus cruentus* (2n = 32) is a popular variety, often cited as a good example of an African indigenous vegetable.

Most species and cultivars have a high rate of nitrogen absorption, and side dressing with N fertilizer is normally required during active growth periods to obtain optimum yield.

A trial was conducted July–November 1999 at AVRDC-ARP to evaluate seed yield response of amaranth to application of different types and rates of N fertilizer. Seeds were sown at a rate of 1.5 kg/ha in 5.4-m^2 beds. Seedlings were later thinned to a spacing of 15 cm within the row. The experiment was laid out in a 3 × 5 factorial RCBD with three replications. Furrow irrigation was applied and weeding carried out as necessary. The treatments were: urea, calcium ammonium nitrate, and

Table 115. *Evaluation of cabbage varieties for black rot resistance*

Variety	Incidence two wks after plant inoculation (%)	Severity two wks after plant inoculation	Incidence at harvest (%)	Severity at harvest	Yield (t/ha)
Hercules	2.7 e[1]	0.0 d	100 a	2.1 e	100.5 a
Conquistador	30.7 c-e	0.3 b-d	100 a	1.3 f	94.2 ab
Golden Acre	21.7 de	0.2 cd	100 a	2.2 e	36.7 f
Glory of Enkhuisen	32.7 cd	0.7 b	100 a	7.8 a	82.2 cd
Gloria F_1	52.1 bc	0.5 bc	100 a	6.5 b	76.6 d
Amigo F_1	63.3 b	0.7 b	100 a	2.7 e	89.6 bc
Amukosi	71.0 b	0.7 b	100 a	2.8 d	38.4 f
Rinda	21.3 de	0.4 bc	100 a	5.2 c	59.8 e
Drumhead	100.0 a	1.8 a	100 a	5.6 c	78.5 d

[1] Means followed by the same letter within column do not differ significantly at P<0.05 by Duncan's multiple range test. Incidence (%); Severity (0-9 scale); 0-no symptoms and 9 plants dead.

ammonium sulphate applied at rates of 60, 90, and 120 kg/ha, respectively. Results showed that urea produced slightly higher seed yield and number of seeds per plant compared to the other treatments. The highest seed yield, 4.3 t/ha was obtained with the application of 120 kg N/ha urea, which resulted in a significant increase in the number of seeds per plant and an increase in seed yield from 37.8 g/plant without N to 58.5 g/plant with 120 kg N/ha.

Yield adaptability potential of African eggplant lines

African eggplant (*Solanum aethiopicum*) is an important traditional vegetable in sub-Saharan Africa, but production technology for the crop is lacking. This experiment, conducted in Arusha, Tanzania, from July to November 1999, evaluated the yield adaptability and horticultural characteristics of 16 eggplant varieties.

The experiment was laid out in RCBD with three replications, in a plot 6.0 × 0.9 m with two rows 90 cm apart, eight seedlings 75 cm apart per row, transplanted on 23 July. NPK (20-10-10) fertilizer was basally applied at a rate of 75 kg/ha. Three weeks after transplanting, 80 kg/ha of urea (46% N) was side dressed in a split application. Other cultural management practices, such as irrigation and weeding, were carried out as necessary throughout the growing season. The first of five harvests was done 20 October.

Foumbot Cameroon and D.B 3 flowered earliest at 48 and 51 days, respectively (Table 116). Dischang Cameroon, Tengeru White, and CN 008 had the largest fruit weight, while Tengeru Long Fruit, Tengeru White, and Foumbot Cameroon gave significantly higher fruit yield, more than 40 t/ha (Table 116). The latter three varieties show promise for local adaptation.

Evaluation of Ethiopian kale accessions for resistance to turnip mosaic virus

Ethiopian kale (*Brassica carinata*) is a multipurpose crop cultivated in the highlands of eastern and southern Africa. Several landraces of the crop are used as a leafy vegetable in the region. A viral disease, identified in earlier studies as turnip mosaic virus (TuMV), is one of the most destructive foliar diseases affecting the crop.

TuMV is transmitted by several aphid species in a non-persistent manner. Common symptoms include yellow or green mosaic and reduced growth. Certain isolates of TuMV cause necrosis of the apical shoots. Farmers' losses due to TuMV can reach 100%, depending on the time of infection. To control TuMV, farmers apply synthetic insecticides to reduce the aphid population. The resulting residue and phytotoxity are a hazard to consumers.

Work began in 1994 to select TuMV resistant plants from landrace populations. Varieties Mbeya Green and Mbeya Purple were obtained from these preliminary selections. Mbeya Purple has since been found to be susceptible to TuMV.

This study assessed newly collected accessions of Ethiopian kale for resistance for TuMV in the greenhouse and field. The objective is to develop improved lines that express a good level (less than 50% disease incidence) of field resistance to TuMV.

Table 116. *Evaluation of 16 African eggplant varieties at AVRDC-ARP, July-November 1999*

Varieties	Days to 50% flowering	Fruit wt. (g)	Fruit set (%)	Yield (t/ha)
Tengeru White	53 b-e[1]	50.9 a	27.8 b	42.2 a
Dakawa I	60 a	25.9 ef	12.8 gh	19.6 cd
Ubembe Muheza	54 b-d	19.6 fg	18.5 c-e	22.8 b-d
Tengeru Round	47 f-h	28.7 d-f	20.9 c	30.8 a-c
Foumbot Cameroon	38 j	46.2 ab	25.4 b	40.1 ab
A.M.O	48 e-h	44.5 a-c	32.8 a	39.2 ab
A.B 8	51 c-f	25.7 ef	34.7 a	34.0 a-c
N 41	49 d-g	34.9 c-e	10.2 h	34.2 a-c
Tengeru Smooth	45 g-i	36.3 b-d	15.7 e-g	29.0 a-d
GE 8	57 ab	11.3 gh	19.1 cd	20.6 cd
CN 008	44 hi	50.6 a	19.6 cd	34.1 a-c
O.A.A 089	56 a-c	19.8 fg	16.4 d-f	29.3 a-d
D.B 3	41 ij	27.2 d-f	13.9 fg	33.4 a-c
C.N 011	50 d-g	3.4 h	13.5 f-h	13.0 d
Tengeru Long Fruit	56 a-c	44.7 a-c	27.3 b	42.8 a
Dischang Cameroon	53 b-d	53.1 a	13.2 d-h	29.9 a-d

[1] Means within the column followed by the same letter are not significantly different at P<0.05 by Duncan's multiple range test.

Seedlings of Ethiopian kale accessions/varieties Loshuu (Tengeru-Tanzania), Figiri (Iringa-Tanzania), Mbeya Green (Tanzania), Mbeya Purple (Tanzania), RRS-V (Zimbabwe), Chibanga (Zambia), NIRS-I (Zambia), and NIRS-II (Zambia) were grown in 12 cm pots filled with a mixture of sterile forest soil, sand, and cattle manure at a ratio of 1:1:2 and arranged on benches in a greenhouse The experiment was RCBD with three replications.

The three-week-old seedlings were mechanically inoculated with an isolate of TuMV. The isolate was obtained from one field-infected Mbeya Green collected from AVRDC-ARP's Madiira farm in Arusha. (This isolate was identified as TuMV by reaction in enzyme-linked immunosorbent assay using kits from Agdia Inc., USA.)

In each replication, 24 plants of each accession/ variety were inoculated and four non-inoculated plants were used as control. Disease incidence and severity were recorded 21 days after inoculation. Disease severity was scored on a scale of 0 to 5, with 0 = no visible symptom, 1 = localized mild mosaic, 2 = systemic mild mosaic, 3 = localized severe mosaic, 4 = systemic severe mosaic, 5 = severe mosaic with reduced growth.

For field evaluation, seeds of the same eight accessions/varieties were sown in a nursery bed on 28 February and seedlings transplanted on 22 March in plots 6.0 × 0.9 m, with 50 × 40 cm spacing between and within rows, respectively. The experiment was RCBD with three replications. Disease incidence and severity were recorded when the first plants bolted.

In the greenhouse experiment, all inoculated plants of each accession expressed mosaic symptoms characteristic of TuMV, indicating susceptibility. However, disease severity varied (Table 117). NIRS-II, RRS-V, and Mbeya Green were least affected. In the field, the disease incidence among accessions ranged from 18% to 96%. NIRS-II had the lowest disease incidence. As in the greenhouse experiment, NIRS-II and Mbeya Green displayed the lowest disease severity.

Except for disease incidence, results of the field experiment confirm observations made in the greenhouse. The difference in disease incidence between the greenhouse and field experiments could be due to disease pressure, which is higher from mechanical inoculation than from natural infection.

Yield response of spider flower plant (*Cleome gynandra*) to different spacing and nitrogen levels

Spider flower plant (C*leome gynandra*), commonly consumed as a vegetable, is indigenous to sub-Saharan Africa. It can be adapted to a wide range of environments, but requires fertile soils.

Table 117. *Evaluation of Ethiopian kale accessions/varieties for resistance to turnip mosaic virus*

Accession	Disease incidence in the greenhouse (%)	Disease severity[2] in the greenhouse	Disease incidence in the field (%)	Disease severity in the field
Loshuu	100 a[1]	4.3 c	91.7 ab	4.33 a
Figiri	100 a	5.0 a	93.3 ab	4.83 a
Mbeya Green	100 a	2.6 d	20.0 d	1.66 bc
RRS-V	100 a	2.3 d	33.3 c	2.20 b
Mbeya Purple	100 a	4.9 a	96.7 a	4.66 a
Chibanga	100 a	4.6 b	88.3 b	4.20 a
NIRS-I	100 a	4.5 bc	95.0 a	4.73 a
NIRS-II	100 a	2.1 e	18.3 d	1.33 c
CV (%)	0	3	4	10

[1] Means followed by the same letter within column do not differ significantly at P<0.05 by Duncan's multiple range test.
[2] Disease severity was rated on a scale of 0 to 5, with 0 = no visible symptom and 5 = severe mosaic and reduced growth.

The plant's yield and growth response to nitrogen and spacing were assessed at AVRDC-ARP's farm in July–November 1999. The experiment was a 3 × 5 factorial, RCBD, with three replications, three spacings (25, 50, and 75 cm), and five nitrogen (urea) levels (0, 90, 120, 150, and 180 kg N/ha). Seeds of the purple stem line were sown along ridges in single rows in beds 6.0 × 0.9 m. The field was irrigated once or twice a week and weeded as necessary.

Leaves were harvested weekly, for seven weeks, beginning five weeks after sowing. The economic and biological yields were recorded, while the number of pods per plant and seed yield were recorded to determine the optimum requirements for seed multiplication.

Economic yield increased significantly, from 7.65 t/ha to 13.03 t/ha, with the application of 90 kg N/ha (Table 118). However, economic yield decreased significantly, from 16.3 t/ha at 25 cm spacing to 8.7 t/ha at 50 cm (Table 119). Seed yield responded to spacing but not to nitrogen application. The number of pods per plant was highest after application of 90 kg N/ha and 75 cm spacing, but there was no corresponding increase in seed yield.

These results indicate that application of 90 kg urea (41.4 kg N/ha), combined with 25 cm spacing, will provide high economic yields. Higher N rates at this spacing were not justified.

Training

Germplasm management training

A regional training course on germplasm management was conducted 26–31 March 2000. Eleven participants (three women) from Angola, Malawi, Zambia, Lesotho, Swaziland, South Africa, Mozambique, Tanzania, Mauritius, and Zimbabwe attended. The course was sponsored by the SADC Plant Genetic Resource Center in Zambia.

Table 118. *Yield characteristics of spider flower plant in response to nitrogen, at AVRDC-ARP, Arusha, July–November 1999*

N levels (kg/ha)	Economic yield (t/ha)	Biological yield (t/ha)	Pods/ plant	Seed yield (kg/ha)	Seed yield (g/plant)
0	7.7 b[1]	0.9 c	393	227	3.9
90	13.1 a	1.5 ab	433	240	4.3
120	13.2 a	1.8 a	397	235	4.2
150	11.5 ab	1.4 ab	419	229	4.1
180	9.9 ab	1.3 bc	345	245	4.3
F test	**	**	ns	ns	ns
CV (%)	36	31	33	18	19

[1] Mean values within the column followed by the same letter(s) are not significantly different at P<0.05 by Duncan's multiple range test.
[2] **, *, ns = Differences are significant at the 0.01, 0.05 levels, or non-significant.

Table 119. *Yield characteristics of spider flower plant in response to spacing, at AVRDC-ARP, Arusha, July–November 1999*

Spacing (cm)	Economic yield (t/ha)	Biological yield (t/ha)	Pods/plant	Seed yield (kg/ha)	Seed yield (g/plant)
25	16.3 a[1]	2.10 a	340 a	410.4 a	4.62 a
50	8.7 b	1.12 b	382 a	180.0 b	4.05 b
75	8.2 b	1.03 b	460 a	115.2 c	3.90 b

[1] Mean values within the column followed by the same letter(s) are not significantly different at P<0.05 by Duncan's multiple range test.

Training courses for Tanzania

Twenty-four trainees from the Ministry of Agriculture and Cooperatives, Tanzania, attended a course on vegetable crop production, 28 May to 3 June at AVRDC-ARP in Arusha. Forty people from NGOs operating in Tanzania attended a similar course conducted 6–9 June. Thirty-two representatives from NGOs participated in a consultative workshop on vegetable research and development in Tanzania on 5 June at AVRDC-ARP.

Seventh regional course

The Seventh Regional Training Course on Vegetable Production in Southern Africa, July–November 2000, graduated 11 men and 9 women from Malawi (1), Tanzania (5), Seychelles (2), Mauritius (1), Zambia (2), Mozambique (1), Swaziland (2), Lesotho (2), Botswana (2), Namibia (1), and Senegal (1).

Training in Sudan

Two training courses in vegetable crops production were held in Yambio and Rumbek counties in southern Sudan, 1–8 July and 24–30 September, respectively. Seventy participants from self-help groups, NGOs, and UNICEF attended the courses organized by AVRDC-ARP in collaboration with UNICEF-Operation Lifeline Sudan.

Tomato processing course

Tomato fruit processing courses were conducted for farmers in the Arusha region of northern Tanzania on 30 August and 12 September. Thirty-seven women and eight men attended.

Research internships

Six undergraduate student interns (five from Tanzania and one from Uganda) from Sokoine University of Agriculture were trained at AVRDC-ARP from 28 February to 1 April. They worked on seed dormancy and germination of African nightshade, collection and preservation of tomato leaf samples for characterization of ToYLV, evaluation and comparison of amaranth varieties, documentation of germplasm material, and establishment of home gardens for effective land utilization.

Field day

A field day was held at AVRDC-ARP on 22 October for people in the Arusha and Kilimanjaro region. More than 125 researchers, extensionists, development workers, company workers, and farmers attended. A question-and-answer session was held on constraints in vegetable crop production, available solutions, and improved technologies. Participants were also given seeds of improved AVRDC lines.

Contact: ML Chadha

Manila peri-urban vegetable project

Asian cities, such as Manila, face an enormous challenge to remedy micronutrient deficiencies among the poor, to recycle solid wastes, and reverse environmental degradation.

The AVRDC peri-urban vegetable project in the Philippines, sponsored by Gesellschaft für Technische Zusammenarbeit (GTZ), is designed to: stabilize the supply of safe and nutritious vegetables to metropolitan areas; and develop an approach for information acquisition, testing, and dissemination suitable to other peri-urban areas in Asia.

Socioeconomics

Technologies introduced from AVRDC to improve production of pak-choi (*Brassica rapa* L. cvg. pak-choi) proved to be profitable based on experimental and survey data from *barangay* (community) San Leonardo and Central Luzon State University (CLSU) in Nueva Ecija. Costs and returns of introduced technologies and showed significant improvement in yield and net income when compared to traditional farmer practices. For example, by sowing in rows on raised beds covered with screen tunnels and by fertilizing with composted household waste, yields increased 247% over the standard practice of broadcast seeding on flat beds with only inorganic fertilizer. The cost differential between improved and standard practices was 103%. The additional expense with improved practices is from purchase of screen, labor costs for bed preparation, seeding in rows, and harvesting/ packaging more produce than obtained from standard practices.

By growing pak-choi in 18 × 18 m screen houses on the CLSU experimental site the incremental net economic benefit relative to open field over wet and dry seasons was 2778 and 10,469 PHP (pesos)/1000 m^2, respectively. Clearly, screen houses are a greater benefit during the dry season than during the wet season because insect pests are most prevalent during the dry season. When grafted tomato was grown under rain shelter (2.5 × 40.0 m) the incremental net economic benefit relative to open field was 21,588 PHP/1000m^2.

These experiences encouraged the project to expand to other provinces in southern Luzon that supply leafy vegetables to Metro Manila. An orientation–training exercise was conducted at one site in each province (Quezon, Batangas, and Laguna). In addition, a farmer field school (FFS) was conducted in Laguna after finishing a similar FFS in Mallorca, San Leonardo, Nueva Ecija. Farmers and agriculture technicians rated the training as positive.

The project used linear programming to calculate annual profit from different crop combinations within and between seasons by varying capital and variables considered to affect production (i.e., active ingredient of pesticides, levels of nitrogen fertilizer, and water supply). With an initial investment of 20,000 PHP/ ha, a farmer could generate income of 487,000 PHP by planting pak-choi/mustard in the wet season and pak-choi/onion in the dry season. This is superior to the onion/eggplant sequence in San Leonardo that generated income of 285,000 PHP/ha.

Introduced technologies require more production inputs than are currently used. Survey results showed that suppliers of agricultural materials in Gapan, Nueva Ecija, could provide the inputs required if additional areas are opened to vegetable production and/or if cultivation is intensified. As well, market outlets in Manila have the means to increase the tonnage of vegetables received and distributed. Currently, in Divisoria alone, 10 brokers or *casadores* trade 66 tons daily. And there is a growing demand for quality (less pesticides and less damage) pak-choi and other leafy vegetable in Metro Manila.

Farmers' negative perceptions of introduced technologies were based on the capital needed to buy screens and on the labor needed to raise beds, sow seeds in rows, and erect screen tunnels. Farmers saw that by using the technologies, yield per unit area increased and pesticides cost was reduced, yet they were unwilling to invest the time and money required to use the new practices. Apparently farmers are most comfortable with old practices, and they lack capital.

We believe that by training farmers in the new practices and by establishing a credit program to provide access to capital for investment, farmers will adopt these new technologies.

Soil and crop nutrition

Soil and crop nutrition research consisted of four sub-activities conducted from summer 2000 to 2001. The first sub-activity was designed to determine the residual effect of six applications of inorganic fertilizer and organic amendments on the yield of kangkong (*Ipomoea reptans*). A trial was conducted at CLSU. Thirty-six plots representing nine treatments and four replications were planted to a sequence of pak-choi, radish, onion, pak-choi, pak-choi, and pak-choi. The treatments were; T1 = nil fertilizer, T2 = ½ recommended rate of fertilizer (½ RR), T3 = household waste compost (HW), T4 = chicken manure compost (CM), T5 = recommended rate of fertilizer (RR), T6 = ½ RR + ½ HW, T7 = ½ RR + ½ CM, T8 = ½ RR + HW, T9 = ½ RR + CM. The amounts of HW and CM applied in T3, T4, T6, T7, T8, and T9 plots were based on complete nitrogen substitution.

Residual effects from amendments applied previously were obtained from the first and the second cuts. Yields of kangkong at first cut were similar in plots previously treated with ½ RR + ½ HW (T6) and ½ RR + HW (T8). The yield of T8 over plots previously amended with RR (T5) was 23.96%. In the second cut of kangkong, plots previously treated with RR gave the highest yield.

The second sub-activity dealt with improvement of fertilizer management and cropping sequence in the peri-urban vegetable areas of San Leonardo. The farmer practice of growing three consecutive crops of pak-choi followed by radish and onion was compared with pak-choi alternated with kangkong then radish and onion. Likewise, the use of urea alone, a common farmer practice, was compared with NPK application with or without organic fertilizers. Three farms were used, each with a different frequency of rice hull application and burning.

Pak-choi yield from the first crop in the sequence did not differ among fertilizer treatments. However, yields from farms where rice hulls were burned every two years (3 t/ha) and every three years (3 t/ha) were much less than was yield from the farms where rice hulls were burned yearly (17–25 t/ha). The low yield was due to severe rotting associated with high rainfall. The farm to which rice hulls were applied and burned annually received 136 mm of rain, but the other farms received 413 and 537 mm.

Application of ½ RR NPK reduced the yield of the third crop in the sequence (pak-choi) on the farm where rice hulls were burned every three years.

In Maligaya clay loam soil, which is N deficient, kangkong's yield response curve was described by the linear equation $Y = 4.8882 + 0.0628X$, $R^2 = 0.97^{**}$. In relatively fertile soil, such as Quingua silty clay loam, the yield response curve was described by the quadratic equation $Y = 10.142 + 0.0473X – 0.0001X^2$, $R^2 = 0.8785^{**}$.

The equation that describes the relationship of nitrogen to radish yield differed among farms. In Maligaya clay loam soil the linear equation was $Y = 1.2224 + 0.0666X$. In Quingua silty clay loam, the relationship was given by the quadratic equation $Y = 58.759 + 0.3394X – 0.0012X^2$, whereas in Quingua silt loam a cubic equation best described the N and yield relationship given by $Y = 67.06 + 0.174X + 0.0012X^2 – 0.006X^3$. The yield response curve suggests that further study is needed to understand if there is a basis for the deviation from the expected linear or quadratic response.

Cost and return analysis indicated a profit from radish even when unfertilized in both Quiangua silty clay loam and silt loam soils, whereas growing of radish in Maligaya soil is less profitable. In fact, profit occurred only at a minimum application rate of 200 kg N/ha.

Grafted tomato to enhance off-season production

During the hot–wet months, tomatoes are grown only in a few hilly areas; production is limited and high prices make tomatoes unaffordable to many consumers. By grafting tomatoes onto eggplant rootstocks and transplanting seedlings onto raised beds protected by rain shelters, tomatoes can be grown during the hot–wet months when flooding and bacterial wilt are major constraints to production.

To develop technologies for tomato production in the hot–wet months we conducted two sets of experiments at CLSU. The first experiment tested the performance of two tomato varieties as scion (Apollo and CLN5915) grafted onto two rootstocks known to possess resistance to bacterial wilt eggplant EG203 and tomato H7996. Grafted seedlings were transplanted onto raised beds with rain shelters constructed from UV resistant plastic. The second experiment involved rootstock EG203 grafted onto scions Apollo and CLN5915. Grafted seedlings were transplanted on raised beds with and without rain shelter. The same cultural management practices were employed in both experiments.

Grafted tomato production under rain shelter

Percent survival of grafted plants was significantly higher than survival of non-grafted plants. Apollo grafted onto EG203 and H7996 had 91.7% and 75.0% survival, respectively, whereas no non-grafted Apollo plants survived the entire growing season. In contrast, CLN5915 grafted unto EG203 and H7996 had 97.2% and 91.7% survival, respectively. Non-grafted CLN5915 had 64% survival.

When Apollo was grafted onto EG203 and to H7996, yields were not significantly different (12.2 and 9.1 t/ha, respectively). In contrast, yield of non-grafted Apollo was only 0.02 t/ha. Similarly, when CLN5915 was grafted onto EG203 and H7996, yields were 28.1 and 22.2 t/ha, respectively, whereas yield of non-grafted was 6.5 t/ha. Grafted CLN5915 out yielded grafted Apollo by a factor of 2.5.

Grafted tomato with and without rain shelters

Percent survival was unaffected by scion, rootstock, and shelter. Survival of Apollo and CLN5915 was 76.5% and 72.5%, respectively, whereas 79.5% and 69.5% of plants survived through the season when grafted onto EG203 and non-grafted, respectively. Survival under shelter was 79% across scions and rootstocks and 70% in open field. In contrast to percent survival, yield was affected by graft and by shelter. There was no yield difference between scions. Single degree of freedom F tests showed that yield from grafted plants (6.7 t/ha) was significantly ($P = 0.027$) greater than yield from non-grafted (4.5 t/ha), and yield under rain shelter (8.1 t/ha) was greater than yield in open field (3.1 t/ha). It is important to note that yields are low because plants were destroyed by a hurricane after only eight harvests, which is about half the standard number of harvests.

In an experiment conducted by the Bureau of Plant Industry, Los Baños, three fresh market tomato cultivars, FMTT-586, CLN 1466A, and BPI Tm 9, were grafted onto rootstock of EG203 and transplanted 11 August 2000 onto beds raised 25–30 cm and covered by a screen shelter, 10.0 × 20.0 × 2.4 m, constructed from 32-mesh screen. Grafted and non-grafted plants of each variety were arranged in a split-plot design with two factors, variety and graft level, and three blocks. Distance between beds and blocks was 0.5 m. Compost at 10 t/ha was applied to beds prior to transplanting, whereas NPK at 168–164–324 kg/ha was applied at the time of transplanting, and at 7 and 30 days after transplanting. Flower clusters were treated with the fruit-set regulator, Tomatotone, on six occasions. Yield was calculated from the fruit weights of eight harvests made from 4 October to 6 November.

There was no interaction between graft level and variety. Yields of BPI-Tm 9 (12.5 t/ha) and FMTT-586 (10.1 t/ha) were not significantly different across graft level, but both cultivars yielded more than CLN 1466A. There was no significant yield difference between graft levels across varieties. All plants were affected with virus and bacterial wilt.

Leafy vegetable cultivars for year-round production in the tropics

Leafy vegetables, such as cabbage, pak-choi, and mustard, are grown year-round in Baguio, a highland area. But supplies from highland areas cannot meet consumer demand, so leafy vegetables are also grown in the lowlands, where they are exposed to severe insect and disease pressures. Therefore, the search for resistant or tolerant accessions is a major part of efforts to promote lowland production. The objectives are to: 1) identify new leafy vegetable crops adapted to Nueva Ecija; 2) construct a database of leafy vegetable varieties identified for year-round production; and 3) come up with ways to reduce crop damage by diamondback moth (*Plutella xylostella*) (DBM), cabbage webworm (*Hellula undalis*) (CWW), and flea beetle (*Phyllotreta striolata*).

Two field designs were used to evaluate the performance of leafy cultivars (except kangkong) at CLSU. Fifty-five accessions were direct seeded into raised beds 1 × 3 m (four rows/bed and 20 cm between rows) inside a screenhouse (32-mesh) and in the open field. Fertilization included a basal application of 10 t/ha organic fertilizer and 60–60–60 NPK followed by side dressing of 30 kg N/ha two weeks after sowing. Insecticides was sprayed in the screenhouse as needed. The two middle rows from each plot were harvested 30–40 days after sowing.

*Pak-choi (*Brassica campestris *L. cvg. pak-choi)*

Sixteen accessions were evaluated in screen houses and in open field over two crops. In the screen house, yields ranged from 24.8 (Bp 39) to 53.1 (Bp 04) t/ha for the first crop and from 31.5 (Bp 39) to 57.8 (Bp 21) t/ha for the second crop, but yield differences were not significant.

As expected, lower yields were obtained in the open field than in the screen house. The lowest open field yield was from Bp 21 (8.2 t/ha) and the highest from Bp 03 (33.6 t/ha). Yields obtained in the second trial were higher, ranging from 13.6 t/hs (Bp 11) to 74.5 t/ha (Bp 21).

*Indian mustard (*Brassica juncea *Coss.)*

Significant yield differences were noted among accessions in screenhouse and in open field. Highest yields were obtained in the screenhouse. There, yields ranged from 24.8 (Bj 01) to 66.2 t/ha (Bj 14). Interestingly, yields in the open field ranged from 7.2 to 65.9 t/ha. And, as in the screen house, Bj 01 gave the lowest yield, whereas there was no significant difference in yield among accessions Bj 03,11, 14, and 15, though yields ranged from 31.1 to 65.9 t/ha.

*Non-heading Chinese cabbage (*Brassica rapa *L. cvg. Chinese cabbage)*

Ten accessions were evaluated. No yield differences were noted. The highest yield was from Bcc 10 with mean yields of 100.4 t/ha from the screenhouse and 44.0 t/ha from the open field.

*Chinese kale (*Brassica oleraceae *L. cvg. alboglabra)*

Yield among accessions varied significantly in the second trial in both screenhouse and open field. In the screenhouse, Ba 08 yielded significantly more (45.9 t/ha) than Ba 05 (14.5 t/ha). Ba 17 might be a promising accession as yields across trials in the screen house (40.9 and 45.7 t/ha in trials 1 and 2, respectively) were less variable than were yields from other accessions. In the open field, however, yields of Ba 17 across trials showed about the same variation as yields of other accessions.

*Choysum (*Brassica rapa *L. cvg. Caisin)*

There were no yield differences among accessions over trials within environments (screenhouse and open field). However, yields from trial 2 were greater than yields from trial 1 in both screen house and open field. In trial 2, yields ranged from 25 to 62 t/ha in the screen house and from 32.6 to 54.3 t/ha in the open field. Bc 02 showed less yield variability across trials in the screenhouse (60 and 61 t/ha) than did other accessions, but in the open field its performance was similar to that of others.

*Kangkong (*Ipomoea reptans *Poir)*

Again, there were no yield differences among accessions. Average yields taken from trials 1 and 2 were 57.34 and 35.8 t/ha, respectively.

Leafy vegetable yield trials in Los Baños

Eight cultivars of leafy vegetables were tested for yield by the BPI–Los Baños in January, February, July, and October 2000. Accessions were seeded in rows 15 cm apart on 1 × 3 m beds. Beds were raised 10 cm and covered with screen tunnels to protect plants from insect damage. Accessions were arranged in random complete block design (RCBD) with three blocks. Compost was applied to beds at 10 t/ha prior to seeding, and NPK at 90–20–20 kg/ha was applied basally. At 10 and 20 days after seeding plants were treated with a foliar fertilizer, Crop Giant, (NPK, 19–19–19 + ME), at 2.5 ml/l.

Most species performed best when seeded in December–February and worst when seeded in August–October. High rainfall during October (809 mm) likely contributed to low yields. Mean yields ranged from a low of 5.6 t/ha for Chinese kale to a high of 13.6 t/ha for pak-choi.

Leafminer infestation was observed across planting dates and vegetable species. Mean ratings (scale 0 to 5) were 1.87, 1.83, and 1.23, respectively, for the three planting periods. Flea beetle infestations were also noted, but severity estimates were not made. Clearly, 32-mesh screen tunnels did not prevent infestation by leafminer and flea beetles. Sixty-mesh screen would prevent insect entry, but would restrict air movement resulting in heat buildup and poor crop growth.

Building partnerships

The project works to develop partnerships with local government units (LGUs), nongovernmental organizations (NGOs), other stakeholders, and farmers to accelerate adoption of peri-urban vegetable production technologies. The project promotes technologies that: 1) enhance productivity and reduce use of pesticides and inorganic fertilizers; 2) reduce health risk related to pesticide exposure; and 3) foster off-season production with reduced risk of economic failure.

Linkages were established with LGUs to facilitate delivery of agricultural extension services to farming communities in provinces identified by the project's socioeconomics group as major contributors of leafy vegetables to markets in Manila. Memoranda of Agreement (MOA) were signed between the project and LGUs. This led to three training activities attended by 78 farmer leaders, 62 agricultural technicians, and 16 researchers from eight municipalities. Later, two farmer field schools (FFS) were held, the first in Mallorca, San Leonardo, Nueva Ecija and the second at Hornalan, Calamba, Laguna. Thirty-one farmers and eight LGU technicians were trained in integrated crop management of pak-choi. The field schools provided hands-on instruction in the use of raised beds during the rainy season as an effective means to reduce flooding and rotting of plants, and in the use of screen tunnels to exclude insect pests, reduce pesticide use, and improve crop quality. Farmers learned that application of urea in excess of the recommended rate does not increase pak-choi yield.

Components of the project, particularly grafted tomato for off-season production, solid waste management for peri-urban production, and integrated crop management for pak-choi , were showcased in technology fairs conducted by LGUs, state colleges and universities, and other scientific organizations. The project was also featured in local and national newspapers, radio, and television. Land Bank of the Philippines (LBP), through its Technology Promotion Center, has pledged money to validate the cost and return from grafted tomato seedling production and use of screen tunnels for pak-choi production. If the technologies are found to be feasible, LBP will provide loans to interested farmers and other clients.

The project's research outputs in socioeconomics, integrated pest management, integrated nutrient management, and partnership building were presented at six scientific conferences. A socioeconomics report was judged best paper while one on building partnerships was judged best poster.

Integrated pest management

Vegetable production in San Leonardo usually suffers from severe insect and disease problems. Pest infestation is high because environmental conditions are conducive to growth and development of hosts and pests year-round. Generally, farmers spray prior to the appearance of any insects (or disease), which results in: 1) excessive cost of crop protection due to unwarranted use of pesticides; 2) decreased efficacy of pesticides because insects develop resistance; and 3) potential human health problems from insecticide residues.

The project develops and promotes integrated pest management (IPM) strategies as a means to reduce pesticide inputs and pesticide residues.

Improved profitability and safety of pak-choi

Three consecutive trials were conducted on one farm to compare farmer and researcher-managed plots for yield and pest development. Farmers used broadcast seeding, flat beds, inorganic fertilizer at 78–37–37 kg NPK/ha (split application), and applied pesticides without regard to pest intensity and crop growth stage. Researchers used raised beds, sowing in rows, inorganic fertilizer at 35–10–10 kg NPK/ha plus 3.5 t/ha chicken manure applied basally, and pesticides based on 'action thresholds' established previously.

Plant and pest numbers, incidence of pest-damaged plants, incidence of diseases, and crop yield were subjected to analysis of variance (ANOVA) to determine treatment effects. Researcher-managed plots yielded significantly more than farmer-managed plots in trials 2 and 3, but not in trial 1 (Table 120). Incidences of DBM and CWW were the same for farmer- and researcher-managed plots across trials. However, the incidence of web blight was less in researcher-managed plots, maybe due to the fungicide (benomyl) applied to the researcher-managed plots in trials 1 and 2. Researcher-managed plots did not receive fungicide in trial 3, but the incidence of web blight in researcher-managed plots was less than in farmer-managed plots that received the fungicide. Generally, farmers applied more insecticide and less fungicide than did researchers. Trial 3 remains an anomaly. Although there were significant treatment effects in trials 1 and 2, yields were low, attributed to DBM, CWW, and web blight. Interestingly, when CWW was absent, but DBM and

Table 120. *Yield, number of cabbage webworm and diamondback moth larvae, percent plants with insect feeding damage and symptoms of web blight and number of insecticide and fungicide treatments applied over three trials of pak-choi at San Leonardo in farmer- managed (FM) and researcher- managed (RM) plots*

Trial	Yield (kg/m²)		Plants harvested (no./m²)		CWW (no./m²)		DBM (no./m²)		Incidence feeding damage (%)		Incidence web blight (%)		Insecticide treatments (no.)		Fungicide treatments (no.)	
	FM	RM	FM	RM	FM	RM	FM	RM	FM	RM	FM	RM	FM	RM	FM	RM
1	1.4	1.4	10	30	0.3	0.1	6.8	7.4	11	3	75	17	5	3	0	1
2	0.3	0.8	7	36	0.6	0.4	3.2	5.2	10	2	50	9	3	5	0	2
3	2.7	3.1	65	62	0.0	0.0	4.4	5.2	1	1	10	5	4	2	1	0

web blight present (trial 3), yields were markedly greater than when the three pests were present (trials 1 and 2). Other factors might have contributed to the high yields noted in trial 3, but it is tempting to speculate that the absence of CWW was the major factor because the number of plants harvested in trial 3 was 46% and 87% greater than the mean number of plants harvested from the farmer- and researcher-managed plots, respectively, in trials 1 and 2.

Pesticide residues

Pak-choi from farmer- and researcher-managed plots in San Leonardo were collected in July and September 2000 and submitted to the Philippine National Analytical Laboratory— BPI for pesticide residue analysis. Residues of chlorpyrifos, methamidophos, profenofos, deltamethrin, fenvalerate, and cypermethrin were detected, but levels were generally less than the maximum residue level (MRL) set by the Association of Southeast Asian Nations. Chlorpyrifos on pak-choi collected in July from farmer-managed plots was the only exception — 0.19 ppm, 3.8-times the MRL for cabbage. In contrast, pak-choi collected from researcher-managed plots in July contained 0.01 ppm chlorpyrifos. The project did not have access to MRL values for leafy vegetables.

Cropping sequence

Farmers in San Leonardo plant three consecutive crops of pak-choi, beginning in the hot–wet season, and thus provide a host for DBM and CWW from June to October. Kangkong, a non-host, was introduced to break the cycle of infestation.

The sequence kangkong, kangkong, pak-choi returned a net income equivalent to 96,397 PHP/ha, compared to 66,818 PHP/ha from three consecutive crops of pak-choi. Calculations are based on yields of 1.086 and 0.804 kg/m^2 for the two crops of kangkong and 0.66 kg/m^2 for pak-choi in the kangkong, kangkong, pak-choi sequence, and a sale price of 5 PHP/kg for kangkong and 10 PHP/kg for pak-choi. Yields from the three consecutive crops of pak-choi were 0, 0.52, and 0.60 kg/m^2. The first crop of pak-choi was destroyed by flood, whereas kangkong survived. Labor costs and materials were 45,781 PHP for the three crops of pak-choi, and 64,503 PHP for the mixed sequence. The difference in cost was primarily due to seed and harvest labor cost, both of which were higher when kangkong was grown.

Screenhouses to limit insect damage

Fifty-five accessions pak-choi, choysum, non-heading cabbage, Chinese kale, and Indian mustard were seeded in four rows on raised beds 1 × 2 m in two screenhouses, each 18 × 18 m. In screenhouse A, two repetitions of 15 accessions each of pak-choi and choysum were seeded. The same pak-choi accessions were planted in open field to compare insect incidence in screen house to incidence in open field. In screenhouse B, 10 accessions each of non-heading cabbage and Chinese kale and five accessions of Indian mustard were planted with two replications. The same accessions were seeded in open field. One insecticide treatment was applied in the screenhouses, whereas accessions in the open field were treated twice weekly regardless of insect incidence. Insect numbers, plant damage from insect feeding, and disease incidence were noted weekly. Two trials were conducted.

Some accessions in screenhouses were infested with DBM and CWW. Infestations of DBM, CWW, flea beetle, and armyworm were observed on all accessions in the open field. Clearly, insecticide treatments in the open field did not prevent infestation and damage. Values for insect feeding damage (scale 0 to 9) were <1 in the screen houses and from 1 to 3 in the open field across accessions and trials. As expected, yield among species in the screenhouses was greater than yield in the open field (Table 121). The trials were not designed to test accession performance between environments so it is not known whether the differences were significant. Rather, the intent was to test accession performance within environments. In screenhouses and in open field, there were yield differences among accessions within some species (see above). (Because insect infestations are not random, we did not test for accession responses using ANOVA.)

Table 121. *Mean yield of Brassica species across two trials in screen house and in open field*

Vegetable species	Yield (t/ha)	
	Screen house	Open field
Pak-choi	32	19
Choysum	34	31
Non-heading Chinese cabbage	56	13
Chinese kale	24	10
Indian mustard	35	28

Natural enemies of diamondback moth and cabbage webworm in Luzon

A survey of insect pests and beneficial insects on crucifers was conducted in the provinces Nueva Ecija, Batangas, Quezon, Laguna, Pangasinan, La Union, and Benguet. Highlands of Baguio, La Trinidad, and Atok are major vegetable producing areas. Larvae of DBM and CWW were collected and transferred onto 14-day-old pak-choi plants in the laboratory. *Diadegma semiclausum*, a parasitoid of DBM, was found to be established in all highland areas. The parasitism of DBM larvae collected on cabbage was 11.1% in La Trinidad and 20% in Atok. In Calamba (lowlands) 22.5% of DBM larvae collected were infested by a *Cotesia* species. We assume that this is *Cotesia plutellae*, because *C. plutellae* was last released in October 1999 by the Asian Vegetable Network (AVNET) in the neighboring town of Cabuyao. Based on our data, the parasitoid *Oomyzus sokolowskii* could supplement *C. plutellae* in controlling DBM populations in Calamba.

In Nueva Ecija, percent infection of CWW by a *Microsporidium* was determined by collecting 100 first and second instar larvae of CWW and transferring them into 100 ml plastic containers where they were reared on an artificial diet. Larvae were checked daily for mortality until adults emerged. Dead larvae were examined under a compound microscope to confirm the presence of Microsporidia. Microsporidia infected a total of 16 percent of CWW larvae.

Biological control of podborer on yardlong bean

Four parasitoids emerged from podborer (*Maruca vitrata*) eggs and larvae were collected in unsprayed fields of yardlong bean (*Vigna sesquipedalis*). The only egg parasitoid was *Trichogramma evanescens*. *T. evanescens* hatched from a single collection in the second crop of 1999. Because of experiments with natural enemies of vegetable insect pests in surrounding fields we suspect that *T. evanescens* was introduced. The other parasitoids were *Exorista xanthaspis, Peribaea orbata*, and *Bassus asper*. *B. asper* was the most prevalent species. Parasitism in unsprayed fields of yardlong bean on the CLSU campus was lowest (1.4%) in the wet season, 2000, and highest (19.9%) in the wet season, 1999. Mean parasitism was higher in untreated plots than in plots treated with insecticides. Total mortality of all larval stages of podborer was 42.2%, of which 9.9% was caused by parasitoids and 32.3% by unknown factors. Mortality was greatest among fifth instar larvae and pupae, and least among third and fourth instar larvae. We were unable to differentiate between first and second instars, but mortality for the two stages combined was 18.1%. Unknown factors caused mortality in all stages, whereas parasites killed only eggs, fifth instars, and pupae. Data suggest that parasitoids in general, and *B. asper* in particular, can contribute to the control of podborer on yardlong bean.

We tested the following materials in y-tube (olfactometer) bioassays for their ability to attract *B. asper*: 1) intact yardlong bean pods; 2) pods previously infested with podborer; 3) pods infested with pod borer larvae; 4) excrements of podborer; and 5) air as control. The olfactometer was made from 59-cm-long glass tubing 4.5 cm in diameter. Test substances were placed in two 500 ml flasks attached to the distal ends of the tube. A pump on the longitudinal end sucked in air at 6.6 liters/hour. One adult *B.asper* per experiment was placed at the longitudinal end of the olfactometer. Experiments were finished after 1 hour or when the parasitoid made a choice for one of the substances in the distal ends. Each experiment was repeated 20 times. *B. asper* was attracted to pods without larvae but previously infested by podborer and to pods with larvae. Pure excrement of podborer attracted *B. asper* adults. The results suggest that *B.asper* uses cairomones emitted by excrement from pod borer larva to locate host plants.

Different concentrations of the commercial insecticides chlorpyrofos, deltametrin, methomyl, and carbaryl were diluted in water and tested for their toxicity to third instar larvae of podborer in pod dip bioassays. Usually six concentrations were used, including the control and the recommended field concentration. Mortality was determined after 48 hours exposure to insecticides. Larvae were considered dead if they were unable to respond visibly to a blunt probe. Results showed that calculated LC_{50} values were greater than concentrations recommended for control of podborer for all four insecticides. This implies that *M. vitrata* has developed resistance to the insecticides tested. Carbaryl had the lowest LC_{50} value of all insecticides tested. With methomyl we tested second, third, and fourth instar larvae of podborer to identify concentration – development stage dependency and found that LC_{50} values increased with larval stage.

Contact: JR Burleigh

Staff

Administration

Dr. Samson C. S. Tsou, Director General, <cstsou@netra.avrdc.org.tw>
Dr. Jürgen Friedrichsen, Deputy Director General, <jfrie@netra.avrdc.org.tw>
Dr. Meisaku Koizumi, Assistant Director General (Project 7 Coordinator), <koiz_arc@ksc.th.com>
Mou-sen Fu, Assistant Auditor, <jimfu@netra.avrdc.org.tw>
Shaw-wei Chai, Associate Comptroller, <nancy@netra.avrdc.org.tw>
Mei-hua Yu, Superintendent, Administrative Services Unit[a]
Jeng-hua Chen, Superintendent, Buildings and Maintenance Unit, <jhchen@netra.avrdc.org.tw>
Sui-fang Wu, Superintendent, Food and Dormitory Services Unit, <lydia@netra.avrdc.org.tw>

Program I: Vegetables in cereal-based systems

Dr. S. Shanmugasundaram, Program Director, <sundar@netra.avrdc.org.tw>

Bulb Allium Unit

Dr. S. Shanmugasundaram, Plant Breeder (Project 2 Coordinator), <sundar@netra.avrdc.org.tw>
Shin-jiun Cherng, Principal Research Assistant, <sjcherng@netra.avrdc.org.tw>
Swee-suak Ko, Principal Research Assistant, <rachelko@netra.avrdc.org.tw>

Legume Unit

Dr. S. Shanmugasundaram, Plant Breeder (Project 3 Coordinator), <sundar@netra.avrdc.org.tw>
Miaw-rong Yan, Research Assistant, <yanmr@netra.avrdc.org.tw>

Pepper Unit

Dr. Terry G. Berke, Associate Plant Breeder[a]
Dr. Peter H. Hanson, Acting Unit Head, <hansp@netra.avrdc.org.tw>
Sheue-chin Shieh, Research Assistant, <jin@netra.avrdc.org.tw>

Plant Pathology: Mycology Unit

Dr. Lowell L. Black, Plant Pathologist, <llblack@netra.avrdc.org.tw>
Dr Tien-chen Wang, Associate Specialist, <tcwang@netra.avrdc.org.tw>

Plant Pathology: Virology Unit

Dr. Sylvia K. Green, Plant Pathologist, <skg@netra.avrdc.org.tw>
Dr. Seung-Ryong Cheong, Associate Plant Pathologist, <cheongsr@netra.avrdc.org.tw>
Wen-shi Tsai, Principal Research Assistant, <wenshi@netra.avrdc.org.tw>
Su-ling Shih, Principal Research Assistant, <suling@netra.avrdc.org.tw>
Ber-tsu Chiange, Principal Research Assistant[ac]

Plant Physiology Unit

Dr. C. George Kuo, Plant Physiologist, <gkuo@netra.avrdc.org.tw>
Dr. Chien-an Liu, Assistant Scientist— Molecular Biology, <liuchien@netra.avrdc.org.tw>
Huei-mei Chen, Associate Specialist, <hmchen@netra.avrdc.org.tw>
Shiow-wen huang, Principal Research Assistant, <wen@netra.avrdc.org.tw>
Dr. Hong-Yul Seo, Postdoctoral Fellow
Hsiang-yi Huang, Principal Research Assistant (Project)
Chun-ling Wang, Principal Research Assistant (Project)

Tomato Unit

Dr. Peter H. Hanson, Associate Plant Breeder (Project 1 Coordinator), <hansp@netra.avrdc.org.tw>
Jen-tzu Chen, Associate Specialist, <jtchen@netra.avrdc.org.tw>

Program II: Year-round vegetable production systems

Dr. Lowell L. Black, Program Director, <llblack@netra.avrdc.org.tw>
Dr. Hubert de Bon, Production Systems Specialist (with duty station in Vietnam), <hubertdebon@hn.vnn.vn>

Crop and Soil Management Unit

Dr. Lowell L. Black, Acting Unit Head (Project 4 Coordinator), <llblack@netra.avrdc.org.tw>
Dr. Volker Kleinhenz, Associate Scientist for Crop and Soil Management Unit[b]
Dr. Chin-hua Ma, Associate Specialist, <mach@netra.avrdc.org.tw>
Dolores R. Ledesma, Assistant Specialist, <didit@netra.avrdc.org.tw>
Yu-chi Roan, Associate Specialist[a]
Deng-lin Wu, Research Assistant, <dlwu@netra.avrdc.org.tw>

Entomology Unit

Dr. N. S. Talekar, Entomologist (Project 5 Coordinator), <talekar@netra.avrdc.org.tw>
Mei-ying Lin, Principal Research Assistant, <turtle@netra.avrdc.org.tw>
Fu-cheng Su, Research Assistant, <sufc@netra.avrdc.org.tw>

Nutrition and Analytical Laboratory

Dr. Samson C. S. Tsou, Biochemist, <cstsou@netra.avrdc.org.tw>
Ray-yui Yang, Principal Research Assistant, <ryy074@netra.avrdc.org.tw>
An-lyn Lee, Principal Research Assistant[a]

Olericulture Unit

Dr. Lowell L. Black, Acting Unit Head, <llblack@netra.avrdc.org.tw>
Lien-chung Chang, Associate Specialist, <lcchang@netra.avrdc.org.tw>

Plant Pathology: Bacteriology Unit

Dr. Jaw-fen Wang, Associate Plant Pathologist, <jfw@netra.avrdc.org.tw>
Chih-hung Lin, Principal Research Assistant, <chlin@netra.avrdc.org.tw>
Ying-ju Tsai, Research Assistant[b], <dinah@netra.avrdc.org.tw>

Socio-economics Unit

Dr. Mubarik Ali, Associate Agricultural Economist (Project 6 Coordinator), <mubarik@netra.avrdc.org.tw>
Dr. Katinka Weinberger, Research Associate - Socioeconomist[b], <weinberg@netra.avrdc.org.tw>
Mei-huey Wu, Principal Research Assistant, <mhwug@netra.avrdc.org.tw>

Program III: Collaboration in research and germplasm management

Dr. C. George Kuo, Program Director (Project 9 Coordinator), <gkuo@netra.avrdc.org.tw>

Computer Services Unit

Hsien-yang Tien, Assistant Specialist, <tien@netra.avrdc.org.tw>
Yuh-ling Chen, Research Assistant, <shirley@netra.avrdc.org.tw>

Farm Operations Unit

Teng-sheng Tu, Superintendent[a]

Genetic Resources and Seed Unit

Dr. Liwayway M. Engle, Geneticist and Head (Project 8 Coordinator), <lmengle@netra.avrdc.org.tw>
Dr. Takanori Sato, Associate Geneticist[b], <ryutoku@netra.avrdc.org.tw>
Yung-kuang Huang, Principal Research Assistant, <ykhuang@netra.avrdc.org.tw>
Jia-chain Shieh, Research Assistant, <jcshieh@netra.avrdc.org.tw>
Ching-huan Chang, Research Assistant, <jessica@netra.avrdc.org.tw>
Shu-chuan Lin, Research Assistant[b] (Project), <smile@netra.avrdc.org.tw>

Information and Documentation Unit: Library

Fang-chin Chen, Officer/Chief Officer, <fcchen@netra.avrdc.org.tw>

Office of Publications and Communications

David G. Abbass, Associate Information Officer (Project 10 Coordinator)
John Stares, Editor/Desktop Publisher[a]
Ronald G. Mangubat, Assistant <mangubat@netra.avrdc.org.tw>

Technology Promotion and Services Unit

Dr. Nung-che Chen, Horticulturist[a] (Project 12 Coordinator)

Li-ju Lin, Principal Research Assistant, <mandy@netra.avrdc.org.tw>

Training Unit

Dr. Thomas Kalb, Training Specialist[b] (Project 11 Coordinator), <kalb@netra.avrdc.org.tw>
Yi-ming Chen, Principal Research Assistant, <ymchen@netra.avrdc.org.tw>

Cooperative Programs

AVRDC/USAID/Bangladesh Project, Dhaka, Bangladesh

Dr. Dharam Pal Singh, Senior Horticulturist/Agronomist[a] <dpsingh45@yahoo.com>

Costa Rica: REDCAHOR Project

Dr. Jürgen Carls, Coordinator[b,a]

Regional Programs

Asian Regional Center, Bangkok, Thailand

Dr. Romeo T. Opeña, Director (CLV Network Coordinator, c/o Dr. Meisaku Koizumi, Acting Director) <koiz_arc@ksc.th.com>
Dr. Thierry X. Jaunet, Associate Plant Pathologist,

African Regional Program, SADC-AVRDC-CONVERDS, Arusha, Tanzania

Dr. Madan Mohan Lal Chadha, Director, <avrdc-arp@cybernet.co.tz>
Dr. Rémi Nono-Womdim, Associate Plant Pathologist
Dr. Mel O Oluoch, Training Specialist at AVRDC-ARP <avrdc@cybernet.co.tz>

AVRDC's "Peri-urban Vegetable Production Systems" Project Philippines Site

Dr. James R. Burleigh, Philippines Site Coordinator, (c/o Dr. Gerard Bruin, Philippine Site Director <gbruin@ne-link.net>)

Outreach Programs

Indonesia–AVRDC Vegetable Research Program

Dr. Prabowo Tjitropranota, Director, Central Research
Institute for Horticulture,
Jalan Ragunan 29, Pasar Minggu, Jakarta, Indonesia

Korea AVRDC Outreach Program

Mr. Won-Jin Kim, Director General <shd@rda.go.kr>
National Horticultural Research Institute
Rural Development Administration
475 Imok-Dong, Jangan-gu, Suwon 440-310, Korea

Malaysia–AVRDC Vegetable Research Program

Dr. Md Sharif bin Ahmad
Director General, Malaysian Agricultural Research and Development Institute,
Kuala Lumpur, Malaysia

Philippines –AVRDC Outreach Program

Adoracion A Virtucio, Project Director <bpi_eg98@laguna.net>
Los Baños National Crop Research and Development Center (BPI-LBNCRDC), BPI Region IV, Lost Baños, Laguna 4030, Philippines

[a] Left during 2000
[b] Arrived during 2000
[c] On study leave
[d] Promoted in 2000

Trainees

Program I: Vegetables in cereal-based systems

Bulb Alliums Unit

Te-Liang Hsu, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Alauddin Khan, Research Intern, Bangladesh (04 January 2000 – 30 April 2000)

Legume Unit

Md Shafiqul Aktar, Graduate Student, Bangladesh (18 October 1999 – 17 May 2000)
Shao-Yi Lu, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Sung-Taeg Kang, Research Intern, Korea (10 February 2000 – 10 July 2000)
Yu-Chun Shen, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Yi-Ray Jiang, Special Purpose Trainee, Taiwan (01 July 1999 – 29 February 2000)

Pepper Unit

Pei-Ju Lin, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Pei-Yi Weng, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Rumman Ara, Research Intern, Bangladesh (28 October 1999 – 28 January 2000)
Sang-sik Nam, Production Intern, Korea (10 December 2000 – 16 December 2000)
Shih-Min Su, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)

Plant Pathology: Mycology Unit

Founge-I Ho, Undergraduate Student Trainee, Taiwan (10 July 2000 – 09 September 2000)
Manuel C Palada, Visiting Scientist, USA (01 September 2000 – 28 February 2001)

Plant Pathology: Virology Unit

Arty Gungoosingh, Special Purpose Trainee, Mauritius (06 March 2000 – 24 March 2000)
Kazuo Yamashita, Special Purpose Trainee, Japan (06 March 2000 – 24 March 2000)
Su-feng Chang, Special Purpose Trainee, Taiwan (06 March 2000 – 24 March 2000)
Tso-chi Yang, Special Purpose Trainee, Taiwan (06 March 2000 – 24 March 2000)
John D Fletcher, Special Purpose Trainee, New Zealand (06 March 2000 – 24 March 2000)
Joung-Kwan Lee, Special Purpose Trainee, Korea (06 March 2000 – 24 March 2000)
Junko Watanabe, Undergraduate Student Trainee, Japan (08 May 2000 – 07 October 2000)
Lilian F Patena, Special Purpose Trainee, Philippines (06 March 2000 – 24 March 2000)
Lolita Dolores, Special Purpose Trainee, Philippines (06 March 2000 – 24 March 2000)
Neni Gunaeni, Special Purpose Trainee, Indonesia (06 March 2000 – 24 March 2000)
Pamela J Fletcher, Special Purpose Trainee, New Zealand (06 March 2000 – 24 March 2000)
Suwanna Kladpan, Special Purpose Trainee, Thailand (06 March 2000 – 24 March 2000)
Ting-chin Deng, Special Purpose Trainee, Taiwan (06 March 2000 – 24 March 2000)
Vilma Conci, Special Purpose Trainee, Argentina (06 March 2000 – 24 March 2000)
Vannak An, Research Intern, Cambodia (01 November 2000 – 31 October 2001)
G B Valand, Visiting Scientist, India (26 April 2000 – 20 May 2000)
V Muniyappa, Visiting Scientist, India (26 April 2000 – 20 May 2000)

Plant Physiology Unit

Eiri Kaku, Undergraduate Student Trainee, Japan (01 August 2000 – 31 August 2000)
Hong-Yul Seo, Postdoctoral Fellow, Korea (28 December 1999 – 27 April 2000)
Hisae Kikuchi, Undergraduate Student Trainee, Japan (11 August 2000 – 10 September 2000)
Ngoc Tri Nguyen, Research Intern, Vietnam (15 November 2000 – 14 November 2001)
Satya Ranjan Saha, Graduate Student, Bangladesh (10 January 2000 – 10 June 2000)

Tomato Unit

Shahabuddin Ahmad, Graduate Student, Bangladesh (18 October 1999 – 15 March 2000)
Makoto Kamijo, Research Scholar, Japan (03 April 2000 – 31 March 2001)
Siou-Fen Ko, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)

Program II: Year-round vegetable production systems

Crop and Soil Management Unit

Nina Rosales, Special Purpose Trainee, Philippines (16 January 2000 – 28 January 2000)
Thanh Hai Vu, Research Intern, Vietnam (15 November 2000 – 30 October 2001)
Michio Yatomi, Research Intern, Japan (03 July 2000 – 21 July 2000)

Entomology Unit

FM Abdur Rouf, Research Intern, Bangladesh (17 January 2000 – 30 April 2000)
FM Abdur Rouf, Research Intern, Bangladesh (18 September 2000 – 17 October 2000)
Gregory Siwon Taplah, Graduate Student, Liberia (25 June 2000 – 29 June 2000)
Gregory Siwon Taplah, Graduate Student, Liberia (20 January 2000 – 14 February 2000)
Liljana Georgievska, Graduate Student, Republic of Macedonia (25 June 2000 – 10 September 2000)
Liljana Georgievska, Graduate Student, Republic of Macedonia (20 January 2000 – 14 February 2000)
Maria Gharuka, Graduate Student, Solomon Islands (25 June 2000 – 10 September 2000)
Maria Gharuka, Graduate Student, Solomon Islands (20 January 2000 – 14 February 2000)
Ting-Hsuan Chang, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Kim Chien Nguyen, Research Intern, Vietnam (10 October 2000 – 09 October 2001)
Md Abdur Rashid, Production Intern, Bangladesh (02 October 2000 – 08 October 2000)
Senani Samarapala Weligamage, Research Intern, Sri Lanka (18 September 2000 – 17 October 2000)
Syed Nurul Alam, Production Intern, Bangladesh (02 October 2000 – 08 October 2000)

Nutrition and Analytical Laboratory

Dan-Guey Chen, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Mei-Chuan Chuang, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Wei-Ming Chen, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Yuh-Der Liaw, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Hathaikarn Srimai, Research Intern, Thailand (01 December 2000 – 28 February 2001)

Olericulture Unit

Dolores Rodriguez Ledesma, Research Fellow, Philippines (06 April 1999 – 04 February 2000)

Plant Pathology: Bacteriology Unit

Tsung Lin Wu, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Momodou D Jabang, Graduate Student, Gambia (30 June 1999 – 31 January 2000)

Socio-economics Unit

Joynal Abedin, Postdoctoral Fellow, Bangladesh (03 July 2000 – 30 September 2000)

Program III: Collaboration in research and germplasm management

Genetic Resources and Seed Unit

Ju-Yu Chien, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)
Ngo Thi Thanh Van, Research Intern, Vietnam (01 August 2000 – 31 October 2000)
Nguyen Song Ha, Research Intern, Vietnam (01 August 2000 – 31 October 2000)
Sudchai Locharoen,Research Intern, Thailand (01 December 2000 – 28 February 2001)
Visitacion C Huelgas, Research Fellow, Philippines (08 January 2000 – 31 May 2000)
Wittaya Sastawittaya, Research Intern, Thailand (14 November 2000 – 16 February 2001)
Yu-Chien Su, Undergraduate Student Trainee, Taiwan (03 July 2000 – 31 August 2000)

Training Unit

Reina Teresa Martinez Mota, Special Purpose Trainee, Dominica (17 October 2000 – 03 November 2000)
Albert Regan Loeak, Special Purpose Trainee, Marshall Islands (17 October 2000 – 03 November 2000)
Amadou Toure, Special Purpose Trainee, Ivory Coast (17 October 2000 – 03 November 2000)
Andrew Ronald George, Special Purpose Trainee, Grenada (17 October 2000 – 03 November 2000)
Apisai Ucuboi, Special Purpose Trainee, Fiji (17 October 2000 – 03 November 2000)
Briancon Bertram Luis, Special Purpose Trainee, Bolivia (17 October 2000 – 03 November 2000)
Chua Tee, Special Purpose Trainee, Philippines (17 October 2000 – 03 November 2000)
Dianna Churyda, Special Purpose Trainee, Indonesia (17 October 2000 – 03 November 2000)
Gale Carwin Dasilva, Special Purpose Trainee, St. Vincent (17 October 2000 – 03 November 2000)
George Fuo Batong Hor, Special Purpose Trainee, Ghana (17 October 2000 – 03 November 2000)
Godwin Lorenzworth Francis, Special Purpose Trainee, St. Kitts (17 October 2000 – 03 November 2000)
Julio Cesar Montoya, Special Purpose Trainee, El Salvador (17 October 2000 – 03 November 2000)
Kean Panao, Special Purpose Trainee, Papua New Guinea (17 October 2000 – 03 November 2000)
Lena Wahyu Marwati, Special Purpose Trainee, Indonesia (17 October 2000 – 03 November 2000)
Quintin Palma, Special Purpose Trainee, Panama (17 October 2000 – 03 November 2000)
Sansook Ratanapol, Special Purpose Trainee, Thailand (17 October 2000 – 03 November 2000)
Sui Hoy Lye, Special Purpose Trainee, Malaysia (17 October 2000 – 03 November 2000)
Supapatn Comwong, Special Purpose Trainee, Thailand (17 October 2000 – 03 November 2000)
Zongo Lingane Jeanne, Special Purpose Trainee, Burkina Faso (17 October 2000 – 03 November 2000)
Anthony W Kellman, Graduate Student, Barbados (20 September 2000 – 29 September 2000)

Staff publications in 2000

Altoveros, N.C., and **L.M. Engle.** 2000. Strategy for collecting germplasm of indigenous vegetables in Bangladesh, Indonesia, The Philippines, Thailand and Vietnam. In **Engle**, **L.M.** and N.C. Altoveros (Eds) 2000. Collection, Conservation and Utilization of Indigenous Vegetables: Proceedings of a Workshop, AVRDC, Shanhua, Tainan, Taiwan, 16–18 August 1999. Asian Vegetable Research and Development Center, pp 100–137.

Chadha, M.L. 2000. Vegetable-Based Approaches for Food Security and Combating Micronutrient Deficiencies in Southern African Countries. A paper presented in the South African Nutrition Congress 2000. 15–18 August 2000. Durban, South Africa.

Chadha, M.L., A.P. Mgonja, **R.Nono-Womdim** and I**.S. Swai[1].** 2000. Vegetable Research and Development in Tanzania. Proceedings of the Second National Vegetable Research and Development Planning workshop held at HORT–Tengeru, Arusha, Tanzania, 25–26 June, 1998. 111p.

Chadha, M.L., **Efren C. Altoveros**[2], **R. Nono-Womdim** and H. Mndiga. 2000. Varietal Evaluation and Seed Production of Vegetable Crops. A compilation of workshop/training course held at AVRDC Africa Regional Program, Arusha, Tanzania, 29 September to 5 October 1997. 107p.

Chadha, M.L., P.D. Mkhatshwa., D.M. Gama and **R. Nono-Womdim** 2000. Vegetable Research and Development in Swaziland. Proceedings of the First National Review and Planning Workshop held at Malkerns Research station, Malkerns, Swaziland, 8–9 March. Asian Vegetable Research and Development Center–Africa Regional Program, Arusha, Tanzania. 68p.

Dutta, O.P. and **S. Shanmugasundaram.** 2000. Hybrid vegetable development in Asia-Pacific. Asian Seed–2000, 25–28 September 2000, Hotel Le Meridian, Bangalore, India.

Engle, L.M., and N.C. Altoveros (Eds) 2000. Collection, Conservation and Utilization of Indigenous Vegetables: Proceedings of a Workshop, AVRDC, Shanhua, Tainan, Taiwan, 16–18 August 1999. Asian Vegetable Research and Development Center. 142 p.

Engle, L.M. 2000. Overview of the project: collection, conservation and utilization of indigenous vegetables. In **Engle, L.M.** and N.C. Altoveros (Eds) 2000. Collection, Conservation and Utilization of Indigenous Vegetables: Proceedings of a Workshop, AVRDC, Shanhua, Tainan, Taiwan, 16–18 August 1999. Asian Vegetable Research and Development Center, pp 12–20.

Engle, L.M., Yung-Kuang Huang[3], and **Tien-Hor Wu[4].** 2000. AVRDC Activities on the conservation of indigenous vegetable germplasm. In **Engle, L.M.** and N.C. Altoveros (Eds) 2000. Collection, Conservation and Utilization of Indigenous Vegetables: Proceedings of a Workshop, AVRDC, Shanhua, Tainan, Taiwan, 16–18 August 1999. Asian Vegetable Research and Development Center, pp 76–85.

Hanson, P.M., D. Bernacchi, **S.K. Green,** S.D. Tanksley, V. Muniyappa, A. Padmaja, **H.M. Chen[5], G. Kuo,** and **J.T. Chen[6].** 2000. Mapping a wild tomato introgression associated with tomato yellow leaf curl virus resistance in a cultivated tomato line. J. Amer. Soc Hort. Sci: 125:15–20.

Lee, Yeong Ho and **Ching-huan Chang[7].** 2000. Effects of seed size and several factors on ultra-drying and germination of ultra-dried seeds in soybean. Korean J. Crop Sci. 45(5):305–309.

Sato, T. 2000. Practical Use of Regional Resources, Superintendence of Food Processing. Vol. 10 Vegetables, Edible Wild Plants and Another Herbaceous Plants. pp 385–395. Nosangyoson-Bunkakyokai, Tokyo, Japan. (In Japanese)

Sato, **T.** 2000. *In-situ* conservation research on wild relatives of tomatoes in Chile: Collaborative research between Chile and Japan. pp 165–186. MAFF International Workshop on Genetic Resources. *In situ* Conservation Research. Ministry of Agriculture, Forestry and Fisheries, Japan.

Shanmugasundaram, S. and **M.R. Yan**[8]. 1999. AVRDC vegetable soybeans for nutritional security, income generation and soil sustainability. pp. 450–451. In: Proceedings of the World Soybean Research Conference VI, 4–7 August 1999, Chicago, Illinois, USA. The University of Illinois, Urbana-Champaign, Illinois; and Soybean Research and Development Council, Des Moines, Iowa, USA.

Srisombun, S., A. Korntong, S. Kaewmeechai, D. Sopanodora, N. Senanarong, A. Dalodom and **S. Shanmugasundaram.** 1999. Genetic improvement of soybean in Thailand. pp. 455–456. In: Proceedings of the World Soybean Research Conference VI, 4–7 August 1999, Chicago, Illinois, USA. The University of Illinois, Urbana-Champaign, Illinois; and Soybean Research and Development Council, Des Moines, Iowa, USA.

Srisombun, S., A. Korntong, T. Maolanon, D. Sopanodora, and S**. Shanmugasundaram.** 1999. Soybean breeding to select for grain and vegetable soybean. pp. 460–461. In: Proceedings of the World Soybean Research Conference VI, 4–7 Aug. 1999, Chicago, Illinois, USA. The University of Illinois, Urbana-Champaign, Illinois; and Soybean Research & Development Council, Des Moines, Iowa, USA.

Shanmugasundaram, S. and **S.C.S. Tsou.** 2000. Quality traits of soybean for food use in expanding its utilization in Asia. Paper presented in the International Soybean Processing and Utilization Conference (ISPUC–III). 15–20 October 2000, Tsukuba, Ibaraki, Japan.

Shanmugasundaram, S. 2000. Present situation and economic importance of legumes in Asia and Pacific Region. A paper presented at the Seminar on Processing and Utilization of Legumes, Asian Productivity Organization, 9–14 October 2000, Tokyo, Japan.

Shanmugasundaram, S., Miao-Rong Yan and **Ray-Yui Yang**[9]**.** 2000. Selection for quality traits in vegetable soybean. Proc. of the Symposium on the Improvements of Breeding and Production Techniques of Legumes, Tea and New Special Crops 2000, 27 November 2000, TARI, Taichung, Taiwan. pp.53–71.

Tsai, W.S., Shih, S.L.,[10] and **Green, S.K**. 2000. Molecular characterization of tomato leaf curl and *Ageratum* yellow vein begomoviruses in Taiwan. Plant Prot. Bull., Taiwan. (42):262-263.

Yan, Miao-Rong, S. Shanmugasundaram, and **Ray-Yui Yang.** 2000. Varietal improvement of vegetable soybean. Proc. of the Symposium on the Improvements of Breeding and Production Techniques of Legumes, Tea and New Special Crops 2000, 27 November 2000, TARI, Taichung, Taiwan. pp. 179 (abstract, in Chinese)

Wang, Jaw-Fen, Jocelyne Oliver, Philippe Thoquet, Brigitte Mangin, Laurent Sauviac, and Nigel H. Grimsley. 2000. Resistance of tomato line Hawaii7996 to *Ralstonia solanacearum* Pss4 in Taiwan is controlled mainly by a major strain–specific locus. Molecular Plant–Microbe Interactions 13 (1): 6–13.

Weinberger, Katinka. 2000. Women's Participation: an Economic Analysis in Rural Chad and Pakistan*,* Development Economics and Policy, Frankfurt: Peter Lang.

Weinberger, Katinka, Johannes Juetting. 2000. The role of local organizations in risk management: Some evidence from rural Chad*,* Quarterly Journal of International Agriculture, No. 3, pp 281-298.

[1] Pathology Unit, AVRDC-ARP, HORTI-Tengeru Office
[2] Project Consultant, AVRDC-ARC
[3] Principal Research Assistant, GRSU
[4] Senior Research Aide, GRSU
[5] Associate Specialist, Plant Physiology Unit
[6] Associate Specialist, Tomato Unit
[7] Research Assistant, GRSU
[8] Research Assistant, Legume Unit
[9] Assistant Specialist, Nutrition and Analytical Laboratory
[10] Principal Research Assistant, Virology Unit

Financial statements

Audited financial statements for the year are available from the Office of the Director General, AVRDC

THE ASIAN VEGETABLE RESEARCH AND DEVELOPMENT CENTER

STATEMENTS OF ASSETS, LIABILITIES AND FUNDS

(Prepared on a Modified Cash Basis and Expressed in US Dollars - Note 2)

	December 31	
	2000	1999
ASSETS		
CASH	$4,870,623	$6,089,300
ADVANCES AND REFUNDABLE DEPOSITS (Note 3)	146,194	107,310
PREPAYMENTS	61,264	160,312
TOTAL ASSETS	**$5,078,081**	**$6,356,922**
LIABILITIES AND FUND BALANCES		
ADVANCE RECEIPTS OF GRANTS (Note 4)	$ -	$1,182,848
RECEIPTS FOR CUSTODY (Note 5)	392,052	384,434
RESERVES FOR EMPLOYEE BENEFITS (Note 6)	1,134,996	1,258,532
FUNDS		
Core fund	666,711	165,763
Working capital fund (Note 8)	900,000	900,000
Restricted core fund	512,438	435,527
Special projects fund	1,166,507	1,711,571
Self-sustaining operation fund	305,377	318,247
Total Funds	3,551,033	3,531,108
TOTAL LIABILITIES AND FUNDS	**$5,078,081**	**$6,356,922**

(With TN Soong & Co report dated March 2, 2001)

THE ASIAN VEGETABLE RESEARCH AND DEVELOPMENT CENTER

STATEMENTS OF CHANGES IN CORE FUND (Note 7)

(Prepared on a Modified Cash Basis and Expressed in US Dollars - Note 2)

	December 31	
	2000	1999
ADDITIONS		
Contributions		
Republic of china	$4,498,516	$3,867,851
Japan	562,000	562,000
Federal Republic of Germany (Note 7)	361,941	500,935
Thailand	116,921	114,714
Republic of Korea	74,983	135,000
Australia	127,069	127,560
Philipines	44,900	43,800
France	221,000	160,685
Total contributions	6,007,330	5,512,545
Grants	1,510	-
Other (Note 7)	1,221,585	1,110,165
Translation adjustment (Note 2)	(268,690)	128,443
Total Additions	6,961,735	6,751,153
DEDUCTIONS		
Capital expenditures (Notes 2 and 7)	148,790	159,852
Operating expenditures (Note 7)	6,261,739	6,838,001
Total Deductions	6,410,529	6,997,853
NET INCREASE (DECREASE) IN FUND	551,206	(246,700)
FUND BALANCE, BEGINNING OF YEAR		
As previously reported	165,763	533,390
Translation adjustment (Note 2)	(50,258)	(120,927)
As restated	115,505	412,463
FUND BALANCE, END OF YEAR	**$ 666,711**	**$ 165,763**

(With TN Soong & Co report dated March 2, 2001)

THE ASIAN VEGETABLE RESEARCH AND DEVELOPMENT CENTER

STATEMENT OF CHANGES IN RESTRICTED CORE FUND (Note 9)

(Prepared on a Modified Cash Basis and Expressed in US Dollars - Note 2)

	December 31	
	2000	**1999**
ADDITIONS		
From German Agency for Technical Cooperation	$472,210	$936,461
DEDUCTIONS		
Transfers to core fund as contributions of Federal Republic of Germany	361,941	500,934
NET INCREASE IN FUND	110,269	435,527
FUND BALANCE, BEGINNING OF YEAR		
As previously reported	435,527	-
Translation adjustment (Note2)	(33,358)	-
As restated	402,169	-
FUND BALANCE, END OF YEAR	**$512,438**	**$435,527**

(With TN Soong & Co report dated March 2, 2001)

THE ASIAN VEGETABLE RESEARCH AND DEVELOPMENT CENTER

STATEMENT OF CHANGES IN SPECIAL PROJECTS FUND (Note 10)

(Prepared on a Modified Cash Basis and Expressed in US Dollars - Note 2)

	Year Ended December 31, 1999					Year Ended December 31, 2000			
Sponsors	Balance Beginning of Year	Translation Adjustment	Additions	Deductions	Balance End of Year	Translation Adjustment	Additions	Deductions	Balance End of Year
BY AVRDC-HO									
Asian Development Bank	($ 47,949)	$ -	$ 639,530	$ 430,752	$ 160,829	$ -	$ 51,569	$ 181,473	$ 30,925
Australia	8,765	210	30,279	17,457	21,797	(327)	16,277	9,613	28,134
DFID/UK	30,968	-	163,713	191,497	3,184	-	306,636	253,640	56,180
GTZ/BMZ/Germany	284,545	(39,288)	717,646	560,368	402,535	(30,831)	234,773	584,704	21,773
Japan	406,436	-	268,000	173,374	501,062	-	368,000	560,750	308,312
COA & NSC/ROC	611,290	14,695	445,682	1,084,435	(12,768)	(153)	860,191	842,879	4,391
RDA/Korea	30,322	-	40,000	23,055	47,267	-	-	18,657	28,610
USAID	(437,295)	-	1,196,270	663,978	94,997	-	752,944	819,932	28,009
UNICEF	-	-	-	-	-	-	115,970	47,846	68,124
Others	77,213	1,051	120,991	134,978	64,277	(1,541)	253,939	213,170	103,505
BY AVRDC-ARC									
SDC/Swiss	31,122	-	938,140	671,302	297,960	-	324,205	262,385	359,780
ASEAN	-	-	-	-	-	-	63,681	3,391	60,290
Others	-	-	149,833	19,402	130,431	-	318,014	379,971	68,474
	$995,417	($23,332)	$4,710,084	$3,970,598	$1,711,571	($32,852)	$3,666,199	$4,178,411	$1,166,507

(With TN Soong & Co report dated March 2, 2001)

Meteorological information

Meteorological data (monthly mean) collected at the AVRDC weather station, 2000

	Humidity (%)	Air temperature (°C)		Soil temperature 10 cm (°C)		Soil temperature 30 cm (°C)		Wind velocity (m/s)	Solar radiation (W-hour/m²)	Precipitation (mm)	Evaporation (mm)
	Daily average	Daily max	Daily min	Daily max	Daily min	Daily max	Daily min	Daily average	Daily average	monthly	Daily average
January	76	22.9	14.1	22.8	18.9	21.3	20.4	2.45	4674	3.1	3.0
February	80	21.5	13.9	23.3	18.6	21.3	20.2	2.75	4474	14.5	2.8
March	76	25.5	16.2	27.9	21.0	23.7	22.3	2.36	6446	9.3	4.4
April	77	29.0	20.6	29.0	23.8	26.2	25.0	1.82	5518	96.0	4.7
May	74	30.7	22.8	31.9	26.3	28.7	27.3	1.71	6026	43.4	5.3
June	76	32.2	24.1	33.6	27.3	30.0	28.6	2.08	6313	183.0	5.7
July	77	32.1	24.2	30.9	27.4	29.5	28.4	2.00	5112	744.0	5.9
August	79	30.8	23.4	29.7	26.6	28.4	27.5	1.92	5227	647.9	4.9
September	68	31.8	23.0	29.7	25.4	28.7	27.6	2.01	4806	96.0	5.3
October	72	31.5	22.6	32.2	26.4	30.0	28.5	1.68	3813	83.7	4.4
November	75	27.3	19.3	27.5	22.0	26.7	25.4	1.53	3081	6.0	2.9
December	72	25.2	16.5	25.8	19.8	24.6	23.2	2.67	2965	12.4	2.9