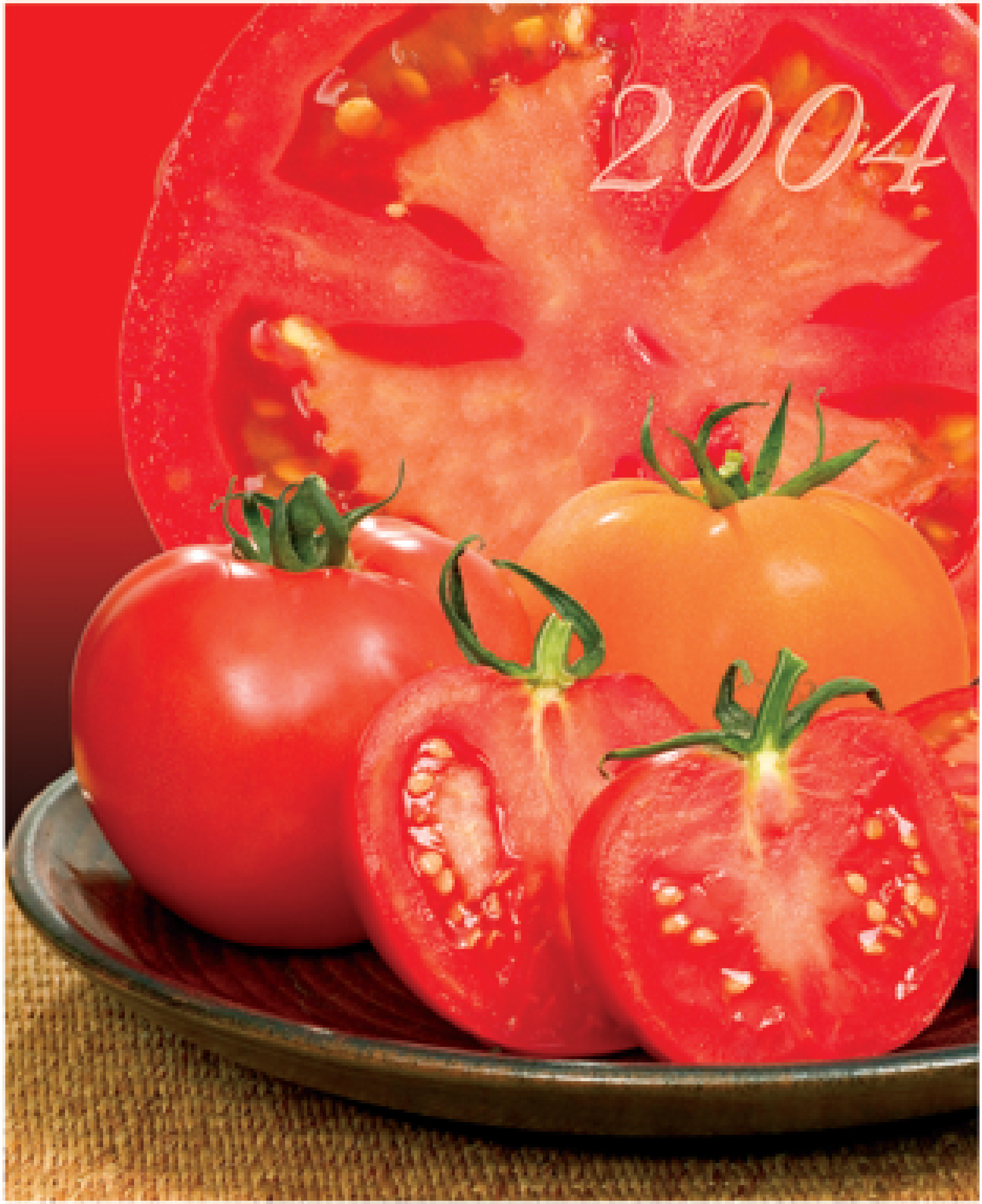
AVRDC Report



AVRDC
The World Vegetable Center

AVRDC Report 2004

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About the cover:
AVRDC is a world leader in the collection, evaluation, and conservation of tomatoes. AVRDC's tomato germplasm is the foundation for a large proportion of tomatoes grown in the tropics. These tomatoes are increasing farmers' incomes, providing new management options for smallholder farmers and improving the quality of diets particularly for the poor.

Contents

Crop and Ecosystem Management

Nutrition

Socio-economics

Communications, Training, and Information

Global Outreach

Foreword

AVRDC –The World Vegetable Center is pleased to present its accomplishments for 2004. This year saw a continuation of the renewal of the Center, with increases in funding, an expanding global programme, and continued renovation of our research and support service facilities.

In 2004, our scientists made significant advances which are helping to improve vegetable yields in the tropics. Among the successes described in this publication are the release of new varieties including high beta-carotene tomatoes and cherry tomatoes.

Diseases and insects are major causes of crop losses in the tropics. Our work on breeding tomatoes with resistance to geminiviruses is continuing to make good progress, while we have also shown that nethouses can be more effective than insecticides for controlling tomato leaf curl virus. New ways to control eggplant fruit and shoot borer have been developed to massively reduce the excessive use of insecticides in this crop. We have also developed anthracnose resistant peppers, and the best lines from our international chilli pepper nursery are being distributed to partners worldwide.

Vegetables are the world's most important source of micronutrients, and micronutrient deficiency is the most widespread form of malnutrition. Our research has shown the high nutritional value of indigenous vegetables and the important role they play in the nutrition of the world's poorest families. We are also continuing to research and develop their supply chains.

Our scientists at head office and in our regional centers in Southeast Asia and Africa are involved in our research as well as in training. Major training programmes have been run in both our regional offices this year, and many trainees from our national partner institutions, from universities and from the commercial seed sector have helped to contribute to the Center's success this year. Their work has enhanced our scientific output and their new skills will be taken back to their parent organizations to build their capabilities to continue to improve tropical vegetable production. I invite you to review the research summarized in this book as a snapshot of the Center's ongoing research for development.

Thomas A. Lumpkin
Director General

Genetic Resources and Seeds

Promoting indigenous vegetables for improved nutrition in Asia

Indigenous vegetables are valuable for diversifying production systems, which may lead to higher incomes for farmers. These vegetables are also useful for diversifying diets, leading to improved health and nutrition. The main objective of the ADB-sponsored "Promoting the Utilization of Indigenous Vegetables for Improved Nutrition of Resource-Poor Households in Asia" (RETA 6067) project is to promote food security and good health in rural households in Asia through enhanced utilization of indigenous vegetables. The following are the accomplishments of this, and related projects, for year 2004.

Germplasm conservation

Through RETA 6067 and its complementary project RETA 5839 ("Collection, Conservation, and Utilization of Indigenous Vegetables") 3,888 accessions have been transferred to AVRDC (Table 1). The collected materials are conserved both in AVRDC and the country of origin.

AVRDC. Regeneration and characterization of 802 accessions belonging to 30 species in 18 genera was done in collaboration with a project funded by the Council for Agriculture, Taiwan. Under the JIRCAS (Japan International Research Center for Agricultural Sciences) project "Evaluation of indigenous vegetable in Tropical Asia for Horticultural and Functional Properties Aimed at Further Diversification of Food Resources," 83 accessions of amaranth (*Amaranthus* spp.) were planted for the purpose of developing procedures for evaluating flooding tolerance in indigenous leafy vegetables.

Bangladesh. A total of 1,043 accessions have been characterized and 143 accessions regenerated. Sixty accessions of yam (*Dioscorea* sp.) are being maintained in the field genebank of the Plant Genetic Resources Center (PGRC) of Bangladesh Agricultural Research Institute (BARI). A total of 372 samples of 10 species were distributed to research organizations, students, and farmers for utilization.

Cambodia. Cambodia transferred to AVRDC 137 accessions of newly collected accessions in 2004. Regeneration and characterization are being done at Kbal Koh Research Station. The genebank of this station was improved through RETA 6067.

Indonesia. Transfer of germplasm from Indonesia is restricted but arrangement for the transfer of collected material is being made.

Lao PDR. A total of 610 accessions collected from different provinces of Lao PDR have been transferred to AVRDC. Identification and characterization are done in two sites: HHRC (Hatdokkeo Horticulture Research Center) in Vientiane and Champasack Agricultural Station.

Malaysia. Malaysia transferred to AVRDC a total of 285 accessions including 54 species in 36 genera. Twenty accessions and 90 accessions of indigenous vegetables from Sarawak and Sabah, respectively, were transferred to MARDI (Malaysian Agricultural Research and Development Institute) for regeneration and storage. In Sarawak, duplicate sets were deposited at the Kebuloh Agriculture Research Center, Kuching. The MARDI Rice Genebank in Penang agreed to include vegetables in their collection for conservation. One hundred accessions were transplanted from July until August to multiply the accessions to have enough seeds for the next season. Characterization was done on 20 accessions including eggplant, chili, pepper and pumpkin. Regeneration of accessions was also done in Sarawak.

Table 1. Summary of number of accessions of germplasm transferred to AVRDC by RETA 6067 member countries as of 31 December 2004.

Country	RETA 5839	RETA 6067 (in 2003)	RETA 6067 (in 2004)	Total
Bangladesh	703	0	75	778
Cambodia	0	0	137	137
Indonesia	0	0	0	0
Lao PDR	-	178	432	610
Malaysia	-	-	285	285
Philippines	147	-	-	147
Thailand	1,388	-	-	1,388
Viet Nam	534	-	9	543
Total	2,772	178	938	3,888

Philippines. Forty-nine accessions were regenerated and characterized in 2003–2004. Another set of 26 accessions of four crops was seeded in December.

Thailand. A total of 236 accessions were characterized and regenerated.

Viet Nam. A part of the accessions was lost due to lack of facilities and poor conditions for seed regeneration. Embryo rescue was resorted to for several indigenous vegetable species. During characterization and evaluation, two varieties each of smooth and ridged sponge gourds, one variety of snake gourd, four varieties of okra were selected as promising varieties to be extended in production. Ex-situ conservation capacity for indigenous vegetables was improved.

Germplasm collection

A summary of the number of samples collected is presented (Table 2). The Cambodian collection now stands at 302. The Indonesian team assembled 383 accessions.

Two collecting expeditions were conducted in Lao PDR. A total of 99 accessions, 10 from Vientiane, 45 from Borikhamsay and 44 from Khammouane were collected. An additional 442 were collected from Savannakhet, Champasack, Sekong, and Saravane provinces. So far the number of accessions collected in Lao PDR totals to 719.

Malaysia met its target of 500 accessions in 2003. Using funds from MARDI, additional collecting was done in February in two areas which were not included in the previous collecting expeditions in Peninsular Malaysia. The two sites cover zone 4 and zone 6 of the Malaysian climatic zones. A total of 28 accessions including 12 species and from 12 sites were collected.

Table 2. Summary of collecting expeditions and number of samples collected.

Country	Expedition date	Sites	Samples collected	Total
Cambodia	2003–2004	Kampong Cham Kampong Thom, Kandal, Kampot	302	302
Indonesia			383	383
Lao PDR	16–25 May 2003	Oudomxay, Luang Prabang,	178	719
		Vientiane, Borikhamxay, Khammouane	99	
	2004	Savannakhet Champasack, Sekong, Saravane	442	
Malaysia	1–13 Sep 2003	Sarawak	172	528
	15–27 Sep 2003	Sabah	104	
	29 Sep–10 Oct 2003	Penin. Malaysia	224	
	Feb 2004	Penin. Malaysia	28	
Total			1,932	1,932

Participatory evaluation

Survey questionnaires for farmers, consumers and traders were developed in collaboration with socio-economists and members of national agricultural research systems (NARS). The survey questionnaires were translated into the national language of the participating countries. Seeds of at least 132 accessions were multiplied by AVRDC and NARS in preparation of these evaluations. This included 112 accessions of 51 species (Table 3) that were selected as promising in the RETA 5839 project.

In 2004, seeds of 67 accessions with potential for promotion were produced at GRSU for inclusion in the Indigenous Vegetable (IV) Seed Kits for use in the participatory evaluation and for distribution in the pilot school gardens. The kits included guidelines on the conduct of the participatory evaluation.

Cambodia. Seeds of selected vegetables were sent to PEDIGREA (Participatory Enhancement of Diversity of Genetic Resources in Asia, a recent initiative by The Centre for Genetic Resources and Partners to enhance in-situ genetic diversity of rice, vegetables and poultry in Asia) and Srer Khmer. Farmers preferred wax gourds TOT 6519, 4056, 4270 and 2406 from Philippines, Viet Nam, Bangladesh, and India respectively. Farmers from Kampong Speu preferred pumpkins from TOT 6516 and 6041 from the Philippines and an unspecified origin; while farmers from Kandal preferred pumpkin TOT 6514 from Philippines and bitter gourd TOT 4204 from Viet Nam.

Indonesia. A total of 158 promising accessions of 53 indigenous vegetables were planted at the IVEGRI (Indonesian Vegetable Research Institute) in Lembang for preliminary evaluation. These included amaranth, Malabar spinach, ivy gourd, jute, roselle, okra, ridged sponge gourd, snake gourd, bitter gourd, false coriander, ginseng, kangkong, pumpkin, chayote, nightshade, sweet fennel, sauropus, and cosmos, among others. Vegetable

Table 3. List of 51 indigenous vegetable species selected for promotion under ADB RETA 6067.

A.	IV species selected by RETA 5839 participating countries:	
1	*Abelmoschus esculentus*	Okra
2	*Amaranthus* spp.	Amaranth
3	*Basella alba*	Malabar spinach
4	*Benincasa hispida*	Wax gourd
5	*Beta vulgaris* cvg. *bengalensis*	Swiss chard group
6	*Brassica oleracea* cvg. *acephala*	Kale group
7	*Capsicum spp.*	Chili pepper
8	*Coccinia grandis*	Ivy gourd
9	*Corchorus* spp.	Jute
10	*Cucurbita moschata*	Pumpkin
11	*Cucumis sativus*	Cucumber
12	*Dolichos lablab*	Hyacinth bean
13	*Lagenaria siceraria*	Bottle gourd
14	*Luffa acutangula*	Sponge gourd (ridged)
15	*Luffa aegyptiaca*	Sponge gourd (smooth)
16	*Momordica charantia*	Bitter gourd
17	*Solanum melongena*	Eggplant
18	*Trichosanthes cucumerina*	Snake gourd
19	*Trichosanthes dioica*	Pointed gourd
20	*Vigna unguiculata* ssp. *sesquipedalis*	Yardlong bean
B.	Additional IVs:	
21	*Allium* spp.	Bulb alliums
22	*Alpinia galanga*	Galanga
23	*Apium graveolens*	Celery
24	*Brassica* spp.	Mustard, pak-choi
25	*Cajanus cajan*	Pigeon pea
26	*Carica papaya*	Papaya, immature
27	*Colocasia esculenta*	Taro
28	*Coriandrum sativum*	Coriander/cilantro
29	*Cucumis sativus*	Cucumber
30	*Curcuma longa*	Turmeric
31	*Cymbopogon citratus*	Lemon grass
32	*Eryngium foetidum*	False coriander
33	*Glycine max*	Vegetable soybean
34	*Hibiscus sabdariffa*	Roselle
35	*Ipomoea aquatica*	Kangkong
36	*Ipomoea batatas*	Sweet potato
37	*Lactuca sativa*	Lettuce
38	*Lycopersicon esculentum*	Tomato
39	*Manihot esculenta*	Cassava (leaf, root)
40	*Moringa* spp.	Horseradish tree
41	*Musa* spp., *M. balbisiana*	Banana flower, fruit
42	*Ocimum* spp.	Basil (sweet, holy)
43	*Solanum torvum,* other *S.* spp.	Devil's fig, plate brush
44	*Pachyrhizus erosus*	Yambean (tuber)
45	*Psophocarpus tetragonolobus*	Winged bean
46	*Raphanus sativus*	Radish
47	*Sauropus androgynus*	Star gooseberry
48	*Sesbania grandiflora*	Sesbania flower
49	*Talinum triangulare*	Waterleaf
50	*Vigna radiata*	Mungbean
51	*Zingiber officinale*, other *Z.* spp.	Common ginger

soybean and high beta-carotene cherry tomato were included because of their health promoting properties.

Initial participatory evaluation and promotion of selected indigenous vegetables was held during a Field Day at IVEGRI on 5 October. There were 46 participants from six villages, namely, Cikole, Cibogo, Cibodas, Cikidang, Cisarua, and Cihanjuang in Lembang, West Java province. Each village was represented by 6–8 participants. Participants included vegetable farmers, housewives/head of households and traders, extension officers, other government officers (from the Assessment Institute of Agricultural Technology) and one non-governmental organization (NGO).

The survey during the participatory evaluation included background information on the respondents and their general knowledge on indigenous vegetables (Table 4). Survey during the participatory evaluation showed that 76.2% of the respondents had grown indigenous vegetables. The indigenous vegetables were mostly grown in the backyard, followed by the field and then as intercrop. Indigenous vegetables were consumed more than four times a week and they were mostly obtained directly from the field. Indigenous vegetables are consumed for their high nutrition and because they are cheap. Availability in the market was identified as a major constraint in the consumption of indigenous vegetables. Respondents agreed that indigenous vegetables can replace imported vegetables.

Participants were not familiar with five indigenous vegetables from the IV Seed Kit. These were basella (89%), okra (94%), roselle (98%), jute (98%) and ivy gourd (96%). The most commonly grown indigenous

Fig. 1. Participatory evaluation of indigenous vegetables in Indonesia.

Table 4. Result of survey on the participants and their general knowledge on indigenous vegetables. Field Day, 5, October 2004, Lembang, West Java, Indonesia.

No.	Descriptions	Frequency n = 46	Percentage (%)
1.	Land ownership		
	a. Owners	14	30.4
	b. Hire	6	13.0
	c. Others	14	30.4
2.	Side jobs		
	a. Labors at farm	16	34.8
	b. Construction	0	0
	c. Others	22	47.8
3.	Have you ever grown indigenous vegetables		
	a. Yes	35	76.1
	b. No	8	17.4
4.	Reason to grow indigenous vegetables		
	a. Cash crops	27	58.7
	b. Food	33	71.7
	c. Others	5	10.9
5.	Reason to consume indigenous vegetables		
	a. High nutrition value	35	76.1
	b. Medicine	8	17.4
	c. Cheap	25	54.3
	d. Good taste	14	30.4
6.	Scoring indigenous vegetables due to phenotypic trait		
	a. Leaf color	4	8.7
	b. Shape	36	78.3
	c. Size of plant	12	26.1
7.	Frequency of consumption of indigenous vegetables per week		
	a. 1-2 times	12	26.1
	b. 3-4 times	12	26.1
	c. > 4 times	18	39.1
	d. Never	0	0
	e. Others	2	4.3
8.	From where do they obtain indigenous vegetables?		
	a. Own field	37	80.4
	b. Buy from market	17	37.0
	c. Others	2	4.3
9.	Where do they grow indigenous vegetables?		
	a. Backyard	16	34.8
	b. Field	16	34.8
	c. Intercropping	18	39.1
	d. Others	2	4.3
10.	Constraints in consumption of indigenous vegetables		
	a. Not always available at market	15	32.6
	b. Bad taste	6	13.0
	c. Others	0	0
11.	Can indigenous vegetables be replaced by imported vegetables?		
	a. Yes	30	78.3
	b. No	2	4.3

vegetables were amaranth, kangkong, nightshade, pumpkin, bitter gourd, basil, lima bean, chayote, sauropus and watercress (Table 5). Table 6 shows the indigenous vegetables selected by the participants. The specific accessions or lines selected by the participants are shown in Table 7. For amaranth, bitter gourd and

Table 5. Indigenous vegetables commonly grown by Indonesian farmers (N = 46).

Crops	No.	Percent
Amaranth	26	57
Kangkong	22	48
Nightshade	17	37
Pumpkin	17	37
Bitter gourd	14	39
Basil	11	24
Lima bean	11	24
Chayote	10	22
Sauropus	8	17
Watercress	5	11

Table 6. The favorite five indigenous vegetables selected by Indonesian participants (N = 46).

Field / Crops	Like strongly	Like	Dislike	Dislike strongly
Field 3				
Chayote	4	29	0	0
Pumpkin	2	28	0	0
Snake gourd	1	25	2	0
Bitter gourd	1	21	2	0
Nightshade	1	17	2	0
Field 4				
Centella asiatica	5	21	4	1
Spilanthes acmella	5	15	6	1
Kangkong	4	8	1	0
Amaranth	3	18	0	0
Sauropus	*1*	*17*	*2*	*0*

Table 7. Accessions/lines selected during the participatory evaluation in IVEGRI.

Crops	Accession/Line
Amaranth	TOT 1807, 1810 and 2337; local variety
Bitter gourd	TOT 7098; local variety
Cherry tomato	TLO 1896 and 1899
Kangkong	TOT 6785
Pumpkin	TOT 6249
Ridged sponge gourd	TOT 3662; local variety
Snake gourd	TOT 6244
Vegetable soybean	AGS 401, 404 and 406

ridged gourd the local varieties were selected because of the participants' familiarity with these.

During the Field Day, indigenous vegetables were prepared based on recipes developed by staff of IVEGRI. The most liked were "snack" amaranth, cooked kangkong, cooked amaranth, cooked jute, cooked sintrong, steamed amaranth, steamed bitter gourd, cooked okra, and cooked snake gourd (Table 8). Although the respondents were not familiar with jute and okra, they were judged as likable. A total of 27 indigenous vegetable recipes were developed for winged bean, hyacinth bean, chayote, and sauropus.

Seeds of 55 accessions of 14 introduced indigenous vegetable species provided by RETA 6067 are being multiplied for distribution to farmers and to support agronomic and participatory research in 2005. These accessions were false coriander (5 acc), kangkong (3 acc), basella (2 acc), amaranth (17 acc), soybean

Table 8. Result of participatory evaluation of indigenous vegetable dishes.

No.	Description	Strongly like	Like	Dislike	Strongly dislike	Abstain
1	Steam bitter gourd 3	4	28	6	0	8
2	Steam bitter gourd 2	6	22	7	0	11
3	Steam bitter gourd 1	7	22	4	1	12
4	Raw cherry tomato	4	28	5	0	9
5	Raw roselle	3	18	15	0	10
6	Cooked roselle	2	10	20	0	14
7	Cooked sintrong	8	24	4	0	10
8	Cooked kangkong 3	9	23	2	0	12
9	Cooked kangkong 2	6	24	4	0	12
10	Cooked basella	4	14	7	3	18
11	Cooked jute	8	14	9	0	15
12	Cooked snake gourd 2	6	28	2	0	10
13	Cooked okra	7	20	7	1	11
14	Cooked kangkong 1	10	27	0	0	9
15	Cooked amaranth 6	10	24	3	0	9
16	Snack amaranth 6	12	24	0	0	10
17	Snack amaranth 1	12	25	0	0	9
18	Snack amaranth 15	15	21	0	0	10
19	Snack amaranth 12	14	19	0	0	13
20	Steam amaranth 1	8	25	1	0	12
21	Steam amaranth 6	5	21	1	0	19
22	Steam amaranth 15	3	14	1	0	28
23	Steam amaranth 10	4	12	1	0	29
24	Cooked amaranth 10	1	9	4	0	32
25	Veg. soybean soup	0	6	0	0	40
26	Veg. soybean soup	0	5	1	0	40
27	Veg. soybean soup	*0*	*6*	*0*	*0*	*40*

(10 acc), tomato (4 acc), okra (2 acc), roselle (1 acc), jute (1 acc), bitter gourd (3 acc), ivy gourd (1 acc), luffa (2 acc), snake gourd (2 acc), and pumpkin (2 acc).

Lao PDR. A total of 48 promising accessions of 13 species of indigenous vegetables were received from AVRDC. They were planted at the National Horticulture Research Center (NHRC) in Vientiane for preliminary evaluation and seed production, for further testing in other sites, and for distribution to the school garden project and to interested farmers. The indigenous vegetables were: amaranth (15 acc), Malabar spinach (2 acc), ivy gourd (1 acc), jute (1 acc), roselle (1 acc), okra (1 acc), ridged sponge gourd (1 acc), snake gourd (1 acc), squash (1 acc), false coriander (5 acc), and kangkong. Tomato (7 acc) and vegetable soybean (10 acc) were also included.

Malaysia. An import permit was prepared for the shipment of the indigenous vegetable Seed Kits for three sites including 57 accessions for evaluation. A meeting to initiate the participatory approach was held in Miri, Sarawak; sites for the participatory evaluation were identified.

Philippines. Forty promising accessions of 10 kinds of indigenous vegetables were planted at the BPI-Los Baños National Crop Research and Development Center (BPI-LBNCRDC) in Los Baños, Laguna for preliminary evaluation and seed production for further testing in other sites. These indigenous vegetables were: amaranth (26 acc), Malabar spinach (2 acc), ivy gourd (1 acc), jute (1 acc), roselle (1 acc), okra (1 acc), ridged sponge gourd (1 acc), snake gourd (1 acc), false coriander (5 acc), and squash (1 acc). Vegetable soybean (12 lines) and high beta-carotene tomatoes (7 lines) were also included.

Unfortunately, the tomatoes and squash were severely infected by virus and had to be uprooted and destroyed. False coriander did not germinate. The cause of germination failure is not known. Seeds of okra (TOT 3886), ridged sponge gourd (TOT 3662), and snake gourd (TOT 6244) were multiplied at BPI-LBNCRDC for inclusion on the on-station participatory evaluation during the dry season 2005 and for further testing in other sites.

The participatory evaluation questionnaires were pre-tested during Field Days in August where respondents were shown indigenous vegetables grown at the BPI-LBNCRDC. The activity was done on separate dates: August 18 for consumers with 38 respondents, August 24 and 25 for trades with 28 respondents, and August 31 for farmers with 21 respondents from the municipalities of Los Baños, Calamba and Bay in Laguna.

All the consumer respondents were familiar with and are utilizing kangkong in their diets. Most of them were also familiar and uses jute, Malabar spinach and amaranth, but not roselle and ivy gourd. The highly preferred traits in the selection of leafy indigenous vegetables were overall appearance, color, taste, nutritional value and shelf life/freshness. In terms of acceptability, amaranth varieties TOT 4868, TOT 5472 and TOT 5473 were rated highly acceptable by most of the consumers. The two varieties, one each from kangkong and Malabar spinach, had similar and high levels of acceptability. Eighteen of the 28 traders, 78% of which were selling the vegetables in the market, were familiar with common leafy indigenous vegetables. All of the traders considered overall appearance, color, texture, nutritional value, shelf life/freshness and marketability of the raw/fresh vegetables as important traits in the selection of leafy indigenous vegetables. Out of the 21 farmer respondents, 17 were familiar with the common leafy indigenous vegetables evaluated. They identified taste, nutritional value, shelf life, marketability of the raw/fresh vegetables and marketability of the seeds and planting materials as the most important quantities/traits to be considered in the selection of leafy indigenous vegetables for promotion. Most of them rated amaranth varieties TOT 5472, TOT 5473, and TOT 2261 with high acceptability. The three varieties, one each from kangkong, Malabar spinach, and jute (TOT 6667), were also rated as highly acceptable.

The sites identified for the participatory evaluation are BPI-LBNCRDC in Los Baños, Laguna, Nueva Vizcaya and Ilocos Sur in collaboration with the Nueva Vizcaya State University (NVSU) and Mariano Marcos State University (MMSU), respectively. Memorandums of Agreements were signed between the universities and the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD). Seeds, survey questionnaires and suggested cultural guides were provided. Okra, roselle, and tomato planted in NVSU demo farm and in the farmers' field in Sta. Barbara, Nueva Viscaya were damaged by the strong typhoon that hit the area during the last week of December 2004. The different gourds that were directly seeded had low germination. In MMSU tomato, kangkong, roselle, and Malabar spinach were planted. NVSU and MMSU collaborators translated the English version of the survey questionnaires into the local languages.

An educational tour in the participatory evaluation, demonstration plots of different indigenous vegetables at BPI-LBNCRDC was conducted in August and participated in by 228 pupils and 11 teachers from the towns of Bay and Los Baños in Laguna.

For promotional activity, seeds of different indigenous vegetables (ridged gourd, snake gourd, ivy gourd, and jute) were provided to areas outside the sites of the project, namely, Ilocos Sur Polytechnic State College (ISPC) at Sta. Maria, Ilocos Sur and Cagayan Valley Integrated Research Center (CVIARC) in Isabela for adaptability tests and selection of potential indigenous vegetable for utilization in the area. MMSU in Batac in Northern Philippines is interested to grow off-season indigenous vegetables due to the high price and high market demand during that season. Cuttings of kangkong from the participatory evaluation field were distributed to the teachers of Mayondon Elementary School and Los Baños Central School for propagation in their respective school garden.

Viet Nam. A pilot study on extension of promising indigenous vegetables in the Hoa Binh province is ongoing. The study aims to increase vegetable consumption and alleviate poverty in these mountainous areas.

Training

A total of 45 person-months of training were provided to staff of national agricultural research systems (NARS). Several NARS staff were trained at AVRDC to use Microsoft Office programs. HHRC conducted training on vegetable production for school teachers and students involved in the school garden project. One staff member of HHRC was sent to AVRDC for three months of training in germplasm regeneration, characterization, and documentation of germplasm. One trainee each from Sabah and Sarawak came for training on genebank procedures. Two researchers, one from PCARRD and one from BPI-LBNCRDC, were trained at AVRDC in regeneration and characterization of legumes and indigenous vegetables. One research staff from the Plant Genetic Resources Center of the Viet Nam Agricultural Science Institute (VASI) was sent to AVRDC for training in documentation and database management.

A standard database design was chosen. Passport and characterization data for 2,708 accessions from Thailand and Bangladesh are now in the database maintained at AVRDC. A CD-ROM listing of collected accessions, passport data, and characterization data is being produced by IVEGRI in Indonesia. Passport data for 283 accessions from Peninsular Malaysia, 126 accessions from Sarawak and 104 accessions from Sabah are now in the database. In Thailand, the databases have been completed for 31 crop groups: amaranth, angled luffa, bitter gourd, jute, blue pea, bottle gourd, basella, coriander, cucumber, eggplant, ivy gourd, lablab bean, lettuce, melon, basil, okra, pepper, pumpkin, roselle, smooth luffa, snake gourd, snap bean, spider flower, sweet potato, tomato, vegetable soybean, kangkong, wax gourd, spilanthes, winged bean, and yardlong bean. In Viet Nam, a database of indigenous vegetables was started.

In collaboration with the NARS, training courses were developed to promote the production and consumption of indigenous vegetables among rural women (Fig. 2). Modules were developed on highlighting the importance of these vegetables in household food security, establishing a garden, producing seed, processing, and cooking indigenous vegetables. Leaflets for 14 crops in the form of indigenous vegetable fact sheets were produced for use in promotional activities. Information on seed development and seed production pattern is now available for 9 species of indigenous vegetables, namely, amaranth, basella, bitter gourd, false coriander, ivy gourd, jute, kangkong, okra and wax gourd based on researches done by the indigenous vegetable team in Thailand.

Fig. 2. Women being trained on processing indigenous vegetables.

School garden programs

Bangladesh. The site of the ADB-funded Northern Crop Diversification Project was chosen for the school garden project. Schools were identified in Bogra, Rangpur and Thakurgaon. Five vegetables (okra, leaf and stem amaranth, Indian spinach, and kangkong) were grown in the school garden with the help of three local officers of a BARI sub-station and local people adjacent to the school. Vegetables have been distributed to the participating students several times.

Lao PDR. Four primary schools (class 3 and 4) with two schools as pilot schools for the school garden activity and two as control were identified. These were Phosy primary school, Huaha primary school, Hatdokkeo primary school and Nong Phanya primary in Vientiane. Indigenous vegetables were planted in approximately 3,000 square meters. Seeds were provided by the project and some teachers and students. Water pumps, watering cans, fencing materials, and tools were provided to encourage teachers and students in the implementation of activities.

Philippines. Coordination with the district supervisor and principals of the three identified elementary schools in Bay, Laguna (Taciano Rizal, Tranca and Masaya), Philippines and site visitation were undertaken. Masaya was identified as the control school and the other two as the pilot schools for the establishment of the indigenous vegetable gardens. Meetings with parents and teachers of the Grades IV and V pupils of the three schools were conducted during the second and third week of June 2004.

Fourteen species of indigenous vegetables were planted in the school gardens: kangkong, amaranth, yardlong bean, cowpea, jute, eggplant, okra, momordica, bottle gourd, winged bean, vegetable soybean, hot pepper, angled luffa, and moringa. Weekly monitoring of activities in the school garden was done (Fig. 3). Continuous harvesting and distribution of harvests to target pupils for inclusion in their diets were done. BPI-LBNCRDC conducted a seminar on “Production and Utilization of Indigenous Vegetables” for the teachers and pupils of the pilot schools.

Thailand. Three schools (2 pilot and 1 control) were identified in the province of Nakhon Ratchasima, Thailand. The vegetables used in the school garden are: leafy vegetables (amaranth, basella, Chinese cabbage, Chinese chives, kangkong), pulses (yardlong bean, winged bean), and other vegetables (ridged and smooth sponge gourds, cucumber, okra, tomato, eggplant, pepper, sweet basil, and holy basil). Tree vegetables (sesbania, sauropus, and acacia) were set as a fence and fruit crops such as banana and papaya were grown near the school garden.

Implementation of the activities in the pilot school garden is well advanced in Thailand. The school garden was found to be well designed. Therefore, it was decided that the design used in Thailand should serve as a model for all the other countries.

The basic design has tree vegetables planted on the perimeter of the garden. Small fruit and leafy vegetables are planted inside the perimeter. One area is set aside for climbing vegetables that require trellises. A water pump was provided by the project to ensure water supply for the school garden.

The Department of Agricultural Extension (DOAE), Thailand was involved in the school garden project. The parents and teachers were involved in all activities of the school garden. Members of neighboring communities were also involved in the construction and demonstrations of the school garden. Staff of the Tropical Vegetable Research Centre (TVRC) and DOAE visited the school garden every two months to answer questions of schoolchildren and teachers. The utilization of the indigenous vegetables through the school garden was successful. Vegetables harvested from the school gardens were cooked as lunch and the children took the vegetables back home to encourage their family households to eat them. They also held vegetable parties in school with teachers and parents helping to prepare indigenous vegetable dishes.

Fig. 3. Schoolchildren tending to their garden of indigenous vegetables in Philippines.

In addition, some plant materials from the school garden were brought back home and planted in the home garden. This is good practice for conservation of indigenous vegetables that is passed on to the children.

During the long holiday, March–May, which was also the summer season, water was insufficient for the school garden. However, the tree vegetables such as acacia, sauropus, sesbania and the fruit trees such as banana could be maintained in the field during this time. In addition, the parents took some vegetables from the schools to grow in their houses. At the beginning of the semester in June, the indigenous vegetable project provided some seedlings such as sesbania, ivy gourd, winged bean, basella, chili, and amaranth for the school gardens. *Trichoderma* was also provided to one of the schools as a biocontrol agent for fungal disease that infected the basella root system. The other activities included six groups of parents assigned to cook using indigenous vegetables from the backyards and the school garden for lunch at Lung Pra Du. At Nong Sao Dieo School, demonstration on cooking indigenous vegetables for the women was carried out by the officer from DOAE and the staff of TVRC. Students of Grade V and VI were given quick tests on common indigenous vegetables grown in the school garden. Prizes donated by the friends and members of the Thai Indigenous Vegetable Family were given to students who obtained highest scores.

In one community where one of the pilot school gardens was located, the demand for kangkong was so much that the school decided to increase the amount of kangkong in the school garden. This defeated the purpose of teaching conservation of diversity and diversifying diets; however, it showed insights to the entrepreneurial interest of the community.

Future activities

A mid-term workshop was held in Kasetsart University, Bangkok, Thailand from 1–3 September. Participants presented progress of the project and proposed future activities. Major recommendations were fast tracking activities of RETA 6067 countries that implemented the project later than the rest through the assistance of AVRDC, preparation of a project framework/ roadmap for each RETA 6067 country based on the overall technical assistance framework, preparation of a report on the financial status of the project, and preparation of a request for extension of the project.

A third phase of the project will be proposed to ADB. This would be to scale up activities to ensure that the long-term goals of food and nutritional security and poverty alleviation are achieved. It will mean inclusion of activities on processing of indigenous vegetables as food and non-food products and training of extension workers and teachers as well as widening linkages to include more government and non-government organizations.

Collection and conservation of vegetable genetic resources

AVRDC through its Genetic Resources and Seed Unit (GRSU) holds in trust for the global community a wide collection of vegetable germplasm including 154 genera of 432 species from 159 countries (Table 9). The number of accessions added in 2004 to the collection is 999, which includes 58 genera and 85 species from 20 countries (Table 10). Accessions of indigenous vegetables were received from Bangladesh (75), Cambodia (137), Lao PDR (432), Malaysia (285) and Vietnam (9) as part of the ADB-funded project "RETA 6067 Promoting Utilization of Indigenous Vegetables for Improved Nutrition of Resource-Poor Households in Asia." The most number of accessions received in 2004 belongs to the genus *Solanum* (164), *Vigna* (127), *Capsicum* (114), *Luffa* (77), *Amaranthus* (58), and *Cucurbita* (57).

A total of 802 accessions belonging to 30 species in 18 genera were planted for regeneration and characterization in 2003–2004 with support of projects funded by the ADB through RETA 6067 and the Council of Agriculture, Taiwan. Another 935 were regenerated and 1,755 characterized in Bangladesh, Cambodia, Indonesia, Malaysia, Philippines, and Thailand. Enough seeds for the active collection and the base collection were produced. Characterization was done following a set of standard descriptors.

Table 9. Accessions of vegetable germplasm conserved at AVRDC, as of 31 December 2004.

Crop	Accessions: Added in 2004	Accessions: Total
Principal crops		
Glycine	2	15,312
Capsicum	114	7,631
Lycopersicon	11	7,244
Vigna radiata	10	5,680
Solanum	164	2,972
Brassica	25	1,783
Allium	-	1,078
Sub-total	326	41,700
Other crops		
Vigna angularis	-	*2,372*
Vigna unguiculata	60	1,390
Luffa	77	727
Phaseolus	4	614
Amaranthus	58	554
Cucurbita	57	485
Cucumis	39	483
Vigna mungo	-	478
Abelmoschus	14	421
Vigna unguiculata ssp. *sesquipedalis*	52	389
Lagenaria	16	298
Lablab	31	293
Momordica	19	238
Pisum	-	223
Ocimum	45	216-
Psophocarpus	18	209
Vigna unguiculata ssp. *unguiculata*	3	110
Corchorus	1	104
Others	179	
Sub-total	673	12,055
Total	*999*	*53,755*
No. of genera		154
No. of species		432
No. of countries		159

Table 10. Number of accessions received by GRSU in 2004.

Species	Accessions
Abelmoschus esculentus	13
Abelmoschus moschatus	1
Amaranthus spp.	58
Anethum graveolens	7
Basella alba	19
Benincasa hispida	24
Brassica juncea	6
Brassica oleracea cvg. cauliflower	1
Brassica rapa	1
Brassica rapa cvg. Chinese cabbage	16
Brassica sp.	1
Canavalia gladiata	4
Capsicum annuum	14
Capsicum frutescens	99
Capsicum sp.	1
Cassia occidentalis	7
Cassia siamea	4
Cassia tora	1
Celosia argentea	9
Centella asiatica	1
Citrullus lanatus	3
Cleome gynandra	19
Clitoria ternatea	1
Coccinia grandis	6
Corchorus olitorius	1
Coriandrum sativum	7
Cosmos caudatus	13
Cosmos sulphureus	1
Crassocephalum crepidioides	1
Crotolaria longirostrata	1
Cucumis melo	7
Cucumis sativus	32
Cucumis sp .	1
Cucurbita spp.	57
Eryngium foetidum	5
Foeniculum vulgare	1
Glycine max	2
Gynura bicolor	3
Hibiscus sabdariffa	8
Ipomoea sp.	1
Lablab purpureus	31
Lactuca indica	2
Lactuca sativa	1
Lagenaria siceraria	16
Luffa acutangula	26
Luffa aegyptiaca	51
Lycopersicon esculentum	11
Momordica charantia	18
Momordica sp.	1
Moringa oleifera	10
Ocimum americanum	2
Ocimum basilicum	37
Ocimum sanctum	5
Ocimum sp.	1
Pachyrhizus erosus	3
Passiflora foetida	2
Pastinaca sativa	1
Perilla frutescens	2
Phaseolus coccineus	2
Phaseolus vulgaris	2
Phytolacca dioica	1
Plantago indica	1
Psophocarpus tetragonolobus	18
Salvia tiliaetolia	1
Sauropus androgynous	2
Sesbania grandiflora	2
Solanum aethiopicum	1
Solanum ferox	19
Solanum indicum	2
Solanum macrocarpon	2
Solanum mammosum	1
Solanum melongena	82
Solanum nigrum	8
Solanum sisymbrifolium	15
Solanum spp.	5
Solanum torvum	26
Solanum xanthocarpum	3
Solena amplexicaulis	3
Spilanthes paniculata	2
Spinacia oleracea	6
Talinum triangulare	1
Trichosanthes cucumerina	12
Vigna radiata	10
Vigna umbellata	2
Vigna unguiculata	60
Vigna unguiculata ssp. *sesquipedalis*	52
Vigna unguiculata ssp. *unguiculata*	3
Others	6
Total	999

Germplasm dissemination

To enhance utilization of germplasm, AVRDC regularly distributes both improved and unimproved vegetable germplasm to collaborating NARS and to various requesting parties.

As part of the activities of the RETA 6067 project, indigenous vegetable seed kits were prepared and disseminated through promotional activities including women training, participatory evaluation programs, and pilot school garden programs in the eight participating countries: Bangladesh, Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Thailand and Vietnam. Seeds of vegetables indigenous to South and Southeast Asia were prepared to be part of the kit. Selection of accessions was based on: 1) recommendations from NARS; 2) high nutritional value; 3) potential for introduction as a new crop; and 4) availability of seeds. Recommended cultivation practices and other technical guides were included in the kits. Seeds were prepared for inspection and issuance of phytosanitary certificates by the Taiwan Bureau of Animal and Plant Health Inspection and Quarantine. Each shipment was accompanied with a Material Transfer Agreement.

A total of 2,046 samples were shipped to countries participating in the RETA 6067 project. Table 3, presented earlier in this report, shows the composition of the IV Seed Kits.

Accessions of leafy vegetables were selected for promotion in these seed kits (Table 11). These accessions had relatively high yield and anti-oxidant activity compared to other accessions within the same species. Selections of cherry tomato, high beta-carotene tomato and vegetable soybean were also included in the seed kit because of their high nutritional value.

All in all, a total of 14,560 accessions (including breeding lines) were sent out from AVRDC of which 92.1% went to 76 countries and the other 5% to AVRDC regional centers in Thailand and Africa (Table 12). Of the total seed distribution, 3% was used by scientists at AVRDC headquarters for use in trials and screening for resistance to insect pests and diseases. At least 20% was germplasm accessions (Table 13).

Contact: Liwayway Engle

Table 11. Indigenous leafy vegetable accessions promoted in seed kits.

Accession	Origin	Traits
Amaranthus spp.		
TOT 5137 (*A. tricolor*)	Thailand	High yielding; high in total anti-oxidants, vitamin C and phenols; green
TOT 5177 (*A. dubius*)	Thailand	High yielding; high in total anti-oxidants, vitamin C and phenols; dark green
TOT 5829 (*A. dubius*)	Thailand	High yielding; high in total anti-oxidants and phenols; dark green
Basella alba		
TOT 4908	Thailand	High yielding; high in total anti-oxidants, vitamin C and phenols; purple stem
TOT 5426	Thailand	High yielding; high in total anti-oxidants and phenols; green stem
TOT 5724	Thailand	High yielding; high in total antioxidants and vitamin C; greenish purple stem
Corchorus spp.		
TOT 4051 (*C. capsularis)*	Viet Nam	High yielding; high in total anti-oxidants, vitamin C and phenols
TOT 6729 (*C. capsularis*)	Taiwan	High yielding; high in total anti-oxidants, vitamin C and phenols
TOT 6749 (*C. olitorius)*	Taiwan	High yielding; high in total anti-oxidants and phenols
Ipomoea aquatica		
TOT 1923A	Indonesia	High yielding; high in vitamin C and phenols; green
TOT 1929	Indonesia	High yielding; high in total anti-oxidants and vitamin C; green
TOT 4212	Thailand	High yielding; high in total anti-oxidants, vitamin C and phenols; green

Table 12. Recipients of germplasm from AVRDC in 2004.

Recipient	Sample no.	Total
External		13,406
Korea	2,879	
Philippines	1,221	
India	1,012	
Mali	942	
China	811	
Thailand	668	
Viet Nam	571	
USA	556	
Netherlands	311	
Cambodia	307	
Others (66)[1]	4,128	
Regional Center/Program		722
AVRDC-ARC	36	
AVRDC-RCA	686	
Internal		432
Virology Unit	130	
Legume Unit	116	
Pepper Unit	100	
Biotechnology Unit	79	
Mycology Unit	3	
International Cooperation Office	2	
Bacteriology Unit	1	
Tomato Unit	1	
Total		14,560

[1]Afghanistan, Argentina, Angola, Australia, Bangladesh, Bhutan, Bolivia, Botswana, Brazil, Burkina Faso, Cameroon, Canada, Czech Republic, Egypt, Eritrea, Ethiopia, Fiji Islands, Finland, Germany, Ghana, Greece, Hong Kong, Indonesia, Iran, Israel, Italy, Japan, Kenya, North Korea, Lao PDR, Lesotho, Malawi, Malaysia, Martinique Islands, Mauritania, Mauritius, Mexico, Myanmar, Nepal, Nicaragua, Nigeria, Oman, Pakistan, Peru, Reunion, Rwanda, Saipan, Sao Tome and Principe, Senegal, Seychelles, Singapore, South Africa, Sri Lanka, St. Vincent and the Grenadines, Sudan, Swaziland, Taiwan, Tanzania, Tonga, Trinidad and Tobago, Turkey, Uganda, United Arab Emirates, United Kingdom, Uzbekistan, and Zambia.

Table 13. Recipients of germplasm accessions from the Genetic Resources and Seed Unit in 2004.

Classification	No.	Sample no.	Purpose
AVRDC-ARC	1	20	For experiment
AVRDC-RCA	1	10	For research
AVRDC headquarters	8	432	Trials; screening for resistance to insect pests, and diseases
Government organization	23	1945	Promotion through school gardens, participatory evaluation and women training; screening for thermotolerance, heat tolerance and drought tolerance
Non-government organization	1	37	For research
University	12	355	For flooding experiments, mapping geminivirus resistance in tomato; observation trials
Private company	1	16	For research
Private individual	1	23	For research
Seed company	5	86	For tomato spotted wilt virus experiments; RAPD markers
Total		2,924	

Crucifer

High yielding broccoli for the hot-wet season

Broccoli is becoming increasingly popular around the world for its flavor, potential cancer-fighting ability, and nutritional qualities. In the hot-wet season of the tropics, most broccoli varieties suffer from damping-off, black rot, and soft rot diseases, poor head development, and low yields. The objective of this study was to identify broccoli varieties adapted to the hot-wet season.

Three evaluation trials consisting of 54, 68, and 108 entries were sown on 30 April, 15 June, and 30 July 2004, and transplanted to the field on 27 May, 14 July, and 7 September 2004, respectively. Seedlings were raised in the greenhouse in plug cells filled with peat moss. Each plot consisted of one 150 cm-wide raised bed, with two rows per bed; spacing between rows and between plants within rows was 50 cm. Each plot included 20 plants. Entries were not replicated. Plant beds were mulched with a layer of rice straw on top. Pesticides were applied as needed to manage insects and diseases. Side shoots were removed to promote the development of a large central head. Yield and number of days between transplanting and harvest were recorded for each entry (Table 1). The chlorophyll content index of mature leaves and heads were measured just before harvest using a Field Scout CM-1000 chlorophyll meter (Spectrum Technologies, Springfield, Illinois, USA) under natural sunlight (Table 2).

In the first trial, favorable weather conditions prevailed during the early growth period but Mindulle Typhoon caused 291 mm of rain to fall from 2–3 July. The subsequent flooding extensively damaged the early maturing varieties, which were beginning to form heads. Most entries in this trial suffered from soft rot disease caused by *Erwinia carotovora*. Yields in general were very low and only one variety shown below yielded over the economic threshold of 10 t/ha of marketable heads during the harvest period from 12 to 29 July. The top yielding variety, BR180 GA415, produced 12.8 t/ha within 58 days after transplanting (DAT).

Transplanting of the second trial was postponed by typhoon. Despite heavy rains, 12 heat-tolerant varieties produced yields over 10 t/ha during the harvest period from 31 August to 21 September. BR209 Green Wind produced the top yield of 13.4 t/ha within 59 DAT.

Transplanting of the third trial was also postponed by rain due to typhoons. A total of 220 mm of rain fell from 10–11 September, but young transplants were not obviously damaged. Although heavy rains ceased after mid-September, the mean temperature in September was 28.0°C. Harvest of the third trial began on 25 October and ended on 18 November. A total of 11 heat-tolerant early maturing varieties yielded over 10 t/ha within 51 DAT. Another 32 moderately early

Table 1. Maturity, yield, and mean head weight of broccoli accessions in three summer trials.[1]

		I			II			III			Mean
Accession	Variety	Maturity (DAT)	Yield (t/ha)	Head wt. (g)	Maturity (DAT)	Yield (t/ha)	Head wt. (g)	Maturity (DAT)	Yield (t/ha)	Head wt. (g)	yield (t/ha)
BR170	CNB-48	54	8.0	298	52	9.5	354	48	10.7	402	9.4
BR180	GA415	58	12.8	550	59	11.7	440	62	13.9	522	12.8
BR186	DG134	56	8.4	628	52	9.1	365	56	15.9	595	11.1
BR195	SF1208	54	5.2	386	49	11.4	426	51	13.2	496	9.9
BR209	Green Wind	-	-	-	59	13.4	502	62	12.0	448	12.7
BR212	RN0413	-	-	-	52	8.6	324	56	12.8	481	10.7
BR228	RN0425	-	-	-	-	-	-	51	14.1	529	14.1
BR245	RN04207	-	-	-	-	-	-	63	17.3	648	17.3
BR253	DG187	-	-	-	-	-	-	62	20.3	763	20.3
BR005	Satomidori (ck)	54	4.2	181	52	6.7	251	56	12.9	484	7.9

[1] Date transplanted: I = 27 May 2004; II = 14 July 2004; III = 7 September 2004 at AVRDC.

Table 2. Horticultural characteristics of broccoli accessions in summer trials.[1]

Accession	Variety	Stem width (cm)	Head thickness (cm)	Head length (cm)	Head width (cm)	Bead size	Chlorophyll[2] head score	Chlorophyll[2] leaf score	Side shoot production
BR170	CNB-48	3.0	4.4	14.7	18.1	Moderate	307	328	Moderate
BR180	GA415	3.7	5.1	13.4	19.0	Moderate	296	343	Moderate-many
BR186	DG134	3.1	5.1	14.0	20.1	Fine-moderate	332	328	Few-moderate
BR195	SF1208	3.4	4.8	13.8	19.2	Fine-moderate	309	311	Few-moderate
BR209	Green Wind	3.1	4.9	13.4	20.0	Fine	316	319	Many
BR212	RN0413	3.5	5.0	13.8	18.4	Moderate	342	338	Moderate-many
BR228	RN0425	3.1	5.8	14.9	21.3	Fine-moderate	315	309	Moderate-many
BR245	RN04207	3.5	4.8	12.5	17.9	Fine	342	364	Moderate
BR253	DG187	3.9	6.6	15.0	18.7	Fine	321	330	Moderate
BR005	Satomidori (ck)	3.2	4.7	15.2	18.7	Moderate	370	310	Few

[1] Data from three trials transplanted 26 May, 15 July and 7 September 2004 at AVRDC.

[2] Index mean of chlorophyll content for five sampled plants measured by Field Scout CM-1000 chlorophyll meter (Spectrum Technologies, Springfield, Illinois, USA).

maturing varieties produced 10 t/ha within 56 DAT. The top yielding variety, BR253 DG187, produced 20.3 t/ha within 62 DAT.

From these three evaluation trials, 10 outstanding varieties: BR170 CNB-48, BR180 GA415, BR186 DG134, BR195 SF1208, BR209 Green Wind, BR212 RN0413, BR228 RN0425, BR245 RN04207, and BR253 DG187, including the check variety BR005 Satomidori, were identified. Among these varieties, four were preferred for their earliness (55 DAT) and consistently high yields: BR186 DG134, BR195 SF1208, BR212 RN0413, and BR228 RN0425. These four outstanding varieties will be evaluated in advanced yield trials under open field conditions next summer.

Heat-tolerant and early maturing broccoli

In 2003, 10 outstanding varieties for heat tolerance and early maturity were selected, namely: BR070 SF1201, BR071 SF1202, BR072 CNB-45, BR073 CNB-50, BR076 DG473, BR094 KY0554, BR116 RN1204, BR117 SF1203, and BR120 RN1205, and the check BR005 Satomidori. These varieties were further evaluated in advanced yield trials under open field conditions in Summer 2004.

Three advanced yield trials including the above entries were sown in plug cells filled with peat moss on 30 April, 15 June, and 30 July 2004, and transplanted to the field respectively on 26 May, 15 July, and 6 September 2004. Plants were grown on two 150 cm-wide raised beds, in double rows with 50 cm between rows and 50 cm between plants within rows. Each plot consisted of 40 plants. A randomized complete block design with three replications was used. Plant beds were mulched with a layer of rice straw. Weekly applications of pesticide mixtures were made to manage insects and diseases. Side shoots were removed to promote the development of a large central head. Yield and number of days between transplanting and harvest were recorded for each entry (Table 3). The chlorophyll content index of mature leaves and heads was measured just before harvest using a Field Scout CM-1000 chlorophyll meter (Spectrum Technologies, Springfield, Illinois, USA) under natural sunlight (Table 4).

In the first trial, early maturing varieties BR070 SF1201 and BR116 RN1204 were damaged seriously by Typhoon Mindulle, which struck Taiwan from 2–3 July. Only two varieties, BR072 CNB-50 and BR117 SF1203, produced yields over the economic threshold of 10 t/ha. BR117 SF1203 produced the highest yield, 11 t/ha within 52 DAT.

In the second trial, plants sustained damage from heavy rains. Only three varieties yielded over 10 t/ha. BR071 SF1202 produced the top yield of 10.8 t/ha within 54 DAT; this was followed by BR117 SF1203 with 10.6 t/ha within 51 DAT.

In the third trial, even though growth was retarded by heavy rains soon after transplanting, all 10 entries produced over 10 t/ha of marketable heads. BR117

Table 3. Maturity, yield, and mean head weight of broccoli varieties in three advanced yield trials.[1]

		I			II			III			Mean
Accession	Variety	Maturity (DAT)	Yield (t/ha)	Head wt. (g)	Maturity (DAT)	Yield (t/ha)	Head wt. (g)	Maturity (DAT)	Yield (t/ha)	Head wt. (g)	yield (t/ha)
BR070	SF1201	60 d[2]	4.0 f	292 bc	54 c	7.1 cd	280 d	57 cd	13.0 bc	487 bc	8.0
BR071	SF1202	59 cd	9.3 bc	363 ab	54 c	10.8 a	407 a	57 cd	14.0 ab	524 ab	11.4
BR072	CNB-45	55 ab	8.8 cd	336 abc	52 bc	10.1 ab	379 ab	53 ab	12.2 c	458 c	10.4
BR073	CNB-50	54 a	10.4 ab	395 a	51 b	8.1 bc	320 cd	54 bc	12.2 c	456 c	10.2
BR076	DG473	56 abc	9.1 bc	342 abc	51 b	8.3 bc	312 cd	57 cd	12.7 bc	474 bc	10.0
BR094	KY0554	52 a	8.4 cd	314 bc	52 bc	5.4 de	272 d	53 ab	11.7 c	439 c	8.5
BR116	RN1204	58 bcd	4.3 ef	268 c	48 a	9.2 abc	343 bc	51 a	13.1 bc	490 bc	8.9
BR117	SF1203	52 a	11.0 a	412 a	51 b	10.6 a	398 ab	56 bc	15.0 a	562 a	12.2
BR120	RN1205	64 e	7.5 d	389 a	57 d	4.0 e	157 e	59 d	13.0 bc	485 bc	8.2
BR005	Satomidori (ck)	56 abc	5.7 e	297 bc	51 b	7.7 c	289 cd	56 bc	12.9 bc	483 bc	8.8

[1] Date transplanted: I = 26 May 2004, II = 15 July 2004, III = 7 September 2004 at AVRDC.
[2] Mean separation within columns by Duncan's Multiple Range Test at $P < 0.05$.

Table 4. Horticultural characteristics of broccoli accessions in three advanced yield trials.[1]

		Stem	Head				Chlorophyll[2]		
Accession	Variety	width (cm)	thickness (cm)	length (cm)	width (cm)	Bead size	head score	leaf score	Side shoot production
BR070	SF1201	3.8	4.6	21.5	18.3	Fine-moderate	354	339	Few
BR071	SF1202	3.6	5.0	20.1	18.9	Moderate	317	308	Few-moderate
BR072	CNB-45	3.7	4.7	22.3	18.0	Large	330	349	Moderate
BR073	CNB-50	3.4	4.7	20.9	18.5	Fine	317	325	Moderate-many
BR076	DG473	3.5	4.7	20.0	17.9	Moderate	341	334	Moderate-many
BR094	KY0554	3.7	4.5	20.6	18.7	Fine-moderate	352	322	Moderate
BR116	RN1204	3.0	5.8	23.0	20.0	Fine	313	307	Moderate-many
BR117	SF1203	3.4	4.6	20.5	19.0	Fine-moderate	344	313	Few
BR120	RN1205	4.0	5.0	21.5	18.8	Moderate	299	330	Few
BR005	Satomidori (ck)	3.5	4.7	21.2	18.4	Fine-moderate	371	324	Few

[1] Data from three trials transplanted 26 May, 15 July, and 7 September 2004 at AVRDC.
[2] Index mean of chlorophyll content for five sampled plants measured by Field Scout CM-1000 chlorophyll meter (Spectrum Technologies, Springfield, Illinois, USA).

SF1203 produced the highest yields again with 15.0 t/ha within 56 DAT, and was followed by BR071 SF1202 with 14.0 t/ha within 57 DAT.

Over the three advanced yield trials, only one variety, BR117 SF1203, produced yields above 10 t/ha in all trials. This variety was most tolerant to hot-wet conditions, followed by BR071 SF1202.

Testing of the four lowest yielding varieties will be halted and the four promising varieties identified from the preliminary yield trial (BR186 DG134, BR195 SF1208, BR212 RN0413, and BR228 RN0425) will be added to our trials in 2005.

Contact: Peter Hanson

Legumes

Development of high methionine mungbean

Methionine and cystine, sulfur containing amino acids (SAA) are often limiting in legume protein. A supplementation study conducted in 1976 at AVRDC showed that by supplementing mungbean with methionine (0.2%), its protein efficiency ratio (PER) could be improved from 0.09 to 2.10. Similarly the biological value of mungbean could be maximized by supplementing mungbean with 0.1% methionine. Therefore, to have a better balanced protein, the SAA in mungbean should be increased by 83%.

Interspecific crosses between mungbean and blackgram in 1976 and 1980 at AVRDC showed that it is possible to improve the methionine content of mungbean through traditional breeding; however, breeding for methionine was discontinued in 1980 since most of the interspecific inbred lines reverted back to mungbean types.

In 1998, AVRDC introduced inbred lines from a cross between mungbean and blackgram from Dr. Brar of Punjab Agricultural University in India and Dr. Bruce Imrie of CSIRO in Australia. The Indian lines were in F_8 generation and the Australian lines were in F_6 generation. A number of promising plants were selected from the population at AVRDC (Table 1).

The methionine contents of AVRDC mungbean accessions (V 2709 and V 2802), a popular mungbean breeding line (VC 1973A), a blackgram accession (VM 2164) along with selected mungbean × blackgram F_8 and F_6 lines from India and Australia, respectively, are presented in Table 2. The methionine content of the Australian interspecific lines was approximately 5 times more than the popular mungbean line VC1973A, whereas the Indian interspecific line was similar to that of VC1973A.

G × B No. 2 and G × B No. 5 were used as parents with the objective of making a bridging cross with both mungbean and blackgram. Two mungbean lines were used as parents, VC 6372(45-8-1) and NM 92. Both mungbean selections were resistant/tolerant to mungbean yellow mosaic virus (MYMV). VM 2164 was used for blackgram.

F_1 and F_2 seeds from the crosses were harvested in 2003. The methionine content of the F_2 population from both crosses were determined using the microbiological assay method. F_2 plants were grown in the greenhouse during autumn of 2003. Selections for high methionine from F_2 derived F_3 progenies were made.

Results showed that F_1 plants from all crosses were normal and they produced normal seeds. The Australian lines (hereinafter referred to as MB) crossed with blackgram produced many normal F_2 seeds; however, when crossed with mungbean, F_2 plants had indeterminate flowering, few pods, and abnormal seeds.

Table 2. Methionine content of mungbean, blackgram and their hybrids.

Sample	Methionine (mg/100 g)	Remarks
VM 2164	105.2 ± 4.1	Blackgram
VC 1973A	8.1 ± 1.0	Mungbean
V 2709	27.0 ± 2.2	Mungbean
V 2802	13.5 ± 1.2	Mungbean
K 851/ UG 297	8.8 ± 0.8	India
G × B No. 2	53.1 ± 3.9	Australia introduced line
G × B No. 5	50.9 ± 1.3	Australia introduced line

Date of evaluation: 15 March 2000.

Table 1. Introduced lines from Australia and India in spring of 1998.

Pedigree	AVRDC no.	Generation	Selections	No. of seeds	Origin
K 851/ UG 218	G × B No. 1	F_8		583	India
C.V. Emerald/ CPI 30067	G × B No. 2	F_6	6-24	134	Australia
C.V. Emerald/ CPI 30067	G × B No. 5	F_6	2-7	109	Australia

The F_2 progenies from the cross between MB and blackgram and its reciprocal, analyzed for methionine content, showed transgressive segregation for higher methionine content (Figs. 1A,B), but this tendency was not apparent with the cross between mungbean and MB (Figs. 2A,B). From both crosses, a number of F_3 plants were selected based on high methionine contents (Table 3). During summer of 2004, selected F_3 progenies were crossed with NM 92 and NM 94 and F_1 seeds were obtained for further screening.

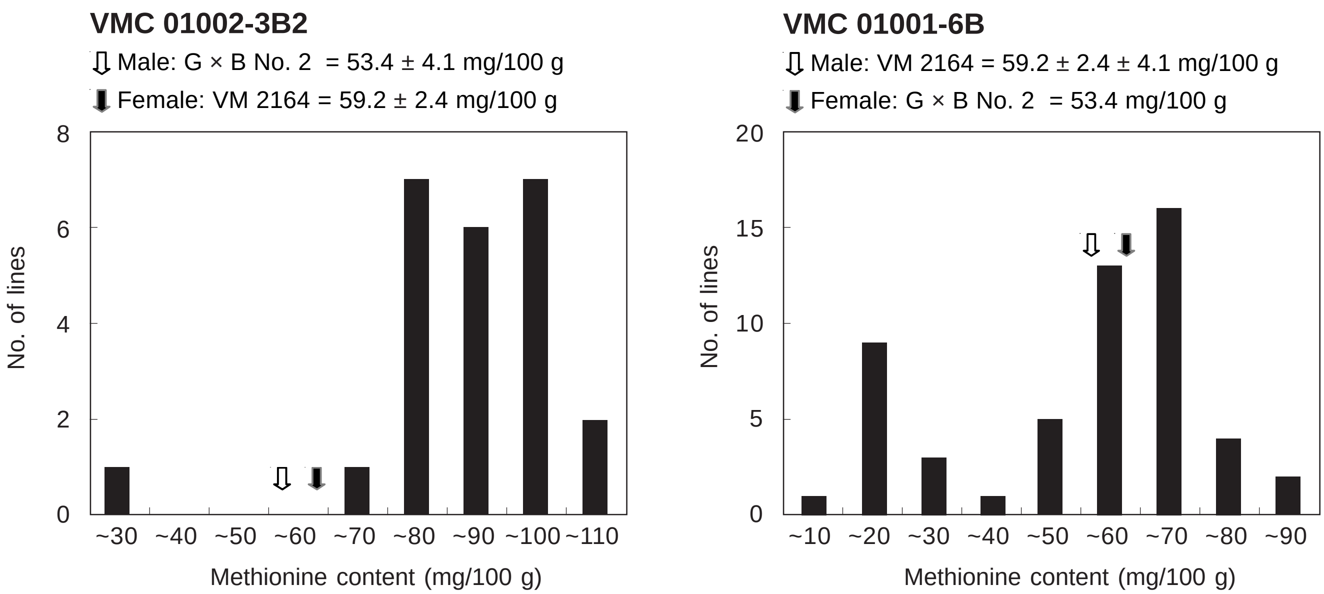


Fig. 1 A. Fig. 1 B.

Figs. 1A, B. Frequency distribution of F_2 progeny from a mungbean-blackgram interspecific male crossed with a blackgram female.

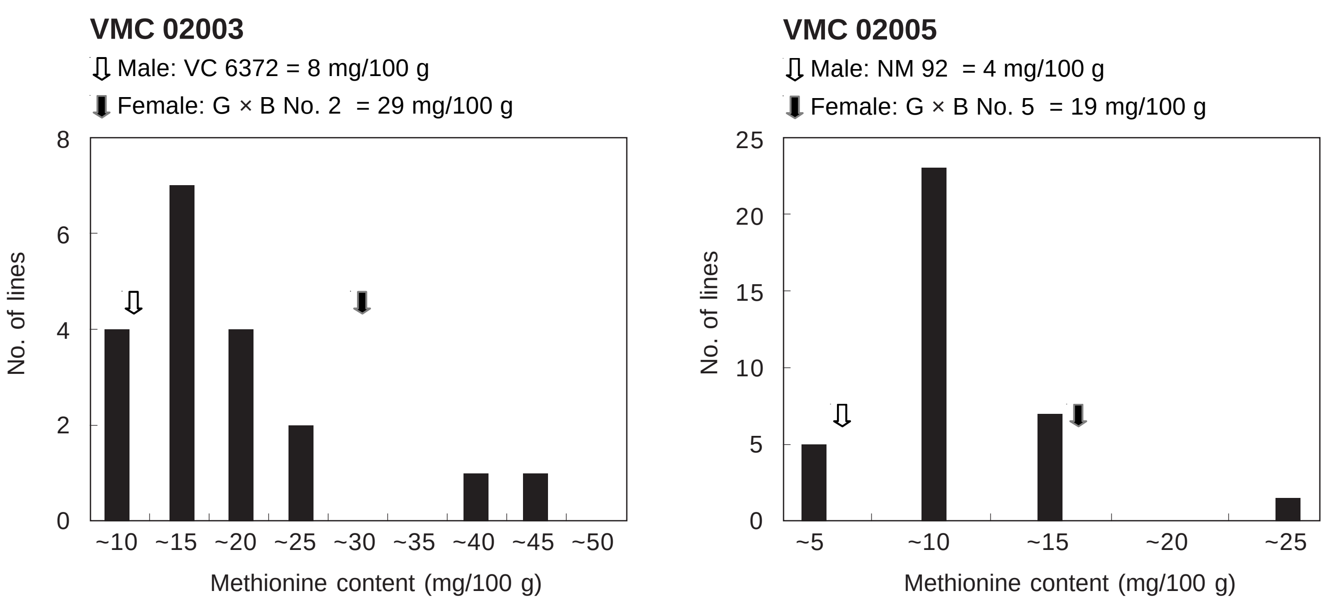


Fig. 2 A. Fig. 2 B.

Figs. 2A, B. Frequency distribution of F_2 progeny from a mungbean male crossed with a mungbean-blackgram interspecific female.

Table 3. F_3 selections with high methionine content used as parents to cross with NM 92 and NM 94 in summer 2004.

Line (F_3) male	Pedigree	No. of F_3 seeds	Methionine content (mg/100 g)	Seed coat color
VMC01001-2B38	G×B No.2/VM 2164	75	101	BL
VMC01001-2B76		105	105	DBR
VMC01001-6B08		136	103	BR
VMC01002-3B04	VM2164/G×B No.2	75	108	BL
VMC01002-3B08		119	107	BR
VMC02003-0215	VC6372/G×B No.2	1	39	BR
VMC02005-0105	NM92/G×B No.5	1 [2]	59	BR
VMC02005-0123		1	20	BL
VMC02005-0135		3	34	BRG
VMC02005-0219		25	20	DBR
VMC02005-0210		1	25	BRG
VMC02005-0216		5	17	DBR
VMC02005-0217		22	22	BL
VMC02005-0228		41	13	BRG

[1]BL = Black; DBR = Dark brown; BR = Brown; BRG = Bright green.
[2]Poor quality seed.

Incorporation of mungbean in cereal fallows in the Indo-Gangetic Plains of South Asia: project summary

Under the umbrella of the South Asia Vegetable Research Network (SAVERNET), the mungbean subnetwork initiated a project, “Improving income and nutrition by incorporating mungbean in cereal fallows in the Indo-Gangetic Plains of South Asia, specifically Bangladesh, India, and Nepal”. The project was supported by the Department for International Development (DFID) of the United Kingdom from 2002–2004.

The goals of the project were to: 1) improve rural household income and employment opportunities; 2) increase nutritional security and diversified healthy diets through increased availability of pulses (mungbean) for the poor in the Indo-Gangetic Plains; and 3) enhance soil fertility in the Indo-Gangetic Plains of South Asia for 500,000 farmers.

A planning workshop was held from 23–25 May 2002 at the International Crops Research Institute for the Semi-arid Tropics (ICRISAT) campus in Patancheru, Hyderabad, India. A total of 21 participants from Bangladesh, India, ICRISAT, and AVRDC deliberated and agreed on the master work plan. The workshop also identified training needs and training participants. A summary of the completed research is presented below:

Production and preliminary impact surveys in Bangladesh and India were completed. The farmers in Barisal, Jessore, and Dinajpur, three major mungbean growing areas of Bangladesh, readily adopted the improved mungbeans and production increased rapidly. The project was successful in improving income and enhancing consumption of mungbean among poor farmers. In the future, labor saving devices need to be introduced to reduce the production costs and consumer prices. Consumers should be educated on the value of mungbean in human nutrition.

In India, the introduction of improved summer mungbean led to higher incomes for farmers. In locations of water scarcity, farmers were replacing rice with mungbean in both summer and kharif seasons. To further increase area and production, the Government may need to ensure markets and profitable prices to farmers.

Bangladesh released three improved varieties from AVRDC’s mungbean lines: BARIMUNG-5, BUMug-1 and BUMug-2. Another new variety, IPK1038-94, will soon be released. In India, the Indian Agricultural Research Institute (IARI) released a selection from AVRDC’s NM 92 as Pusa Vishal (also called as Pusa Bold); while Punjab Agricultural University (PAU) released a selection from AVRDC’s NM 94 as SML 668; and GB Pant University for Agriculture and Technology released Pant Mung 5, a selection from AVRDC’s VC 6318(46-40-4). Bhutan released AVRDC’s VC 2778A and BARIMUNG-2. In Nepal, VC6372 (45-8-1) and NM94 are ready for release.

Due to drought, farmers in Punjab were forced to plow in their transplanted rice seedlings. For the affected 2,000 farmers the government provided improved mungbean SML 668 for the kharif season. The crop grew well and the farmers obtained a yield of about 1.0 to 1.5 t/ha. As a result SML 668 has been approved and released for kharif season planting as well. SML668 is the only variety that is recommended for both summer and rainy seasons in Punjab.

Mungbean leaf and seed samples collected from India in 2002 and 2003 were tested for mungbean yellow mosaic virus (MYMV). Most leaf samples showed a positive reaction for MYMV. The seed coat of small seeds with yellow symptoms was positive for MYMV—this is the first record of MYMV on the mungbean seed coat; however, the cotyledons and the young seedlings from such samples did not have MYMV. MYMV ratings of the newly released varieties SML 668 and Pusa Vishal were low, indicating high levels of resistance.

DNA fingerprinting of 21 and 32 varieties were completed in 2002 and 2003, respectively. The varieties appeared to have a narrow genetic base. The 21 varieties evaluated in 2002 were clustered into four groups while the 32 varieties evaluated in 2003 formed two major clusters. A reasonable amount of variability among the varieties indicated potential for additional yield improvement.

On-farm participatory trials were conducted by CIMMYT (International Maize and Wheat Improvement Center), LIBIRD (Local Initiatives for Biodiversity, Research and Development), and FORWARD (Forum for Rural Welfare & Agricultural Reform for Development) in 21 districts of Nepal during 2003. Farmers' perceptions and selection of promising varieties were completed. The area and production of mungbean in Nepal is expected to expand so as improve the farmers' income and nutrition as well as their soil's fertility.

A total of 40 agronomic experiments were conducted at PAU in India; at Jessore, Dinajpur, and Gajipur in Bangladesh; and at AVRDC during 2002 and 2003. Results showed:

- The February–March planting date provided the highest yield. Delayed plantings led to lower yields.
- A plant population density of 400,000 plants/ha was generally best (regardless of variety) in Bangladesh and India, but a lower density of 200,000 plants/ha produced the highest yields at AVRDC.
- A seed rate of 37.5 kg/ha was optimum for new varieties SML 668 and Pusa Vishal.
- No-tillage systems were consistently as economical as using tillage or tillage with straw mulch. The no-tillage systems saved time and resources.
- In summer plantings, three to four irrigations were required for sandy soils, whereas two to three irrigations were sufficient in clay soils. In kharif season plantings, two to three irrigations were required in sandy soils, and one irrigation was sufficient in clay soils.
- The amount of water required to produce a mungbean crop (30 to 50 cm) was only 17–20% that needed to produce a rice crop.
- Initial studies revealed that inclusion of mungbean in cereal-based (wheat-rice) cropping systems can add at least 37 kg N/ha to the soil.
- Soaking seed in water for 8 to 12 h hastened germination, improved plant stands, and increased yields in moisture stressed areas such as Dinajpur in Bangladesh. However, seed soaking had no effect in locations that were not suffering from moisture stress, such as at AVRDC and Punjab.
- The pod wall of SML 668 was thicker and therefore was less susceptible to weathering damage caused by rain.
- Hardseededness was most often observed under adverse weather and with varieties whose seed weight was less than 40 mg.

Information dissemination and training were active components to the project. A package of recommended cultural practices was developed and distributed to extension staff and farmers in Bangladesh and India. The nutrition group in PAU has developed and published a set of 24 recipes in English and Punjabi. These recipes have been widely distributed to women in both rural and urban areas. Seven scientific works were published through this project's activities.

Seven scientists from India and two from Bangladesh were each trained at AVRDC for three months. Two Bangladeshi scientists visited PAU and observed the research, extension, and mechanical harvesting of mungbean. Six scientists, including the Vice Chancellor and Director of Research from PAU, went on a project monitoring tour of Bangladesh.

Seed are now being multiplied on a large scale for widespread dissemination. In Bangladesh, seven agencies multiplied seed of six varieties for dissemination to farmers. A seed exchange program was instituted in which the farmers were given seeds of improved varieties in exchange for their seeds of a local variety. The total quantity of seeds produced was 11,538 t, which was sufficient to sow 330,000 ha in 2004.

In India, the Indian Agricultural Research Institute (IARI), PAU, a private seed company and five other agencies produced a total of 6.948 t of seeds of SML 668. These seeds were sufficient to sow 200,000 ha in 2004. Farmers from neighboring states have recently come to the Punjab to get the seeds of the variety.

International dissemination and evaluation of improved lines

Mungbean

A total of 277 sets of mungbean trials were distributed to 34 cooperators in 26 countries in 2004. Sri Lanka released AVRDC breeding line VC 6173B-20G as MI-6.

AVRDC breeding lines NM 92, NM 94 and VC 6372(45-8-1) were evaluated against the check variety Chin Dou #6 in Shan-Xi, China. The differences in yield among the lines and the check variety were nonsignificant. However, NM 92 matured in 86 days, 13 days earlier than the Chin Dou #6. All the AVRDC lines have been found to be tolerant to MYMV in South Asia; this disease is not yet a problem in China.

Grain soybean

In 2004, a total of one nursery trial set and 193 accessions/breeding lines were distributed to 11 cooperators from 7 countries. The grain soybean lines were predominantly of types resistant/tolerant to soybean rust. Soybean rust has recently caused serious losses in Brazil, Africa, and the USA.

The results from a replicated trial conducted during the late rainy season trial in Prabuddhabhat, Thailand showed that AGS 410 and AGS 413 gave significantly higher yields (2.45 t/ha) compared to the local variety KKU 35 (0.8 t/ha). AVRDC materials matured 5 days earlier (80 days) compared to the local variety. Yields of the AVRDC entries were comparable with SJ 4 (2.08 t/ha).

Indonesia released AVRDC grain soybean line GC 87072-10-1 as Panderman. Bhutan released GC 86018-427-3 and Uganda released GC 00138-29.

Vegetable soybean

In 2004, a total of 24 nursery trial sets and 617 accessions/breeding lines were distributed to 59 cooperators in 34 countries around the world.

A replicated test in Shan-Xi, China showed that four AVRDC lines (AGS 337, AGS 291, AGS 329 and AGS 363) produced graded pod yields ranging from 7.8 to 9.9 t/ha. Yields of AGS 337 and AGS 291 were highest (9.9 and 9.3 t/ha, respectively).

Glabrous vegetable soybeans

Damage caused by soybean pod borer (*Grapholitha glycinivorella*) is a major problem in vegetable soybean production. A study in 1973 showed that glabrous podded soybean varieties suffered less damage from pod borers compared to pubescent podded soybean varieties. All major commercial varieties grown today have pubescent pods.

The objective of this study is to develop vegetable soybean varieties with glabrous gene (P1) and evaluate them for resistance to different pod borers in different countries. Initial crosses between pubescent AGS 292 and a glabrous inbred line that was derived from G10137 and D62-7812 were made in 1991. Modified backcrosses were made including F_2 selections with pubescent Kaohsiung No. 2 (KS #2) in 1993, F_3 selections with pubescent Kaohsiung No. 3 (KS #3) in 1995, and F_4 selections with pubescent Kaohsiung No. 5 (KS #5) in 1999. The seeds of glabrous types were small and it took time to backcross the selected large-seeded parents to recover large seed size and glabrous trait.

A promising glabrous breeding line AGS 406, with large seed and non-vining plant type, was selected and evaluated for yield and adaptation in an advanced yield trial (AYT) in 2001. The trial was planted on 13 February, 7 August, and 16 October in spring, summer, and autumn seasons, respectively. The plot size was 5 m x 2 m and the harvest size is 5 m x 1 m. Trials used a randomized complete block design (RCBD) with four replications.

Four additional glabrous, large-seeded selections were evaluated along with 35 other entries in two independent intermediate yield trials (IYTs) sown in spring (3 February), summer (15 July) and autumn (7 September) seasons of 2004. The plot size for these trials was 2 m x 2 m and the harvest plot size was 2 m x 1 m. These trials both used RCBD with two replications.

The results of the AYT are shown in Table 4. AGS 406 was as good as the check variety KS #5 for yield and most other traits in spring, summer, and autumn seasons. Seeds of this line are available for international testing.

In the spring season IYT, two entries produced a graded pod yield of more than 10 t/ha (Table 5); however their sugar content was significantly lower than the check varieties and their maturity was about 10 days longer than the checks. In this particular trial,

Table 4. Performance of glabrous podded AGS 406 compared to standard lines AGS 292 and KS #5.

Lines	Graded pod yield (t/ha)	Days to maturity	100-green bean wt. (g)	No. of graded pods per 500 g	Harvest index (%) Total pods	Harvest index (%) Graded pods	Shelled bean wt. per 500 g	Sugar (%)	Pod color[2]
Spring									
AGS 406	6.60	77.0	66.2	191	45.6	26.8	261	12.3	3.72
AGS 292 (ck)	7.23	77.0	65.0	175	54.2	29.2	243	12.5	3.89
KS # 5 (ck)	5.80	78.0	70.6	170	42.4	21.0	249	11.7	3.89
Mean of all entries	6.25	82.6	68.5	165	44.5	22.7	240	11.3	4.34
LSD (0.05)	0.94		4.0	13	2.6	3.3	19	0.6	0.22
CV (%)	10.3		4.0	5.3	4.0	10.0	5.4	3.7	3.4
Summer									
AGS 406	5.80	73.0	68.2	225	42.7	25.3	280	8.2	4.08
AGS 292 (ck)	7.93	73.0	67.1	181	55.8	38.8	264	7.5	4.87
KS #5 (ck)	5.88	73.0	79.2	183	47.0	30.7	269	8.3	3.88
Mean of all entries	5.74	75.0	72.7	186	47.9	27.0	270	7.6	4.20
LSD (0.05)	0.91		3.0	8	2.4	3.0	8	0.5	0.39
CV (%)	10.9		2.9	3.1	3.5	7.5	2.0	4.6	6.3
Autumn									
AGS 406	2.70	76.0	67.9	188	45.0	17.5	255	12.1	4.70
AGS 292 (ck)	4.82	71.0	62.4	185	47.5	30.3	216	14.2	4.84
KS #5 (ck)	2.40	71.0	68.6	179	42.3	15.5	243	12.6	3.43
Mean of all entries	3.75	75.8	67.5	177	47.3	21.3	229	12.8	4.41
LSD (0.05)	1.14		5.1	17	3.3	5.0	14	0.5	0.37
CV (%)	21.0		5.2	6.5	4.8	16.1	4.3	2.8	5.7

[1] Spring, summer, and autumn trials were sown on 13 February, 7 August, and 16 October 2001, respectively, at AVRDC.
[2] Pod color rated on 1–6 scale with 1 = very dark green-yellow and 6 = pale green-yellow.

line GC99009-6-1-1-3 was found to be most promising since it produced significantly higher yields than the checks with little longer maturity but similar sugar content as KS #5. AGS 292 was superior to both this line and KS #5 for maturity and sugar content (Table 5). The yield advantage of GC99009-6-1-1-3 over the checks was lost during the summer; its maturity was significantly longer than the checks. Sugar contents were not measured. Data of the autumn season trials are being analyzed at the time of this writing.

In another IYT in Taiwan, GC99009-6-3-1-1 outyielded the checks in the spring but not the summer. Its days to maturity were later than the checks and its sucrose content was intermediate between the relatively sweet AGS 292 and the less sweet KS #5 (Table 6).

Contact: Motoki Takahashi

Table 5. Performance of glabrous entries compared with AGS 292 and KS #5.[1]

Lines	Graded pod yield (t/ha)[2]	Days to maturity	100-green bean wt. (g)	No. of graded pods per 500 g	Harvest index(%)		Shelled bean wt. per 500 g	Sugar (%)	Pod color[3]
					Total pods	Graded pods			
<u>Spring</u>									
GC99009-22-1-1-1	10.63	90.0	77.1	151	50.0	30.8	254	8.4	3.36
GC99009-2S-22-1-1	11.00	90.0	77.1	156	47.2	32.5	196	9.0	3.16
GC99009-2S-22-1-3	7.25	86.0	77.1	155	37.9	22.9	254	7.5	2.96
GC99009-6-1-1-3	9.75	85.0	72.0	163	47.8	29.5	247	11.2	3.37
AGS 292 (check)	6.38	77.0	78.9	184	50.1	24.7	286	15.1	3.71
KS #5 (check)	5.98	83.0	71.5	179	43.3	22.1	272	10.4	3.30
Mean of all entries	8.02	84.5	74.4	166	45.2	25.1	257	11.0	3.35
LSD (0.05)	1.75	0.7	8.5	14	4.3	4.6	35	1.0	0.47
CV (%)	10.8	0.4	5.7	4.3	4.7	9.1	6.8	4.5	7.0
<u>Summer</u>									
GC99009-22-1-1-1	155.0[2]	81.0	64.6	-	49.5	30.9	-	-	-
GC99009-2S-22-1-1	220.0	81.0	69.7	-	53.1	36.7	-	-	-
GC99009-2S-22-1-3	149.0	81.0	69.7	-	47.3	30.1	-	-	-
GC99009-6-1-1-3	178.0	81.0	70.3	-	46.5	32.1	-	-	-
AGS 292 (check)	176.0	67.0	56.7	-	51.5	36.4	-	-	-
KS #5 (check)	152.0	67.0	64.7	-	44.1	29.7	-	-	-
Mean of all entries	170.6	74.5	66.1	-	46.1	29.3	-	-	-
LSD (0.05)	88.3	4.9	11.7	-	7.5	9.0	-	-	-
CV (%)	25.6	3.3	8.7	-	8.1	15.3	-	-	-

[1] Spring and summer trials were sown on 3 February and 15 July 2004, respectively, at AVRDC.
[2] Graded pod weight in summer was measured in grams using five randomly selected plants from the experimental plot.
[3] Pod color rated on 1–6 scale with 1 = very dark green-yellow and 6 = pale green-yellow.

Table 6. Performance of glabrous entries compared with AGS 292 and KS #5.[1]

Lines	Graded pod yield (t/ha)[2]	Days to maturity	100-green bean wt. (g)	No. of graded pods per 500 g	Harvest index (%)		Shelled bean wt. per 500 g	Sugar (%)	Pod color[3]
					Total pods	Graded pods			
<u>Spring</u>									
GC99009-2S-9-1-3	6.18	83.0	64.5	182	47.2	25.0	260	10.0	2.74
GC99009-6-3-1-1	9.38	86.0	86.6	131	43.4	29.3	249	11.9	2.96
GC99009-9-1-1-1	8.30	86.0	72.3	164	44.9	27.9	253	8.8	3.25
AGS 292 (check)	6.13	77.0	81.3	179	51.8	27.8	262	14.8	3.28
KS #5 (check)	3.90	83.0	77.6	164	41.5	21.1	260	10.2	3.10
Mean of all entries	7.80	84.6	78.4	159	48.4	27.2	257	10.7	3.26
LSD (0.05)	2.49		7.1	13	4.5	5.7	20	1.1	0.41
CV (%)	15.7		4.5	3.9	4.6	10.4	3.8	5.0	6.2
<u>Summer</u>									
GC99009-2S-9-1-3	211.0[2]	67.0	63.9	-	50.0	35.5	-	-	-
GC99009-6-3-1-1	186.0	81.0	76.7	-	49.4	30.6	-	-	-
GC99009-9-1-1-1	157.0	81.0	75.5	-	59.0	31.3	-	-	-
AGS 292 (check)	188.0	67.0	57.7	-	51.1	37.2	-	-	-
KS #5 (check)	119.0	67.0	67.1	-	39.5	25.4	-	-	-
Mean of all entries	167.1	73.5	70.1	-	44.9	29.3	-	-	-
LSD (0.05)	71.6	8.3	16.3	-	7.6	7.2	-	-	-
CV (%)	21.1	5.6	11.4	-	8.4	12.1	-	-	-

[1] Spring and summer trials were sown on 3 February and 15 July 2004, respectively, at AVRDC.
[2] Graded pod weight was measured in grams using five randomly selected plants from the experimental plot.
[3] Pod color rated on 1–6 scale with 1 = very dark green-yellow and 6 = pale green-yellow.

Pepper

Fourteenth International Chili Pepper Nursery (ICPN 14)

AVRDC's pepper breeding program seeks to combine superior traits into broadly useful backgrounds of hot peppers for use in production regions around the world. Adaptation to warm, humid climates, and resistance to several important diseases are our main breeding goals, but we continue to select for acceptable fruit shapes, sizes, pungencies and flavors, as well as high yield potential. Following rigorous evaluation and selection in segregating populations, advanced generation selections are first evaluated in replicated preliminary yield trials, and the best 5–7 lines are included in our International Chilli Pepper Nursery (ICPN). This set is distributed to interested cooperators around the world, who are encouraged to evaluate them in replicated variety trials under their local growing conditions. In 2004, 77 sets of seed of the Fourteenth ICPN trial (ICPN 14) were distributed to collaborators in 35 countries.

ICPN14 includes 10 inbred lines and 2 hybrid varieties (Table 1). ICPN14-1, ICPN14-4, and ICPN14-7 are long-term checks representing short (5 ± 2 cm), medium (10 ± 2 cm) and long (15 ± 2 cm) fruit lengths, respectively. ICPN14-11 is an experimental hybrid combination developed at AVRDC using two inbreds from ICPN sets, and ICPN14-12 is a commercial hybrid variety popular in Taiwan.

The yield trials for ICPN14 were conducted in the summer and autumn seasons of 2004, using RCBD with three replications and 24 plants in each entry plot. The summer trial was sown on 21 June, and harvested at approximately two-week intervals, on 14 and 25 October and 8 and 18 November. Average temperature during the trial ranged from 24–32°C. The autumn trial was sown on 7 September, and harvested on 18 and 27 January, 14 February and 2 March 2005; average growing temperature ranged from 20–28°C. Performances in the two seasons were compared statistically for fruit length, fruit width, fruit weight, plant height, and total yield (Table 1).

There were significant differences in fruit length, width, and weight between the growing seasons. Across all entries, average fruit size was larger in the autumn growing season compared to the summer, but average yields were not significantly different between seasons, indicating that fruit set in summer was greater than in the autumn. Significant entry × season interactions in most parameters indicated that entries responded differently to the seasonal conditions.

Disease resistance and various fruit traits are also important traits in variety selection. Resistance to cucumber mosaic virus (CMV), chili veinal mottle virus (ChiVMV), potato virus Y (PVY), tomato mosaic virus (ToMV), bacterial wilt (BW) and *Phytophthora* blight (PC3) were assayed during 2004 on seedlings, under controlled screenhouse conditions. Dry matter and total capsaicin contents of fruit harvested 25 October were analyzed by AVRDC's Nutrition Unit via high performance liquid chromatography (HPLC). Results are presented in Table 2.

Overall, two check varieties ICPN14-7 [9955-15], and ICPN14-9 [9950-5197] performed best, displaying high yields that were stable under both high and low temperatures, with medium pungency, and at least partial resistance to several diseases. ICPN14-9 in particular, displayed high levels of resistance to three viruses (CMV, ChiVMV, and PVY) as well as bacterial wilt. Yields of these lines were close to those produced by the hybrid check varieties, and reports from our international cooperators indicate that these two inbred lines are widely adaptable. Seed of these inbreds is available from the AVRDC Pepper Unit, upon request.

The hybrid check ICPN14-11 [CCA5217 AVRDC hybrid] performed substantially better than the commercial hybrid check, indicating that AVRDC's inbred pepper lines display good combining ability and may serve well as parents in hybrid variety development programs.

Table 1. Seasonal comparison for ICPN14 entries on fruit size and yield characteristics.[1]

		Fruit length		Fruit width		Fruit weight		Plant height		Fruit yield	
		Summer	Autumn	Summer	Autumn	Summer	Autumn	Summer	Autumn	Summer	Autumn
Entry	Pedigree (cm)[2] (cm)	(cm)	(cm)	(g)	(g)	(cm)	(cm)	(t/ha)	(t/ha)		
ICPN14-1	PBC 142 (ck)	7.3	8.1	1.0	1.2	2.6	4.0	61.3	65.6	15.4	19.3
ICPN14-2	0207-7510	11.2	12.6	1.0	1.2	5.9	9.0	46.4	47.3	21.8	13.3
ICPN14-3	0207-7521	12.6	12.9	1.2	1.5	7.7	13.1	59.9	58.5	21.8	18.9
ICPN14-4	9852-173 (ck)	9.6	10.7	1.4	1.8	9.8	12.5	58.5	63.9	27.4	17.5
ICPN14-5	0207-7532	12.7	14.6	1.6	1.8	11.1	18.1	62.9	67.7	26.5	18.5
ICPN14-6	0237-7502	11.4	12.0	1.3	1.6	7.1	11.8	54.6	57.5	18.6	18.7
ICPN14-7	9955-15 (ck)	16.4	18.5	2.0	2.5	19.2	37.0	60.8	49.6	31.9	30.4
ICPN14-8	0237-7508	10.0	10.2	1.2	1.3	5.9	8.1	53.1	53.1	29.0	18.7
ICPN14-9	9950-5197	12.0	13.3	1.6	1.8	11.1	14.1	67.5	63.9	30.8	31.5
ICPN14-10	0137-7538	10.0	10.8	1.7	2.1	12.9	17.6	65.4	68.8	28.5	25.4
ICPN14-11	CCA5217	13.1	13.2	1.5	1.7	10.7	14.4	77.9	70.8	34.2	34.9
ICPN14-12	F1 Hy Hot 26 (hybrid ck)	13.9	16.1	1.4	1.5	11.6	18.0	63.8	70.8	22.1	29.9
Mean		11.7 b	12.8 a	1.4 b	1.8 a	9.5 b	14.8 a	61 a	61.5 a	25.7 a	23.1 a
Season-LSD(0.05)[3]		1.0		0.2		1.6					
Entry-LSD(0.05)[4]		0.9		0.2		1.6		6.3		5.6	
Entry		**		**		**		**		**	
Season		*		**		**		NS		NS	
Entry × Season		*		NS		**		**		**	

[1] Summer and autumn trials were sown on 21 June and 7 September 2004, respectively, at AVRDC.

[2] Different letters following values denote statistically different performance of an entry between trials.

[3] Season-LSD(0.05): least significant difference for comparison of each entry value in summer vs. autumn evaluations.

[4] Entry-LSD(0.05): least significant difference for comparison across entry values within each trial.

NS, *, ** Nonsignificant or significant at $P < 0.05$ or 0.01, respectively, for comparisons across all entries in two trials.

Table 2. Disease resistance assay and chemical compound analysis for entries of ICPN14.

ICPN index	Entry	CMV (% res.)	ChiVMV (% res.)	PVY (% res.)	ToMV (% res.)	BW (% res.)	PC3 (% res.)	Dry matter (g/100 g)	Total capsaicin (mg/100 g)
ICPN14-1	PBC 142 (ck)	38	100	0	0	42	0	23.3	107.3
ICPN14-2	0207-7510	42	96	100	0	100	0	15.7	6.0
ICPN14-3	0207-7521	63	0	100	0	14	48	17.0	23.8
ICPN14-4	9852-173	0	0	100	0	59	0	13.6	4.1
ICPN14-5	0207-7532	63	0	68	0	67	17	13.0	9.3
ICPN14-6	0237-7502	50	0	100	0	100	71	15.8	37.5
ICPN14-7	9955-15 (ck)	33	8	74	0	59	0	12.7	15.6
ICPN14-8	0237-7508	83	0	96	0	94	67	15.3	30.2
ICPN14-9	9950-5197 (ck)	100	92	96	0	91	0	12.3	11.2
ICPN14-10	0137-7538	100	8	100	0	100	0	13.6	12.0
ICPN14-11	CCA5217	92	0	100	0	100	0	NT	NT
ICPN14-12	F_1 Hy Hot 26 (hybrid ck)	75	0	NT	NT	100	0	NT	NT

CMV = cucumber mosaic virus; ChiVMV = chili veinal mottle virus; PVY = potato virus Y; ToMV = tomato mosaic virus; BW = bacterial wilt (*Ralstonia solanacearum*); PC3 = *Phytophthora capsici*, severe strain. Total capsaicin measured in mg/100 g fresh weight via high performance liquid chromatography.
NT = not tested.

Breeding for anthracnose-resistant lines with desirable horticultural traits

Pepper is very important in Korea and Southeast Asia. The yield of red pepper, however, is reduced by infection with anthracnose (*Collectotrichum gloosporioides, C. capsici,* and *C. acutatum*), late blight (*Phytophthora capsici*), viruses, and other diseases.

Although the breeding lines PBC 81(*Capsicum baccatum*), PBC 932 (*C. chinense*), and KAR (*C. baccatum*) have been used as parental materials for breeding varieties resistant to anthracnose, it has proven difficult to transfer the resistance genes to *C. annuum* due to cross incompatibility. New breeding materials with high cross–compatibility and good horticultural traits are needed. In 2003 new sources of resistance to anthracnose in *Capsicum annuum* were identified in regeneration plots of AVRDC's GRSU (Table 3). These new accessions were advanced one generation after individual plant selection for resistance via artificial inoculation and evaluation under controlled conditions. Some of these selected lines were then crossed with anthracnose-susceptible inbred lines with desirable horticultural traits in order to combine resistance to anthracnose with traits such as large fruit size, high pigment concentration, and high yield potential. Parental lines and F_1 hybrids were screened for resistance to anthracnose. At the same time, these selected parental lines were subjected to a second cycle of evaluation and reselection for anthracnose resistance.

Table 3. Passport data of new *C. annuum* sources of resistance to pepper anthracnose identified from the germplasm being maintained at AVRDC.

Accession	Donor	Pedigree	Origin
TC06903 (R95)	PBC1430	Apaseo Pasilla	Mexico
TC06912 (R97)	PBC1439	Ancho Mulato	USA
TC06941 (R102)	PBC1478	Pasilla	Australia

Individual plants from accession TC06903 (R95-1, R95-11, and R95-15), accession TC06912 (R97-4, R97-15, and R97-16), and accession TC06941 (R102-1 and R102-4) were chosen for further study and intercrossing with horticulturally desirable lines. For evaluation of resistance to anthracnose, 30 plants of each line were produced and transplanted under net tunnels in the field. Five full-sized immature green fruits representing each plant were chosen, placed in the incubation chamber in a completely randomized arrangement, and inoculated. A suspension of inoculum of the *Colletotricum acutatum* isolate Cg153 at a concentration of 10^7 conidia/ml was applied individually to each whole fruit, using high-pressure (2 kg/cm^2) spray. Inoculated fruits were kept at 25 ± 2ºC and about 100% relative humidity in the inoculation room; the room was generally maintained in darkness except for occasional visits. Symptom severity was evaluated by index from 1 (highly resistant) to 9 (highly susceptible) nine days after inoculation.

In making F_1 hybrids, eight lines carrying resistance to anthracnose were utilized, including R95-1, R95-11, R97-4, R95-15, and R102-1 described above; which are still segregating lines. Also used were AS65, an F_3 selection from the cross Long Fruit (*C. annuum*) × KAR (*C. baccatum*), and 0038-9155-15-1, which is a BC_3F_5 selection from the AVRDC cross CCA5239 (IR [*C. annuum*] × PBC932 [*C. chinense*]). As parents with superior horticultural traits, 10 inbred *C. annuum* lines were used, including PBC 385, Susan's Joy, G5 (a California Paprika type), and several advanced lines from the AVRDC chili pepper breeding program. Approximately 100 F_1 combinations were made using these inbred lines as parents. For the evaluation of resistance to anthracnose, 10 plants of each hybrid were transplanted into field beds which were covered with gray plastic mulch, and the plants were covered with 24-mesh netting. Five fruits from each plant per entry were inoculated as described above. Fruit samples were arranged in the incubation room in a completely randomized design (CRD) with five full-sized immature green fruits representing each plant.

Reselection of new sources of anthracnose resistance

Even though individual plant selections were extracted from the three new sources of resistance, most of them displayed substantial variation in reaction upon evaluating progeny plants for reaction to *C. acutatum*. Average symptom severity within the heterogeneous populations was greater than that of the genetically uniform, resistant check KAR. Symptom severity of the most resistant plants within each accession family was similar to the resistant check line KAR and the interspecific backcross selection 0038-9155-5-1 (Table 4). Some selections, such as R102-1 and R102-

Table 4. Frequency distribution of disease reaction of new lines segregating for resistance to anthracnose.

Entry	Species		Pedigree/ inbred line	Inoculated plants (no.)	Resistant[1]	Intermediate	Susceptible	Resist. plants (%)	Severity means of population[2]
					No. of plants, (mean score)				
TC06903	*C. annuum*	PBC 1430 'Apaseo Pasilla'	R95-1	18	8 (2.4)	9 (4.0)	1 (6.0)	44.4	3.0 b
TC06903	*C. annuum*		R95-11	16	12 (2.3)	3 (3.9)	1 (7.0)	75.0	2.9 b
TC06903	*C. annuum*		R95-15	16	14 (1.8)	2 (3.7)	0 (0.0)	87.5	2.1 c
TC06912	*C. annuum*	PBC 1439 'Ancho Mulato'	R97-4	18	6 (2.4)	11 (4.6)	1 (7.0)	33.3	4.0 b
TC06912	*C. annuum*		R97-15	17	12 (2.4)	4 (3.8)	1 (8.2)	70.6	3.1 b
TC06912	*C. annuum*		R97-16	19	11 (2.2)	8 (3.9)	0 (0.0)	57.9	2.9 b
TC06941	*C. annuum*	PBC1478 'Pasilla'	R102-1	20	20 (1.6)	0 (0.0)	0 (0.0)	100.0	1.6 d
TC06941	*C. annuum*		R102-4	11	20 (1.3)	0 (0.0)	0 (0.0)	100.0	1.3 e
KAR (res.ck)	*C. baccatum*			5	5 (1.0)	0 (0.0)	0 (0.0)	100.0	1.0 e
0038-9155-5-1	*C. annuum* × *C. chinense* BC_3F_5			5	5 (1.0)	0 (0.0)	0 (0.0)	0.0	1.0 e
Long Fruit (susc. ck)	*C. annuum*			5	0 (0.0)	0 (0.0)	5 (8.8)	0.0	8.8 a

[1] Plants were rated as resistant (1 – <3), intermediate (3 – <6), and susceptible (6 – 9).
[2] Evaluated nine days after inoculation.
Mean separation by Waller-Duncan's multiple range test at $P < 0.05$.

4 (Pasilla, TC06941-1, and -4), were uniformly highly resistant (average severity score across 20 plants was 1.6 and 1.3). Most of the initial selections still expressed substantial plant-to-plant variability. All initial selections produced at least a few progeny plants with average severity scores less than 3.0, indicating that continued reselection should be produced.

Evaluation of the progenies of selected plants from the new resistant accessions (*C. annuum*) displayed substantial continued variability in reaction to laboratory inoculation with anthracnose. When inoculated by high pressure spray method, the expression of disease severity was very uniform between fruits within the same accession. Eleven plants with superior horticultural traits and strong resistance reaction were selected for further genetic stabilization following the artificial inoculation in the inoculation chamber (Table 5).

Evaluation of F_1 hybrids

Most hybrids using parents from the new sources of resistance proved to be somewhat variable, indicating that the resistant parent plants were still segregating for disease resistance. Hybrid FN 361, which combined the resistant parent 0038-9155-5-1 (*C. annuum* × *C. chinense* BC_3F_5) with the moderately resistant PBC385, showed a strongly dominant reaction for resistance, while crosses between this resistant parent and susceptible parents (e.g., FN399 and FN410) produced a generally intermediate reaction in the F_1 generation. On the other hand, hybrid FN406, a cross between 0038-9155-5-1 and the new resistant source R102-1, produced a lower average resistance than FN361, which involved the moderately resistant parent line PBC385. And so it was considered that disease reaction differs according to combination, and some factors conditioning resistance in various sources may differ from each other (Table 5). Most of the hybrids derived from the new resistant material such as R95, R97, and R102 (*C. annuum*) showed high combining ability in horticultural traits such as fruit shape (Table 6 and Figs. 1–3).

Although the new resistant materials R95, R97, and R102 carry the chlorophyll retainer gene (*cl*), hybrids displayed the normal early development of red and bright red mature color, confirming the recessive nature of that gene.

Table 5. Reaction of lines after inoculation with anthracnose.

Entry	Cross no.	Pedigree	Generation	Inoculated plants (no.)	Resist.[1] plants (no.)	Interm. plants (no.)	Susc. plants (no.)	Resist. plants (%)	Mean severity of population
FN 301	A1	KAR (res. ck)	P	5	5			100	1.0 m
FN 302	A2	Long Fruit (susc. ck)	P	5			5	0	8.8 a
FN 303	A8-1	PBC385	P	5	5			100	2.5 h-l
FN 304	A9-2	ICPN12#4(Kulim/HDA295)	P	5		5		0	4.0 def
FN 305	A10-1	ICPN12#6(Saegochu/PBC385*5)	P	5		5		0	4.0 de
FN 306	A11-2	ICPN12#7(0038-9955-15) 'Susan's Joy'	P	5			5	0	8.6 a
FN 307	A12-2	Phichit 1	P	5			5	0	7.9 a
FN 308	A14-1	Cabe-Besar Blitar B	P	5		5		0	4.0 de
FN 309	A16-2	G5 (California Paprika type)	P	5			5	0	7.6 ab
FN 310	A17-2	0038-9155-15-1(*C.ann.XC.chin.*)BC_3F_5	P	5	5			100	1.0 m
FN 311	A94-1	TC06903-1	P	5		5		0	4.5 bc
FN 312	AS65	(KARxLF)F3	P	5	5			100	1.4 m
FN 314	R95-1	TC06903 'Apaseo Pasilla'	P	18	8	9	1	44	3.0 lm
FN 315	R95-11	TC06903 'Apaseo Pasilla'	P	16	12	3	1	75	2.9 klm
FN 317	R97-4	TC06912 'Ancho Mulato'	P	18	6	11	1	33	4.0 i-l
FN 318	R97-15	TC06912 'Ancho Mulato'	P	17	12	4	1	71	3.1 jkl
FN 320	R102-1	TC06941 'Pasilla'	P	20	20			100	1.6 m
FN 361	A8-1 × A17-1	PBC385 X 0038-9155-15-1	F_1	10	10			100	1.3 m
FN 372	A10-1 × R102-1	ICPN12#6X R102	F_1	9	4	4	1	44	3.8 e-i
FN 374	A10-2 × R95-1	ICPN12#6X R95	F_1	10	1	9		10	3.9 efg
FN 377	A11-1 × R95-1	ICPN12#7X R95	F_1	10		5	5	0	5.7 cd
FN 388	A13-2 × R95-11	Cabe-Besar BlitarX Apaseo Pasilla	F_1	11	6	5		55	2.5 j-m
FN 389	A14-1 × R95-1	Cabe-Besar Blitar BX Apaseo Pasilla	F_1	10	6	4		60	2.5 jkl
FN 399	A16-2 × A17-1	G5 X 0038-9155-5-1	F_1	8	2	6		25	3.7 efg
FN 404	A17-1 × R95-1	0038-9155-5-1X R95	F_1	10	7	3		70	2.8 g-l
FN 406	A17-2 × R102-1	0038-9155-5-1X R102	F_1	9	7	2		78	2.8 h-l
FN 410	A94-1 × A17-1	R94(TC06903) X 0038-9155-5-1	F_1	9	5	4		56	3.1 g-k
FN 412	A94-1 × R95-1	R94(TC06903) X R95	F_1	8	1	7		13	3.7 e-h
FN 413	A94-1 × R102-1	R94(TC06903) X R102	F_1	9	4	5		44	3.2 f-j
FN 420	A97-4 × A7-1	R97(TC06912) X VC228-5-1-2-2-1	F_1	10		6	4	0	5.4 cd
FN 424	A97-15 × A7-1	R97(TC06912) X VC228-5-1-2-2-1	F_1	10	2	5	3	20	4.7 de

[1] Plants were rated as resistant (1 – <3), intermediate (3 – <6), or susceptible(6 – 9) nine days after inoculation.
Mean separation by Waller-Duncan's multiple range test at $P < 0.05$.

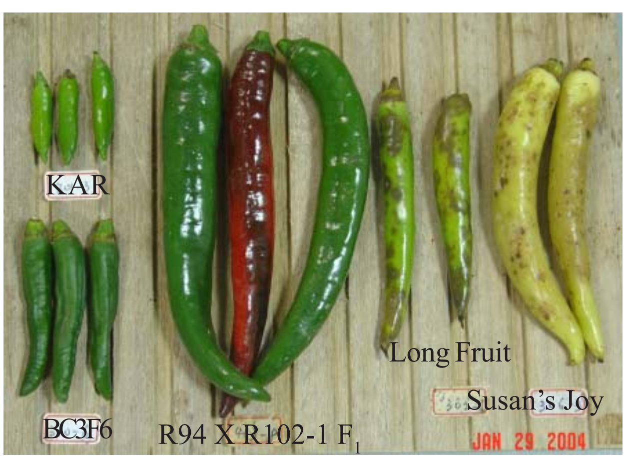


Fig. 1. Disease resistance reaction of individual plants from FN 413-8 (R94 × R95).

Fig. 2. Disease resistance reaction of individual plants from FN 388-2 (Cabe-Besar Blitar × R95) and FN412-4 (R94 × R95).

Table 6. Fruit characteristics and reactions to anthracnose inoculation among selected individual plants and hybrids.

Entry	Cross no.	Pedigree	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Disease severity[1]
FN 301-1	KAR (res. ck)	*C. baccatum*	5.1	1.2	2.0	1.0 ± 0.00
FN 302-2	Long Fruit (susc. ck)	*C. annuum*	11.2	1.8	9.3	9.0 ± 0.00
FN 310-1	0038-9155-5-1-1	(*C.annuum* × *C.chinense*)BC_3F_5	9.9	1.6	8.0	1.0 ± 0.00
FN 311-5	R94-5	TC06897	11.5	2.1	13.3	9.0 ± 0.00
FN 314-18	R95-1-18	TC06903, PBC1430, Apaseo Pasilla	19.6	2.7	32.0	1.0 ± 0.00
FN 315-3	R95-11-3	TC06903, PBC1430, Apaseo Pasilla	18.2	2.6	26.0	1.0 ± 0.00
FN 316-6	R95-15-6	TC06903, PBC1430, Apaseo Pasilla	14.3	2.0	13.3	1.2 ± 0.45
FN 317-13	R97-4-13	TC06912, PBC1439, Ancho Mulato	12.2	5.5	84.0	2.0 ± 0.71
FN 318-13	R97-15 –3	TC06912, PBC1439, Ancho Mulato	11.0	5.1	74.0	1.8 ± 1.10
FN 319-14	R97-16-14	TC06912, PBC1439, Ancho Mulato	9.1	5.4	42.0	1.0 ± 0.00
FN 320-1	R102-1-1	TC06941, PBC1478, Pasilla	15.6	2.6	24.7	1.0 ± 0.00
FN 320-10	R102-1-10	TC06941, PBC1478, Pasilla	18.3	2.6	30.0	1.0 ± 0.00
FN 320-19	R102-1-19	TC06941, PBC1478, Pasilla	19.8	2.6	30.7	1.0 ± 0.00
FN 322-10	R102-4-10	TC06941, PBC1478, Pasilla	8.6	1.5	4.7	1.0 ± 0.00
FN 322-14	R102-4-14	TC06941, PBC1478, Pasilla	10.0	1.7	8.7	1.0 ± 0.00
FN 361-2	A8-1 X A17-1	PBC385(BW-R) × 0038-9155-5-1 'Susan'sJoy'	11.2	1.8	8.7	1.0 ± 0.00
FN 372-5	A10-1 X R102-1	ICPN12#6(Saegochu/PBC385*5) × R102	20.6	2.2	23.3	1.8 ± 0.45
FN 374-4	A10-2 X R95-1	ICPN12#6(Saegochu/PBC385*5) × R95	17.0	2.1	22.0	3.2 ± 0.84
FN 377-9	A11-1 X R95-1	ICPN12#7(9955-15) × R95	20.5	2.4	36.7	4.4 ± 0.55
FN 382-3	A12-1XAS65	Phichit 1 × (KARxLF)F3	4.0	1.0	2.0	1.0 ± 0.00
FN 388-2	A13-2XR95-11	Cabe-Besar Blitar × R95	20.2	2.0	2.5	4.8 ± 1.89
FN 389-7	A14-1XR95-1	Cabe-Besar Blitar B × R95	17.0	1.9	22.7	3.0 ± 1.00
FN 399-1	A16-2XA17-1	G5 (California Paprika type) × 0038-9155-5-1	17.7	2.5	22.7	3.0 ± 0.71
FN 404-6	A17-1XR95-1	0038-9155-5-1 × R95	15.6	2.2	16.7	2.6 ± 0.89
FN 406-1	A17-2XR102-1	0038-9155-5-1 × R102	17.1	2.1	20.7	2.1 ± 0.84
FN 410-2	A94-1 X A17-1	R94 × 0038-9155-5-1	14.4	1.8	14.7	1.6 ± 0.55
FN 413-8	A94-1 X R102-1	R94 × R102	18.1	2.5	25.3	3.0 ± 0.00
FN 420-9	A97-4 X A7-1	R97 × VC228-5-1-2-2-1	15.7	4.2	51.3	4.0 ± 0.00
FN 424-9	A97-15 X A7-1	R97 × VC228-5-1-2-2-1	16.0	3.8	54.7	1.3 ± 0.58

[1] Plants were rated as resistant (1 – <3), intermediate (3 – <6), or susceptible (6 – 9) nine days after inoculation.

Fig. 3. Disease resistance reaction of individual plants from FN 377-4 (ICPN12#7 × R95) and FN399-1 (G5 × 0038-9155-5-1).

Reaction of pepper breeding lines to anthracnose using histological methods

In 2003, new sources of resistance to anthracnose in *Capsicum annuum* were identified in regeneration plots at AVRDC. These sources were advanced one generation after individual plant selection for resistance via artificial inoculation and evaluation under controlled conditions. Some of these selected lines were then crossed with anthracnose-susceptible inbred lines with desirable horticultural traits in order to combine resistance to anthracnose with traits such as large fruit size, high pigment concentration, and high yield potential. Parental lines and F_1 hybrids were screened for resistance to anthracnose. At the same time, these selected parent lines were subjected to a second cycle of evaluation and reselection for anthracnose resistance.

The purpose of this study was to evaluate varieties with different levels of resistance to anthracnose using histological methods.

Four accessions in *C. annuum* were selected from the regeneration plots of AVRDC GRSU in 2002. For stabilization of segregating population, TC06903 (R95-1, R95-11, and R95-15), TC06912 (R97-4, R97-15, and R97-16), and TC06941 (R102-1 and R102-4) were selected after these were inoculated artificially from the pepper breeding plot of AVRDC in 2003.

In creating an F_1 hybrid, we used TC06903 (R95-1) as one parent; this line is still segregating for resistance. For the other parent, we used inbred lines TC06897 (R94-1) and Susan's Joy (9955-15-1), which have desirable horticultural traits but are susceptible to anthracnose.

Identification of resistance reactions to anthracnose between four different F_1 hybrids, three parents, resistant check KAR (*C. baccatum*), and susceptible checks Long Fruit (*C. annuum*) and Susan's Joy was initially conducted using anatomical methods. Five fruits from each plant per accession were inoculated. Evaluation for fruit reaction to anthracnose occured at the growth stage intermediate between immature and mature fruit. Treatment was arranged in RCBD with five replications of fruit per accession.

A *Colletotrichum acutatum* isolate, Ca 153, was multiplied on potato dextrose agar (PDA) medium. Inoculation method used high-pressure (2 kg/cm^2) spray and the inoculation was applied to the whole fruit with concentration of 10^7 conidia/ml. Inoculated fruits were kept at 25 ± 2 °C and about 100% relative humidity in an incubation room. The disease severity rating was evaluated by index from 1 (highly resistant) to 9 (highly susceptible) nine days after inoculation. The fruit were then paraffin-embedded and microsectioned to the desired thickness between 15-20 µmeter. The samples were attached to slides, which were then rehydrated, stained and washed. Samples were then observed under the microscope.

The anatomical ratings for average severity of disease index of the heterogeneous entries were a little higher than that of KAR and lower than those of Long Fruit and Susan's Joy. FN 413-8 and FN 377-5 (F_1 hybrids) showed resistance, while FN 412-4 and 380-5 (F_1 hybrids) showed moderate resistance to anthracnose (Table 7). Resistance was significantly different between entries by Waller-Duncan's multiple range test at $P < 0.05$.

After artificial inoculation and microsectioning, the pericarp showed significant different disease reactions among entries under microscopic examination. No disease reaction showed in the pericarp of resistant check KAR (FN 301, Fig. 4). A few slightly raised lesions showed on the pericarp of resistant F_1 FN 377-

Table 7. List of pepper varieties used for fruit extraction in distilled water method and histological method.

Entry	Background	Variety	Disease index[1]	Description
FN 377-5	F_1	Susan's Joy (9955-15-1) x TC06903 (R95-1)	2.7 c	Resistant
FN 380-5	F_1	Susan's Joy (9955-15-1) x TC06903 (R95-1)	5.3 b	Moderate resistance
FN 412-4	F_1	TC06897 (R94-1) x TC06903 (R95-1)	4.0 bc	Moderate resistance
FN 413-8	F_1	TC06897 (R94-1) x TC06903 (R95-1)	2.0 d	Resistant
FN 301-1	OP (res. check)	KAR (*C. baccatum*)	1.0 e	Highly resistant
FN 302-2	OP (susc. check)	Long Fruit (*C. annuum*)	8.7 a	Highly susceptible
FN 306-2	OP (susc. check)	Susan's Joy (9955-15-1)(*C. annuum*)	8.7 a	Highly susceptible

[1] Plants were rated as resistant (1 – <3), intermediate (3 – <6), or susceptible (6 – 9) nine days after inoculation. Mean separation by Waller-Duncan's multiple range test at $P < 0.05$.

5 (Fig. 5). The raised lesion on the pericarp of moderately resistant F_1 FN 380-5 showed acervuli, mycelium and conidiophores clearly (Fig.6). Mycelium with acervuli containing spore masses were visible on the pericarp of susceptible check Long Fruit (FN 302-2, Fig. 7).

Contact: Paul Gniffke

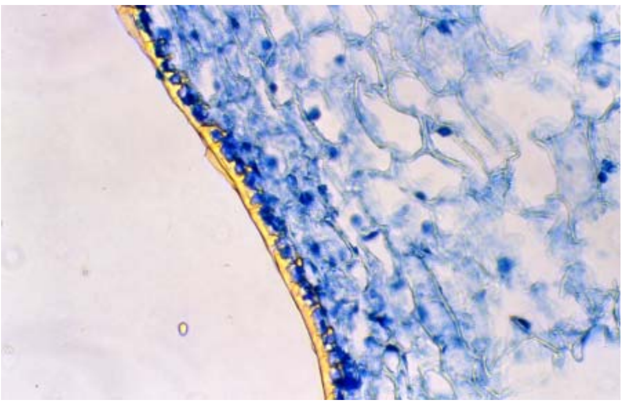


Fig. 4. Microsection of fruit pericarp of resistant check KAR (inbred line FN 301-1) that showed a high level of resistance to anthracnose (disease index = 1.0).

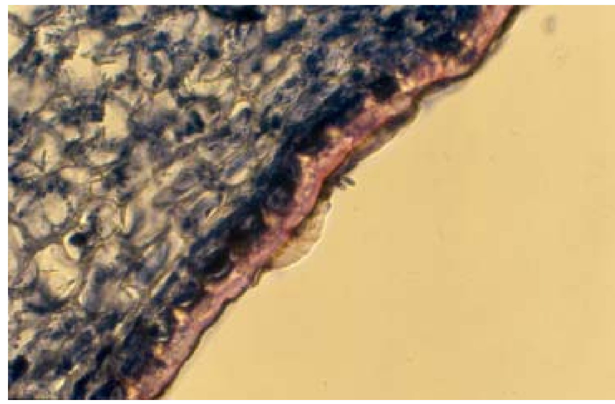


Fig. 5. Microsection of fruit pericarp of F_1 hybrid FN 377-5, that showed resistance to anthracnose (disease index: 3).

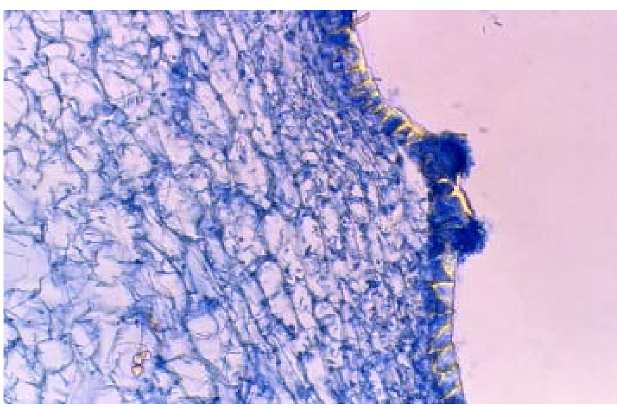


Fig. 6. Microsection of fruit pericarp of F_1 FN 380-5, that showed moderate levels of resistance to anthracnose (disease index: 5).

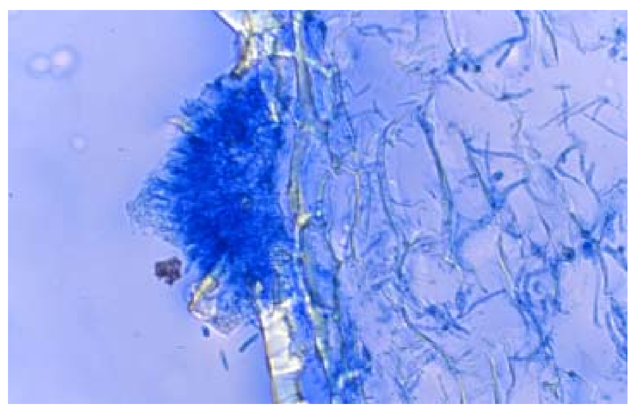


Fig. 7. Microsection of fruit pericarp of susceptible check Long Fruit (inbred line CK 302-2) that showed high susceptibility to anthracnose (disease index: 9.0).

Tomato

Geminivirus-resistant determinate tomato lines

Tremendous yield losses of tomato due to whitefly-transmitted geminiviruses has made host resistance an essential feature of tropical tomato varieties. In 2001, AVRDC distributed geminivirus-resistant tomato lines that carried the 'Ty-2' allele derived from Indian tomato variety H24. Although Ty-2 resistance was effective against many monopartite geminiviruses in Asia and the Middle East, it was ineffective against many geminiviruses in other parts of Asia and Central America. Consequently, we have diversified the sources of geminivirus resistance used in the program in order to improve the geminivirus resistance of our lines. One preliminary yield trial (PYT) was conducted at AVRDC during the late 2004 cool-dry season to evaluate the yield and horticultural characters of geminivirus-resistant fresh market determinate lines. The PYT entries included lines with Ty-2 resistance only (prefixes with CLN2623, CLN2634, CLN2644) and other lines derived from crosses segregating for 'Ty-2' and other geminivirus-resistance genes (prefixes of CLN2671 and CLN2679). The PYT was sown 31 August 2004 and transplanted on 30 September. Plots consisted of one 1.5 m-wide bed with two 4.8-m-long rows per bed (24 plants). Plants were staked and pruned. Entries were replicated twice and plots were arranged in RCBD. Plots were harvested three times during January–March 2005.

All entries demonstrated high levels of resistance to the Taiwan geminivirus and the resistance of lines derived from multiple geminivirus resistance sources (CLN2679 and CLN2671) was not superior to those lines based on 'Ty-2' alone (CLN2623, CLN2634, CLN2644) (Table 1). Although parents of CLN2679 and CLN2671 have different geminivirus resistance genes, in the absence of appropriate molecular markers, one does not know which particular geminivirus resistance genes the F_6 lines of CLN2679 and CLN2671 contain. Marker development is in progress and in the future lines containing the geminivirus resistance genes can be determined. Entries CLN2679A, CLN2679C, and CLN2623A were selected for seed increase and international distribution based on yield and fruit qualities.

Table 1. Yield and horticultural characteristics of determinate fresh market tomato lines in a preliminary yield trial.[1]

Entry	Marketable yield (t/ha)	Days to maturity	Fruit weight (g)	Fruit no./ plant	Solids (°Brix)	Acid[2]	Color[3] (a/b)	BW[4] (% survival)
CLN2671A	86	105	95	26	3.35	0.23	2.00	63
CLN2679A	99	106	69	60	3.75	0.37	1.84	16
CLN2679B	73	105	98	32	4.05	0.42	1.89	15
CLN2679C	99	105	89	40	3.35	0.32	1.91	39
CLN2623A	103	106	73	47	4.25	0.37	2.05	47
CLN2634A	96	107	123	31	4.45	0.34	1.90	8
CLN2644A	103	106	60	65	3.95	0.32	1.91	79
CLN2644B	97	105	57	51	4.60	0.35	1.91	95
CLN2498E (check)	110	106	98	42	3.25	0.26	1.77	80
CV (%)	8	0.4	4	18	6	9	5	-
LSD (0.05)	18	1	7	19	0.50	0.07	0.19	-

[1] Transplanted 30 September 2004 at AVRDC.
[2] Equivalent of citric acid.
[3] 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.
[4] Percentage of healthy plants after drench inoculation with the bacterial wilt pathogen in a separate greenhouse trial.

Tomato trials for the APSA workshop

In order to benefit as many farmers as possible, AVRDC provides seed of its inbred lines to private seed companies as well as public institutions. AVRDC's Material Transfer Agreement for improved germplasm allows private seed companies to directly commercialize AVRDC lines or use the lines as parents in development of new lines. This year AVRDC hosted a workshop in May with members of the Asia & Pacific Seed Association (APSA) and several tomato field trials were established as part of the workshop.

One preliminary yield trial (PYT1) of the determinate inbred tomato lines currently distributed internationally and a second trial of fresh market tomato hybrids (PYT2) were carried out at AVRDC during Spring 2004. Both PYTs were sown on 19 January 2004, transplanted on 3 March and harvested three times from 25 May–15 June 2004. PYT trial plots consisted of two 1.5 m-wide beds with two 4.8-m-long rows per bed (24 plants). Plants were staked and pruned. Entries were replicated three times and plots were arranged in RCBD.

All PYT1 and PYT2 entries carry the 'Ty-2' gene for geminivirus resistance derived originally from H24 as well as tomato mosaic virus resistance conferred by the $Tm2^2$ allele, and resistance to other diseases also. Geminivirus infection was high on the susceptible checks (CLN2026D in PYT1 and FMTT586 in PYT2) even though the trials were conducted in early spring when geminivirus is not usually a problem until late in the growing season.

In PYT1, the CLN2498-prefixed entries yielded about 50 t/ha, significantly greater than most other entries; these lines produce a semi-determinate plant type with moderately firm fruit in the 80–90 g range (Table 2). Small seed quantities (100 seeds per entry per recipient) of entries in PYT1 are available upon request.

In PYT2, hybrids FMTT 1066 and FMTT 1082 produced fairly good yields and fruit qualities. Line 29-19-11-27-4-1 (recoded CLN2468A) will be offered internationally in the future.

Table 2. Yield and horticultural characteristics of semi-determinate fresh market tomato lines in Preliminary Yield Trial 1.[1]

Entry	Marketable yield (t/ha)	Fruit set (%)	Days to maturity	Fruit weight (g)	Fruit no./ plant	Solids (°Brix)	Acid[2] (%)	Color[3] (a/b)	BW[4] (% survival)	Disease[5] resistance
CLN2498D	56	48	90	76	50	4.0	0.35	1.94	62	WTG, ToMV, F-1, GLS
CLN2498E	48	47	90	82	40	3.8	0.34	1.93	80	WTG, ToMV, F-1
CLN2498F	53	47	89	83	44	4.3	0.37	2.04	59	WTG , ToMV, F-1
PT4722B1F6A	38	46	87	62	41	4.7	0.54	1.86	60	WTG ,ToMV, F-1, GLS
PT4722B1F6B	33	46	87	52	41	4.8	0.55	1.93	60	WTG ,ToMV, F-1, GLS
CLN2545DC6A	40	57	87	48	49	5.0	0.57	1.87	35	WTG ,ToMV, F-1, GLS
CLN2545DC6B	45	51	88	51	46	4.9	0.56	1.99	65	WTG ,ToMV, F-1, GLS
CLN2545DC6C	39	44	87	48	48	5.1	0.64	2.03	52	WTG ,ToMV, F-1, GLS
CLN2468DC7A	28	47	87	58	37	4.6	0.39	1.90	85	WTG ,ToMV
CLN2468DC7B	30	46	87	50	42	4.9	0.36	1.93	91	WTG ,ToMV, F-1
CLN2026D (check)	17	45	87	49	27	4.8	0.41	2.03	60	ToMV, F-1, F-2, GLS
H24 (check)	36	52	89	60	48	4.7	0.63	1.96	-	ToMV, F-1
CV (%)	10	14	0.7	7	16	5.0	7.5	6.0		
LSD (0.05)	7	11	1	7	11	0.4	0.06	0.20		

[1] Transplanted 3 March at AVRDC.

[2] Equivalent of citric acid.

[3] 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.

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

[5] ToMV=tomato mosaic virus; WTG= whitefly-transmitted geminivirus; F-1 and F-2=resistance to races 1 and 2, respectively, of the fusarium wilt pathogen; GLS=gray leaf spot

Table 3. Yield and horticultural characteristics of determinate fresh market tomato hybrids evaluated in Preliminary Yield Trial 2.[1]

Entry	Marketable yield (t/ha)	Fruit set (%)	Days to maturity	Fruit weight (g)	Fruit no./ plant	Solids (°Brix)	Acid[1] (%)	Color[2] (a/b)	BW[3] (% survival)	Disease[4] resistance
TLCV15	33	53	88	52	54	4.8	0.44	1.85	72	WTG, ToMV, F-1
FMTT1037	17	44	87	65	42	4.6	0.40	1.94	98	WTG, ToMV, F-1
FMTT1038	32	47	88	69	32	5.0	0.49	2.15	83	WTG, ToMV, F-1
FMTT1065	29	44	88	75	44	4.9	0.48	2.20	90	WTG, ToMV, F-1
FMTT1066	29	48	88	65	43	5.2	0.49	2.16	100	WTG, ToMV, F-1
FMTT1082	34	43	88	69	31	5.1	0.39	2.12	82	WTG, ToMV, F-1
FMTT847 (hyb. ck.)	26	33	88	84	32	5.	0.39	2.03	90	WTG, ToMV, F-1
FMTT586 (hyb. ck.)	13	32	90	94	29	4.9	0.47	1.89	100	ToMV, F-1
Avinash 2	33	56	90	88	42	4.7	0.49	1.98	-	WTG, ToMV, F-1
CV (%)	17	15	1	7	19	6	9	3		
LSD (5%)	8	12	0.7	9	12	0.5	0.07	0.11		

[1] Transplanted 3 March 2004 at AVRDC.

[2] Equivalent of citric acid.

[3] 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.

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

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

Tomatoes for specialty markets

Dark green-shouldered tomatoes are very popular in selected regions of Asia. A preliminary yield trial (PYT) of indeterminate fresh market tomato hybrids was carried out at AVRDC during the autumn to identify those suitable for the host country. All FMTT-prefixed entries are resistant to geminivirus, tomato mosaic virus, and bacterial wilt. ThePYT was sown on 15 July, transplanted 18 August and harvested from 25 October to 15 December 2004. Plots included one 1.5 m-wide beds with two, 2.4-m-long- row per bed. Plants were staked and pruned. Entries were replicated twice and plots were arranged in RCBD. Based on high yield and fruit characters, hybrids FMTT1029, FMTT1047, FMTT1048, and FMTT1098 were selected for regional and international testing (Table 4).

High ß-carotene tomatoes may be especially beneficial in vitamin A deficient areas of Africa and Asia. High ß-carotene cherry tomato hybrids were evaluated in a late autumn-early spring PYT. Entries with the CHT prefix are resistant to geminivirus and tomato mosaic virus. The PYT was sown 28 October 2003, transplanted 28 November 2003, and harvested six times between 25 March and 28 April 2004. Plots included one 1.5 m-wide bed with two 2.4-m-long rows per bed. Plants were staked and pruned. Entries were replicated twice and plots were arranged in RCBD. Hybrids CHT1622, CHT1628, CHT1629, and CHT1631 were submitted to several regional cooperators for further testing.

Table 4. Yield and horticultural characteristics of fresh market tomato hybrids in a preliminary yield trial.[1]

Entry	Total yield (t/ha)	Fruit set (%)	Days to maturity	Fruit weight (g)	Solids (°Brix)	Acid[2]	Color[3] (a/b)	WTG[4] reaction	BW[5] (% survival)
FMTT1027	73	55	71	130	3.8	0.29	1.99	R	92
FMTT1029	78	50	71	104	4.1	0.22	2.40	R	72
FMTT1031	79	48	68	124	3.8	0.23	1.78	R	79
FMTT1034	73	46	70	120	3.8	0.23	1.87	R	87
MTT1047	76	51	70	109	4.4	0.30	2.00	R	80
FMTT1048	65	55	70	108	4.1	0.26	1.94	R	88
FMTT1053	64	46	68	90	4.5	0.27	2.13	R	94
FMTT1098	69	40	75	131	3.9	0.27	1.17	R	97
Taichung ASVEG #4 (ck)	61	32	73	113	4.4	0.29	1.83	S	73
Taichung ASVEG #10 (ck)	55	32	75	144	4.2	0.34	1.97	S	59
Means of all entries	65	50	69	106	4.2	0.27	1.95	-	-
LSD (0.05)	14	17	46	14.9	0.4	0.06	0.37	-	-

[1] Transplanted 18 August 2004 at AVRDC.

[2] Equivalent of citric acid.

[3] 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 zero. The a/b ratio increases to zero and above as the fruits ripen toward a dark red.

[4] WTG = whitefly-transmitted geminiviruses; R = resistant; S = susceptible.

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

Table 5. Yield and horticultural characteristics of ß-carotene cherry tomato hybrids in a preliminary yield trial.[1]

Entry	Total yield (t/ha)	Fruit set (%)	Days to maturity	Fruit weight (g)	Solids (°Brix)	Acid[2]	Color[3] (a/b)	Lycopene (mg/100g)	ß-carotene (mg/100g)	WTG[4] reaction
CHT1622	93	86	87	17	5.3	0.48	0.97	3.81	2.23	R
CHT1623	82	89	89	18	5.1	0.44	0.93	3.49	2.12	R
CHT1626	96	91	86	16	5.2	0.48	1.01	3.95	2.08	R
CHT1627	94	87	89	18	5.3	0.46	1.02	3.66	2.31	R
CHT1628	94	89	87	16	5.5	0.40	0.69	1.97	1.87	R
CHT1629	95	84	89	16	5.6	0.41	0.66	1.75	2.09	R
CHT1631	103	88	87	17	5.6	0.44	1.04	3.68	2.59	R
CHT1634	103	88	90	18	5.3	0.45	0.98	3.58	2.31	R
CHT1638	89	83	89	17	5.4	0.43	1.83	10.0	0.58	R
CHT1639	93	94	87	17	5.4	0.45	1.98	9.9	0.55	R
Tainan ASVEG #6(check)	71	68	85	10	5.9	0.45	1.59	7.60	0.74	S
Hualian ASVEG #13 (check)	89	78	90	13	6.8	0.41	0.84	2.66	2.64	S
Means of all entries	92	85	88	16	5.4	0.43	0.95	3.69	1.82	-
LSD (0.05)	19	13	4	2.3	0.6	0.05	0.88	0.45	0.09	-

[1] Transplanted 28 November 2003 at AVRDC.

[2] Equivalent of citric acid.

[3] 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 zero. The a/b ratio increases to zero and above as the fruits ripen toward a dark red.

[4] WTG = whitefly transmitted geminiviruses; R = resistant; S = susceptible.

Evaluation of tomato hybrids for heterosis

Heterosis refers to the increased yield and overall performance of F_1 hybrids derived from the cross of two inbred lines. Higher levels of heterosis are more likely when the parents carry a high frequency of dominant alleles or when overdominance gene action is present. Crossing of inbred lines derived from unrelated gene pools increases the chances of finding higher levels of heterosis. The purpose of this experiment was to evaluate heterosis for yield and fruit characters of hybrids produced from three AVRDC tester lines crossed to lines introduced from other regions, and to identify introduced lines with potential to contribute genes that might increase the yield and quality of AVRDC lines.

Three AVRDC testers were crossed to eight exotic lines (Table 6). The exotic lines were chosen from outside breeding programs with goals similar to those of AVRDC and nearly subtropical environments. The experiment was sown 24 July and transplanted 21 August 2003 at AVRDC. The experimental design was a RCBD with three replications. Plots were two, 20-cm-high beds with one row per bed. Spacing was 40 cm between plants and 150 cm between beds. Beds were covered by gray plastic mulch and covered by rice straw. Twenty mature fruits per plot were taken for analysis of color, pH, and solids contents. Data were analyzed using Statistical Analysis System (SAS) with the SAS macro program for line × tester analysis developed at the International Rice Research Institute. Percent heterosis was calculated as $(F_1 – HP)/HP$ where HP is the value of the respective high parent.

Variation among parental lines (testers and exotic lines) for yield and other characters was high (Table 6). Geminivirus infection was a major factor in the experiment and the resistant lines (CLN2460, CLN2123C, F10, and CLX3727) produced higher yields than the susceptible parents. Results show a large yield advantage for hybrids compared to inbred lines. Almost all (92%) hybrids yielded more than their respective high parent and average heterosis was 40% (Table 7). Heterosis of two hybrids (CLN1621E × L27 and CLN1621E × NCHS-1) exceeded 100%. Hybrid performance for average fruit weight and other fruit traits fell between those of their respective parents, resulting in negative percent heterosis values.

General combining ability (GCA) is the average of all F_1 sharing a common parent expressed as a deviation from the overall mean of all crosses. Positive GCA values for yield of the four geminivirus resistant parents indicated that hybrids with one of these lines as a parent produced higher yields than average (Table 8). Hybrids with F10 as a parent yielded the highest on average, which is reflected by its high GCA value. We found high and positive GCA values for FLA7771 and DR-

Table 6. Origin, horticultural and fruit characters of hybrid parents.[1]

Entry	Origin	Yield (t/ha)	Maturity (days)	Fruit weight (g)	Solids (°Brix)	Color (a/b)[2]	pH
CLN1621E (tester)	AVRDC	25	112	38	4.2	1.80	4.07
CLN2460 (tester)	AVRDC	50	114	72	4.1	2.11	4.10
CLN2123C (tester)	AVRDC	40	114	53	3.6	1.86	4.25
F10 (line)	Israel	56	123	102	4.0	1.90	4.42
L27 (line)	Israel	6	129	84	4.6	0.48	4.13
Saladette (line)	USA-Texas	24	113	51	4.4	1.88	4.19
FLA7771 (line)	USA-Florida	32	121	112	4.4	1.93	4.21
CLX3727 (line)	India	47	115	60	4.3	1.84	4.15
Siberia (line)	Russia	3	111	33	4.4	2.12	4.14
NCHS-1 (line)	USA-No.Carolina St. Univ.	24	122	79	5.1	1.93	4.34
DR-3-2-6 (line)	Holland	39	117	79	4.0	2.09	4.23
TLCV15 (hybrid check)	AVRDC	52	114	58	4.3	1.91	4.19
Mean	-	49	115	67	4.3	1.91	4.17
LSD (0.05)	-	19	4	15	0.5	0.23	0.10

[1] Transplanted 21 August 2003 at AVRDC.

[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 zero. The a/b ratio increases to zero and above as the fruits ripen toward a dark red.

Table 7. Means of F_1 hybrids and percentages of heterosis for horticultural and fruit characters.

Cross	Mkt yield (t/ha)		Days to maturity		Fruit weight (g)		Solids		Color[1]		pH	
	F_1 mean	Heterosis (%)	F_1 mean	Heterosis (%)	F_1 mean	Heterosis (%)	F_1 mean	Heterosis (%)	F_1 mean	Heterosis (%)	F_1 mean	Heterosis (%)
CLN1621E x F10	63	12	113	–8	63	–39	4.4	4	1.99	5	4.14	–6
CLN2123C x F10	93	66	114	–7	78	–23	3.9	–2	1.68	–11	4.23	–4
F10 x CLN2460	78	38	113	–8	77	–24	4.2	2	2.04	–3	4.16	–6
CLN1621E x L27	56	130	113	–12	67	–20	4.6	0	1.89	5	4.19	2
CLN2123C x L27	64	59	114	–12	65	–23	4.9	6	1.72	–7	4.19	–1
L27 x CLN2460	52	4	114	–12	70	–17	4.9	6	1.94	–8	4.26	3
CLN1621E x Saladette	42	72	112	–1	51	1	4.3	–2	1.97	5	4.12	–2
CLN2123C x Saladette	55	38	113	–1	51	–5	4.6	–4	1.86	–2	4.17	–2
Saladette x CLN2460	58	16	118	3	71	–1	4.2	5	2.02	–4	4.22	1
CLN1621E x FLA7771	63	97	114	–6	76	–32	4.1	–8	1.92	–1	4.15	–1
CLN2123C x FLA7771	58	45	114	–6	77	–32	4.3	–2	2.03	5	4.20	–1
FLA7771 x CLN2460	56	12	114	–6	87	–23	4.5	2	2.02	–4	4.10	–2
CLN1621E x NCHS-1	55	125	114	–6	65	–17	4.2	–18	2.02	4	4.26	–2
CLN2123C x NCHS-1	55	27	114	–7	50	–36	4.5	–13	1.85	–4	4.16	–4
NCHS-1 x CLN2460	58	36	115	–6	64	–19	4.4	–14	2.02	–4	4.21	–3
CLN1621E x CLX3727	65	38	114	–1	58	–3	4.3	2	1.98	8	4.05	–2
CLN2123C x CLX3727	63	33	113	–1	66	10	4.1	–4	1.74	–6	4.04	–5
CLX3727 x CLN2460	64	27	114	0	69	–4	4.0	–7	1.99	–6	4.00	–4
CLN1621 x Siberia	25	2	111	–1	42	11	4.6	4	2.02	–5	4.10	–1
CLN2123C x Siberia	49	21	112	–2	46	–14	4.7	8	2.01	–5	4.20	–1
Siberia x CLN2460	39	–23	113	–1	53	–27	4.4	0	2.21	4	4.14	0
CLN1621E x DR-3-2-6	49	27	114	–3	62	–21	4.0	–6	2.05	–2	4.17	–1
CLN2123C x DR-3-2-6	53	33	115	–2	75	–5	3.5	–13	1.76	–16	4.21	–1
DR-3-2-6 x CLN2460	64	28	115	–2	92	17	3.9	–6	2.03	–4	4.17	–2
Mean	49	40	115	–4.5	67	–14.4	4.3	–2.5	1.91	–2.3	4.17	–2

[1] Transplanted 21 August 2003 at AVRDC.

[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 zero. The a/b ratio increases to zero and above as the fruits ripen toward a dark red.

3-2-6 for fruit weight, L27 for solids content, and Siberia for color. Specific combining ability (SCA) measures whether actual F_1 performance was better or worse than expected on the basis of the average GCA values of the parents. Hybrids demonstrating high yield and high SCA included CLN2123C × F10, CLN1621E × FLA7771, and CLN1621E × CLX3727.

Based on its high GCA with AVRDC tester lines and geminivirus resistance, F10 from Israel may be particularly useful as a parent in crosses with AVRDC lines to develop both new hybrids and new improved inbred lines. Because of the sometimes hot environment of Israel and excellence of its breeding programs, it is very possible that Israeli tomato germplasm might contain genes to improve AVRDC lines. We will make an effort to evaluate more germplasm from Israel.

Contact: Peter Hanson

Editor's note:
The Tomato Unit worked in collaboration with the Nutrition Unit on "Diversity in eggplant for superoxide scavenging activity, total phenolics, and ascorbic acid." This report is in the Nutrition chapter.

Table 8. General combining ability[1] (GCA) and specific combining ability[2] (SCA) effects of testers, lines, and F_1 for horticultural and fruit characters.[3]

Entry	Yield (t/ha)	Maturity (days)	Fruit weight (g)	Solids (°Brix)	Color[3] (a/b)	pH
Parents, GCA effects						
CLN1621E (tester)	–5.1	–0.58	–5.0	0.00	0.03	–0.01
CLN2460 (tester)	1.1	0.71	7.3	–0.01	0.08	0.00
CLN2123C (tester)	3.9	–0.13	–2.3	0.01	–0.12	0.01
LSD (0.05) (testers)	6.7	1.4	5.5	0.17	0.08	0.04
F10 (line)	20.6	–0.08	6.9	–0.14	–0.04	0.02
L27 (line)	0.0	–0.08	1.7	0.50	–0.1	0.05
Saladette (line)	–5.5	0.58	–7.9	0.07	0.01	0.01
FLA7771 (line)	1.8	0.25	14.2	–0.01	0.04	–0.01
CLX3727 (line)	6.6	0.14	–1.3	–0.18	–0.05	–0.13
Siberia (line)	–20.0	–1.75	–18.7	0.25	0.13	–0.01
NCHS-1 (line)	–1.6	0.36	–5.7	0.05	0.01	0.05
DR-3-2-6 (line)	–1.8	0.58	10.8	–0.54	0.01	0.02
LSD (0.05) (lines)	10.9	2.3	8.9	0.27	0.13	0.06
Crosses, SCA effects						
CLN1621E × F10	–10.1	0.25	–5.0	0.23	0.05	–0.03
CLN2123C × F10	11.5	0.79	7.8	–0.25	–0.10	0.04
F10 × CLN2460	–1.3	–1.04	–2.7	0.03	0.05	–0.01
CLN1621E × L27	4.0	0.25	5.2	–0.18	0.01	–0.01
CLN2123C × L27	2.4	0.13	–0.4	0.08	–0.01	–0.04
L27 × CLN2460	–6.5	–0.38	–4.8	0.10	0.01	0.05
CLN1621E × Saladette	–4.7	–1.42	–1.4	–0.09	–0.01	–0.04
CLN2123C × Saladette	-0.3	–1.21	–4.9	0.23	0.02	–0.02
Saladette × CLN2460	5.1	2.63	6.3	–0.15	–0.01	0.05
CLN1621E × FLA7771	8.7	0.25	1.0	–0.23	–0.10	0.01
CLN2123C × FLA7771	–4.8	0.13	–0.8	0.02	0.16	0.03
FLA7771 × CLN2460	–3.9	–0.38	–0.2	0.21	–0.06	–0.04
CLN1621E × NCHS-1	4.5	0.47	10.5	–0.13	0.03	0.06
CLN2123C × NCHS-1	–5.2	–0.32	–7.2	0.09	0.00	–0.07
NCHS-1 × CLN2460	0.7	–0.15	–3.4	0.04	–0.03	0.01
CLN1621E × CLX3727	6.2	0.69	–1.5	0.20	0.05	0.03
CLN2123C × CLX3727	–4.8	–0.43	3.9	–0.04	–0.05	0.00
CLX3727 × CLN2460	–1.4	–0.26	–2.3	–0.16	0.00	–0.03
CLN1621 × Siberia	–7.3	–0.42	0.2	0.00	–0.09	–0.03
CLN2123C × Siberia	7.3	0.46	1.0	0.16	0.05	0.04
Siberia x CLN2460	0.0	-0.04	-1.3	-0.16	0.04	0.00
CLN1621E x DR-3-2-6	-1.3	-0.08	-9.0	0.19	0.07	0.00
CLN2123C x DR-3-2-6	-6.1	0.46	0.5	-0.29	-0.07	0.01
DR-3-2-6 x CLN2460	7.3	-0.38	8.5	0.10	0.00	-0.01
LSD (0.05) (SCA effects)	18.9	4.0	15.5	0.47	0.23	0.10

[1] General combining ability is the average performance of all F_1 crosses sharing a common parent expressed as a deviation from the overall mean of all crosses.
[2] Specific combining ability measures whether actual performance of a particular F_1 is better or worse than expected on the basis of the GCA values of the parents.
[3] Transplanted 21 August 2003 at AVRDC.
[4] 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 zero. The a/b ratio increases to zero and above as the fruits ripen toward a dark red.

Entomology

Mechanisms of host plant resistance to eggplant fruit and shoot borer

Eggplant fruit and shoot borer (EFSB), *Leucinodes orbonalis*, is a serious pest of eggplant in South and Southeast Asia. Larvae of this insect bore inside plant shoots and fruits making fruits unmarketable. Damage may occur as early as 4 to 6 weeks after transplanting, reaching peak density at fruiting stage. Vegetable farmers spray frequently, at times daily, to kill larvae before they enter fruits. This pesticide abuse has triggered the insect to develop resistance to nearly all registered insecticides. It has also created a resurgence of secondary insect pests, created toxic residues in the environment, and harmed natural predators and parasitoids of EFSB.

The development of eggplant lines resistant to EFSB is an effective and environmentally friendly method for combating the pest. In earlier studies we discovered eggplant accession EG058 to show moderate yet inconsistent resistance to the pest at various locations. EG058, however, is highly susceptible to cotton leafhopper, *Amrasca devastans*, a serious pest of eggplant during the cool-dry season. Commercial variety Turbo has consistently been less damaged than AVRDC's standard susceptible check EG075 in studies at AVRDC-Asian Regional Center (ARC), Thailand. Two accessions from the Bangladesh Agricultural Research Institute, namely BL009 and ISD006, also have shown resistance to EFSB. In this trial we evaluated morphological and biochemical characteristics of these 'resistant' lines, using EG075 as a susceptible check.

The land was roto-tilled and worked into 1.5-m-wide beds. Three adjacent beds were grouped into an overall plot size of 4.5 m × 10 m, with an empty distance of 1.5 m between two plots. Five-week-old seedlings of each accession were transplanted in four replications using RCBD. Transplanting date was 1 May 2004.

Crops were grown using customary cultural practices including basal fertilizer application, timely irrigation, weeding, and pruning leaves around the base of the plant. No insecticides or fungicides were applied. We began recording the number of plants showing damage to shoots once flowering commenced. When fruits became ready for harvest, marketable fruits were harvested weekly and percentages of damaged fruits were recorded. Data were subjected to analysis of variance (ANOVA) followed by comparison using Tukey's test of honest significant difference (HSD) at the 5% probability level.

The morphology of leaves was evaluated since EFSB adult lays its eggs on leaves. The hatching larvae prefer not to feed on the leaves; rather, they crawl over the leaf surface to reach the tender shoots or fruits for feeding. Hence we studied trichome density as a possible factor contributing to host plant resistance. The third or fourth leaf from the top of plants was selected in 10 plants. Sections of size 5 mm × 5 mm, devoid of leaf veins, were cut from the leaves. Ten fresh shoots of 15 cm from the same plants in each accession were cut from the distal portion, and it was divided into three regions namely, top (1–2 cm from top), middle (7–8 cm from top) and bottom (14–15 cm). Shoot samples were 1 mm × 1 mm. Each leaf and shoot sample was placed transversely on a clean glass slide and trichomes were counted using a stereoscopic microscope and expressed as trichome density per square millimeter. Data were subjected to two-way ANOVA followed by comparison using Tukey's tests of HSD at the 5% probability level.

We also considered that the resistant accessions might possess certain secondary metabolites, which will interrupt the normal physiological processes of the EFSB larvae, resulting in antibiosis. Therefore, we investigated the role of biochemical factors responsible for antibiosis of EFSB larvae on eggplant.

A colony of EFSB was reared on an artificial diet developed by AVRDC. The diet consists of a 90% portion of commercial diet of polyphagous insects (such as beet armyworm [BAW], *Spodoptera exigua*) fortified with a 10% portion of dry eggplant fruit powder. To initiate a new colony, EFSB larvae were collected from damaged fruits in the field and fed on the diet. Pupae, which are formed on diet container lids, were maintained in a cage and emerging adults were confined in a round plastic or acrylic chamber, the inner walls of which were lined with rough paper or nylon net. A seedling of eggplant, placed at the bottom of the chamber, was separated from the rest of the chamber by nylon netting. Adults readily mated and laid eggs on the netting. The eggs were then placed over an artificial diet for hatched larvae to feed upon. Larvae could also be reared on fresh eggplant fruits in the laboratory if the continuous supply of pesticide-free eggplant fruit is readily available.

The BAW diet was fortified with eggplant shoot powder and fruit powder from all evaluated accessions. The quantity of fortified fraction was always maintained at 10% original dry eggplant shoot/fruit powder. In all these studies, first-instar larvae were released on the fortified diets and their growth and development were monitored daily until the larvae pupated and adults emerged. We recorded insect mortality. Any diet that did not allow successful pupation of larvae and emergence of pupae into adults, and normal duration of larval and pupal stages, was considered to contain the eggplant fruit-derived anti-feeding or nutrient deficient factors. Data were subjected to ANOVA and comparison using Tukey's tests of HSD at the 5% probability level.

The results of the field experiment are summarized in Tables 1 and 2. The percentages of damaged fruits for EG058, Turbo, BL009 and ISD006 were significantly less than the susceptible check, EG075. Damage to shoots was also significantly less for EG058, Turbo, BL009, and ISD006 than the susceptible check. As these varieties/accessions possess significantly higher resistance, use of these varieties/accessions will reduce the need for pesticide use in combating EFSB.

Results in our study of the mechanisms of resistance to EFSB are summarized in Tables 3–5. The leaf trichome density was significantly higher in the susceptible accession EG075 than all the resistant accessions. In general, the abaxial (lower) surface possesses significantly more trichomes than the adaxial (upper) surface. Though there was a significant difference in the leaf trichome density, its influence in imparting resistance was not clear as the difference between the susceptible and resistant accessions were too low. There was a significant difference among the selected eggplant accessions in shoot trichome density also in all shoot parts. However, the resistant accessions EG058 and Turbo possessed significantly less trichomes than the susceptible accession EG075, while the other two resistant accessions BL009 and ISD006 generally possessed more trichomes than

Table 1. Resistance of eggplant accessions to egglant fruit and shoot borer in field (fruit damage).

Accession	Fruit damage (%)							
	15 July	22 July	29 July	05 Aug	12 Aug	19 Aug	26 Aug	Mean
EG 075	0.00	11.30 a	6.64 a	9.13 a	17.30 a	21.00 a	0.00	9.34 a
EG 058	0.00	0.00 b	0.00 b	0.00 b	0.00 b	0.21 b	0.00	0.03 b
Turbo	0.00	0.00 b	0.00 b	0.00 b	0.00 b	0.83 ab	0.00	0.12 b
BL 009	0.00	1.56 b	0.00 b	0.00 b	0.36 b	0.40 b	0.00	0.33 b
ISD 006	0.00	0.00 b	0.00 b	0.00 b	0.53 b	1.11 ab	0.00	0.23 b
Tukey's HSD (5%)	-	7.78	4.37	5.04	4.34	20.56	-	4.39
ANOVA	NS	**	***	***	***	*	NS	***

NS, *, **, *** Nonsignificant and significant at $P < 0.05$, 0.01, or 0.001, respectively.

Table 2. Resistance of eggplant accessions to EFSB in field (shoot damage).

Accession	Shoot damage (%)							
	15 July	22 July	29 July	05 Aug	12 Aug	19 Aug	26 Aug	Mean
EG 075	22.50 a	16.67 a	11.70 a	14.17 a	75.00 a	75.00 a	15.00 a	32.86 a
EG 058	0.00 b	0.00 b	6.67 a	0.00 a	0.00 b	0.83 b	0.00 b	1.07 b
Turbo	0.00 b	0.00 b	5.00 a	0.83 a	0.00 b	0.00 b	0.00 b	0.83 b
BL 009	0.00 b	1.67 b	5.83 a	0.00 a	3.33 b	0.00 b	1.67 b	1.79 b
ISD 006	0.00 b	0.00 b	4.17 a	0.00 a	3.33 b	1.67 b	0.00 b	1.31 b
Tukey's LSD (0.05)	6.50	9.67	11.39	5.45	29.54	27.78	8.67	19.06
ANOVA	***	***	NS	***	***	***	***	***

NS, *, **, *** Nonsignificant and significant at $P < 0.05$, 0.01, or 0.001, respectively.

EG075. Hence, among these selections, trichome density does not appear to impart resistance to EFSB.

Results of the effect of eggplant shoot fortifications in artificial diet on growth and development of EFSB are summarized in Table 4. There was no significant difference in larval duration, pupal duration, pupal weight, and percent adult emergence of the insects fed on diets fortified with shoots from either the resistant accessions, the susceptible accession, or the BAW diet alone (check). However, pupation percentage of EFSB on diet fortified shoots of the susceptible accession, EG075 was similar to that of insects fed on BAW diet alone, which were significantly higher than those of insects fed on diet fortified with shoots from BL009. Values for all other resistant accessions, namely, EG058, Turbo, and ISD006 were intermediate and similar to either of the extremes.

The effects of eggplant fruit fortifications in artificial diet on growth and development of EFSB are summarized in Table 5. There was no significant difference in percent pupation of the insects fed on diets fortified with fruits from either the resistant accessions or the susceptible accession and the BAW diet alone (check).

The duration of the larval stage for insects fed on BAW diet containing 10% fruit fortification from ISD006 was significantly higher than the larvae on BAW diet containing 10% fruit fortification from other two resistant accessions, Turbo and BL009. Larval period of the insects fed on all other diets was intermediate and similar to either of the extremes.

The duration of the pupal stage for insects fed on BAW diet containing 10% fruit fortification from ISD006 was significantly lower than the pupae on BAW diet containing 10% fruit fortification from the other three resistant accessions EG058, Turbo and BL009. Pupal period of the insects fed on other diets was intermediate and similar to either of the extremes.

Pupal weight of EFSB on BAW diet containing 10% fruit fortification from EG058 was similar to the pupal weight of insects fed on BAW diet fortified with fruits of ISD006, which were significantly higher than that

Table 3. Trichome density on leaves and shoots of selected eggplant accessions.

Accession	Leaf Trichomes (no./mm^2)			Shoot Trichomes (no./mm^2)			
	Abaxial	Adaxial	Mean	Top	Middle	Bottom	Mean
EG 075	24.36	9.87	17.11 a	35.80 b	30.60 b	29.70 b	32.03
EG 058	21.16	7.52	15.86 b	24.90 c	21.00 c	14.30 c	20.07
Turbo	19.71	6.79	14.34 c	17.60 d	14.10 d	11.60 c	14.43
BL 009	22.67	9.05	13.25 cd	39.70 b	36.90 ab	39.20 a	38.60
ISD 006	18.47	7.02	12.75 d	55.70 a	40.40 a	35.90 ab	44.00
ANOVA	Variety		***	Variety			***
	Surface		***	Part			***
	Variety ×surface		NS	Variety × part			***

NS, *, **, *** Nonsignificant and significant at P < 0.05, 0.01, or 0.001, respectively.

Table 4. Effects of eggplant shoot fortifications on growth and development of eggplant fruit and shoot borer (diets consisted of 90% commercial beet armyworm (BAW) diet and 10% fortification).

Accession	Larval mortality (%)	Pupation (%)	Larval duration (d)	Pupal duration (d)	Pupal weight (g)	Adult emergence (%)
EG 075	11.7 a	88.3 b	23.0	6.00	0.0165	73.00
EG 058	36.7 ab	63.3 ab	23.0	6.08	0.0155	74.00
Turbo	35.0 ab	65.0 ab	22.8	6.17	0.0169	68.20
BL 009	53.3 b	46.7 a	22.3	6.17	0.0135	72.20
ISD 006	35.0 ab	65.0 ab	22.5	5.77	0.0137	64.00
Check	13.3 a	86.7 b	23.1	6.00	0.0144	73.90
Tukey's HSD (0.05)	26.26	26.26	4.17	0.44	0.0043	27.52
ANOVA	***	***	NS	NS	NS	NS

NS, *, **, *** Nonsignificant and significant at P < 0.05, 0.01, or 0.001, respectively.

of pupae on both BAW diet fortified with fruits of Turbo and BAW diet alone. Pupal weight of the insects fed on all other diets was intermediate and similar to either of the extremes.

The percentage of adult emergence of EFSB on BAW diet containing 10% fruit fortification from Turbo was significantly lower than the insect fed on BAW diet containing 10% fruit fortification from all other accessions and BAW diet alone.

These results indicate that certain chemical factors present in certain eggplant accessions can interrupt insect feeding, resulting to their slower growth and development. Hence, the resistance in certain accessions could be attributed to this antibiosis.

Table 5. Effects of eggplant fruit fortifications on growth and development of eggplant fruit and shoot borer (diets consisted of 90% commercial beet armyworm diet and 10% fortification).

Accession	Larval mortality (%)	Pupation (%)	Larval duration (d)	Pupal duration (d)	Pupal weight (g)	Adult emergence (%)
EG 075	26.7	73.3	19.5 ab	8.5 ab	0.0167 ab	78.0 a
EG 058	35.0	65.0	19.5 ab	9.5 a	0.0184 a	71.0 a
Turbo	38.3	61.7	18.3 b	9.0 a	0.0147 b	43.7 b
BL 009	40.0	60.0	18.3 b	9.0 a	0.0149 ab	74.5 a
ISD 006	40.0	60.0	22.2 a	7.2 b	0.0169 a	86.4 a
Check	23.3	76.7	19.5 ab	8.5 ab	0.0132 b	83.0 a
Tukey's HSD (0.05)	29.79	29.79	3.69	1.71	0.0036	25.96
ANOVA	NS	NS	*	**	**	***

NS, *, **, *** Nonsignificant and significant at $P < 0.05$, 0.01 or 0.001, respectively.

Rearing of *Maruca* pod borer in laboratory conditions

Tropical vegetable legumes such as yardlong bean (*Vigna unguiculata* ssp. *unguiculata*, cvg. *sesquipedalia*), lablab bean (*Dolichos lablab*), common bean (*Phaseolus vulgaris*), mungbean (*Vigna radiata*) and others are important food crops grown in South and Southeast Asia. They serve as valuable sources of plant proteins in the human diet, especially in these regions where consumption of animal protein for economic or social reason is historically low. Additionally, these legumes fix their own nitrogen, thereby improving soil fertility, in many situations, at no cost.

Tropical vegetable legumes are highly susceptible to pests and diseases, which reduce yields and quality of the produce. Among the plethora of arthropod pests, mainly insects, the *Maruca* pod borer, *Maruca vitrata* (F.) (syn. *M. testulalis*) (Lepidoptera: Pyralidae), is a serious pest of vegetable legumes, particularly in *Vigna* and *Dolichos*. *Maruca* larvae attack flowers and young pods, and 20–80% yield losses are reported.

At present, farmers rely exclusively on the application of chemical insecticides to combat *Maruca* pod borer, especially on vegetable legumes such as yardlong bean and lablab bean. In order to get effective pest control, larvae must be killed within a very brief period soon after hatching from eggs laid on leaves and before they start boring inside flowers or pods, because once the larvae enter into plant parts, they are inaccessible for most ordinary control measures. This leads farmers to spray their crop very frequently. However, such excessive pesticide uses are already causing familiar economic, environmental and human health problems. In order to develop alternative safe, economical and sustainable measures to control this pest, more research is needed to understand the insect and its relationship with its host and the environment.

At present, the only way to obtain insects for study is to collect them from infested plants during the legumes growing season. Not only is it difficult to collect enough uniform-quality insects to produce reliable results, but research can only be conducted at certain times of the year, so the search for a solution to this pest problem is prolonged. In order to overcome these constraints, AVRDC has developed methods for rearing *Maruca* pod borer in the laboratory throughout the year. The procedure outlined below, used successfully at AVRDC for the past year, can form the basis of a procedure for use in any laboratory, even if some details need to be modified to suit local conditions.

Diets commonly used for rearing polyphagous insects such as *Helicoverpa armigera*, *Spodoptera exigua*, or *S. litura* can also be used for rearing *Maruca* pod borer if they are supplemented with cowpea or mungbean seed powder or sesbania (*Sesbania cannabina*) leaf powder. The formula used at AVRDC is the commercial diet developed for *S. exigua* (BAW diet) and sold by BioServe Inc., USA, with the addition of cowpea or mungbean seed powder or sesbania leaf powder to the BioServe diet mixture.

To prepare the cowpea or mungbean seed powder, we collect dry mature seeds, grind the seeds to a very fine powder, and then refrigerate in tightly sealed containers until needed. To prepare the sesbania leaf powder, we collect young tender leaves, wash them thoroughly with tap water, and chop them. We dry the chopped pieces in the sun or in an oven at 60 ºC for 48–72 hours. We grind the dried leaves to a very fine powder and refrigerate in tightly sealed containers.

For cowpea and mungbean seed powder, we add 3.5 g agar to 175 ml distilled water in a glass beaker and mix thoroughly. We slowly bring the suspension to a boil, stirring intermittently, and continue boiling until the agar has dissolved and the solution has become clear. Since diets with sesbania leaf powder dry quickly, we use 25 ml more water and prepare as explained above. The solution is allowed to cool to 55 ºC.

We combine the dried cowpea/mungbean seed powder or sesbania leaf powder with selected BAW diet in ratios of 40:60, 60:40 and 80:20 each, and pour the mixture into a large blender. We add the cooled (55ºC) agar solution, and blend the mixture thoroughly for about a minute. The diet is poured into storage containers, allowed to solidify, and refrigerated until needed.

Each diet was infested with 30 larvae in ten replications. Data were subjected to analysis of variance (ANOVA) followed by comparison using Tukey’s Honest Significance Test at the 5% probability level.

The results of the experiment are summarized in Table 6. No larval mortality was observed in Mungbean + BAW diet (60:40) +175 ml water. However, it was statistically at par with other diets such as Cowpea + BAW diet (40:60) +175 ml water, Cowpea + BAW diet (60:40) +175 ml water, Cowpea + BAW diet (80:20) +175 ml water, Mungbean + BAW diet (40:60) +175 ml water and Mungbean + BAW diet (80:20) +175 ml water, which recorded 3.33, 23.33, 13.33, 26.67 and 13.33% mortality, respectively.

None of the diets containing sesbania were suitable for rearing *Maruca* in the laboratory as they recorded higher mortality. A similar trend was also observed in pupation, pupal weight, larval duration, pupal duration and adult emergence. Hence, mungbean and or cowpea are better substrates with the BAW diet to rear *Maruca* pod borer under laboratory conditions.

Table 6. Growth and development of *Maruca vitrata* on different diet materials.

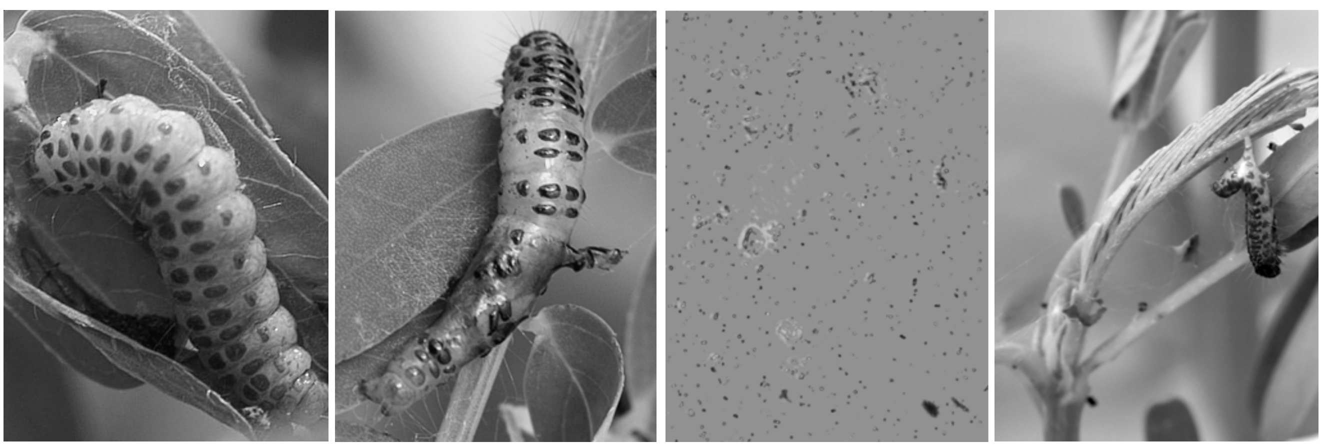
Diet	Larval mortality (%)	Pupation (%)	Larval duration (d)	Pupal duration (d)	Pupal weight (g)	Adult emergence (%)
Cowpea + BAW diet (40:60) + 175 ml water	3.33 c	96.70 a	10.22 ab	5.92 b	0.0578 a	83.33 a
Cowpea + BAW diet (60:40) + 175 ml water	23.33 bc	76.70 a	10.55 a	6.02 b	0.0568 a	60.00 a
Cowpea + BAW diet (80:20) + 175 ml water	13.33 c	86.70 a	10.67 a	6.32 b	0.0526 a	70.00 a
Mungbean + BAW diet (40:60) + 175 ml water	26.67 bc	73.30 a	11.13 a	6.73 b	0.0579 a	66.67 a
Mungbean + BAW diet (60:40) + 175 ml water	0.00 c	100.00 a	10.50 a	6.43 b	0.0579 a	76.67 a
Mungbean + BAW diet (80:20) + 175 ml water	13.33 c	86.70 a	10.80 a	5.81 b	0.0497 ab	53.33 a
Sesbania + BAW diet (40:60) + 175 ml water	86.67 a	0.00 b	11.50 a	0.00 c	0.0000 d	0.00 b
Sesbania + BAW diet (60:40) + 175 ml water	100.00 a	0.00 b	9.74 ab	0.00 c	0.0000 d	0.00 b
Sesbania + BAW diet (80:20) + 175 ml water	100.00 a	0.00 b	11.30 a	0.00 c	0.0000 d	0.00 b
Sesbania + BAW diet (40:60) + 200 ml water	83.34 a	0.00 b	10.70 a	0.00 c	0.0000 d	0.00 b
Sesbania + BAW diet (60:40) + 200 ml water	66.67 a	3.33 b	9.78 ab	0.00 c	0.0427 b	0.00 b
Sesbania + BAW diet (80:20) + 200 ml water	63.33 ab	3.33 b	9.20 ab	0.00 c	0.0282 c	0.00 b
Sesbania plant	46.67 ab	20.00 b	13.00 a	9.00 a	0.0456 b	6.67 b
Tukey’s LSD	34.39	28.52	2.68	0.95	0.0057	33.64
ANOVA	***	***	**	***	***	***

NS, *, **, *** Nonsignificant and significant at $P < 0.05$, 0.01, or 0.001, respectively.

Identification of parasitoids and a new entomopathogenic virus for the control of *Maruca* pod borer, *Maruca vitrata*

The *Maruca* pod borer, *Maruca vitrata* is the most serious constraint in the production of vegetable legumes, particularly yardlong bean, mungbean, lablab bean and cowpea, in Asia and Africa. It has also been observed in the green manure legume, sesbania (*Sesbania cannabina*), which is commonly grown in Taiwan during summer. It feeds concealed inside leaf whorls of sesbania. As sesbania is not sprayed with any pesticides, a large number of natural enemies were found attacking *M. vitrata*. Two hymenopteran parasitoids, *Apanteles taragamae* and *Dolichogenidea* sp. (Braconidae), and two unidentified dipterans (Tachinidae) were found active in the sesbania fields. The tachinids were collected and sent for identification to the Natural History Museum, United Kingdom. It was identified as *Nemorilla maculosa* (Meigen) (Diptera:Tachinidae).

A new entomopathogenic virus was recently found to be infecting *M. vitrata* in the field in Taiwan, which was probably the first report from Asia. Gel electrophoresis of the viral genome and larval symptomology identified the virus as a nuclear polyhedrosis virus (NPV) belonging to the family Baculoviridae. Baculoviruses are best known from the Lepidoptera besides Hymenoptera, Diptera and Trichoptera. The virions of NPVs are occluded in protein bodies called polyhedra and each polyhedra may contain few to many virions. After ingestion by the insect and multiplication in the nuclei of midgut cells, other tissues such as fat and epidermal, as well as haemocytes are infected. Early larval stages of *M. vitrata* are highly susceptible than the latter stages. An infected larva becomes sluggish, pinkish in color (Fig. 1), loses appetite, becomes fragile and then ruptures to release polyhedra (Figs. 2, 3). Dead larvae are often found hanging from the top of plants, a phenomenon known as tree top disease or wipfelkrankeit (Fig. 4). The infected insect will die within a few days to a week, depending upon the larval stage, dose and other environmental factors. We are now pursuing virus production techniques, establishing dose-response relationships, and evaluating the possibilities for including this virus into an integrated pest management strategy for *M. vitrata*.



Figs. 1–4. (from left to right). Larva is infected; larva ruptures; released polyhedra; and dead larva hanging from the top of the plant.

Identification of chemical attractants for striped flea beetle in pak-choi

Striped flea beetle (SFB), *Phyllotreta striolata*, is a serious insect pest of crucifers worldwide, especially in the tropics. Adult beetles lay eggs near the base of crucifer plants, which subsequently hatch into larvae that feed on plant debris in soil before pupating there. SFB adults emerge from the soil and feed on the cotyledons and true leaves of crucifers, creating shotholes. When they emerge in large numbers, they can quickly devastate young seedlings or reduce yields in mature plants. Therefore timely detection and management of this pest is important. Though farmers can control this pest by using large quantities of chemical pesticides to kill adults, soil-dwelling larvae are hard to kill by such insecticide treatments. Since the SFB are specific to crucifers, we have been attempting to extract and identify chemicals in crucifer foliage that attracts SFB, which can be employed as an alternative to pesticides. In this regard, we have employed numerous solvents and extraction procedures to isolate and identify these chemicals.

The aboveground portions of 4–5-week-old pak-choi (*Brassica rapa* L. cvg. *pak-choi*), a crucifer, were blended with water in a Waring blender. The slurry was filtered through Whatman #1 filter paper and the filtrate was bioassayed for attraction of SFB adults (Treatment 1, Table 7). Pak-choi plants were dipped in hexane, which was confined in a glass beaker for 30 s, and the beaker with plants immersed in solvent was placed in a household microwave oven and run for 30 seconds. The pak-choi plants were discarded and the extract was poured in a separatory funnel. This resulted in formation of two layers. The small water extract layer at the bottom and large hexane layer at the top were isolated and bioassayed for attraction of SFB adults (Treatments 2 and 3, respectively).

The water extract layer was quartered and the first quarter of the water layer was freeze-dried and bioassayed for attraction of SFB adults (Treatment 4). The freeze-dried water layer was then dissolved in alcohol, which was also bioassayed for attraction of SFB adults (Treatment 5). The second quarter of water fraction (Treatment 6) was acidified (pH = 4) whereas the third quarter was extracted with alkali (pH = 9). These acidified and alkali treated water extracts were then bioassayed for attraction of SFB adults (Treatments 7 and 8, respectively). The acidified and alkali treated water extracts were extracted with hexane and bioassayed for attraction of SFB adults (Treatments 9 and 10, respectively).

Table 7. Attraction of striped flea beetle to various fractions of microwave assisted extract of pak-choi leaves.

Treat-ment	Extracts	Attraction Index[1]
1	Water phase	–0.18
2	Hexane phase	–0.26
3	Hexane phase – dissolved in acetone	–0.15
4	Water phase (freeze-dried)	–0.16
5	Water phase (freeze-dried) – dissolved in alcohol	0.11
6	Water phase (pH = 4, pH = 9)	–0.22
7	Water phase (pH=4)	–0.29
8	Water phase (pH=9)	–0.06
9	Hexane phase (pH=4)	–0.27
10	Hexane phase (pH=9)	–0.17
11	Water Phase – after centrifuge (upper liquid)	–0.20
12	Water Phase – after centrifuge (lower impurity)	–0.75
13	Water Phase – after centrifuge (upper liquid + lower impurity)	–0.75
14	Flavor of pak-choi	–0.23
15	Pak-choi leaves	0.53
16	Pak-choi leaves after extraction	0.73

[1] Measured as difference between adults attracted to extract treatments minus the adults attracted to water (check treatment) divided by total number of adults released.

The fourth quarter of the water fraction (Treatment 13) was centrifuged at 10,000 rpm for 10 minutes. The supernatant and the lower sediment were collected separately and bioassayed separately (Treatments 11 and 12, respectively) and in combination (Treatment 13) for attraction of SFB adults.

Attraction tests were conducted using bioassays of various extracts to evaluate preference of SFB adults reared in laboratory on potted pak-choi plants. The insects were denied access to any food for 24 h before bioassay. The extract to be bioassayed was absorbed on a plug of cotton, and solvents were allowed to evaporate. The cotton plug was placed at one end of a 1.2-m-long, 4.5-cm-diameter hollow glass tube. At the opposite end, a cotton plug dipped in solvent only was placed to serve as check. In the central 20-cm-long detachable portion of the tube, we placed the SFB adults. The center of the detachable tube was equipped with an outlet hole in the middle. The outlet was attached to a source of suction. The entire tube was covered with dark cloth. Air from the tube was sucked continuously for 4 h and the numbers of SFB adults congregated around the plant extract or solvent check were recorded. Each such bioassay was repeated at least four times. A similar bioassay was also conducted using intact fresh leaves of pak-choi (Treatment 15) and leaves after extraction (Treatment 16). Check arms of both such tests were left empty. The Attraction Index was calculated using the following formula by counting the number of insects attracted towards the check arm and number of insects attracted towards the extract arm:

$$\text{Attraction Index (AI)} = \frac{\text{No. of adults attracted to extract treatments} - \text{No. of adults attracted to water (check treatment)}}{\text{Total no. of adults released}}$$

Fresh pak-choi (AI = 0.53) and leaves after extraction (AI = 0.73) attracted more SFB adults than the check (Table 7). However, no other extracts, except polar fraction of microwave-assisted extraction in hexane of pak-choi plants (AI = 0.11) (Fig. 5 and Table 7), showed consistent attraction of SFB adults. We have further pursued using the polar phase of microwave-assisted extract with the purpose of identification of active chemicals in this fraction through liquid chromatography-mass spectrometry (LC-MS) and it was found that the polar phase of microwave-extract has a group of compounds and not any single compound. Hence, we are further pursuing to elucidate the chemical nature of the individual compounds.

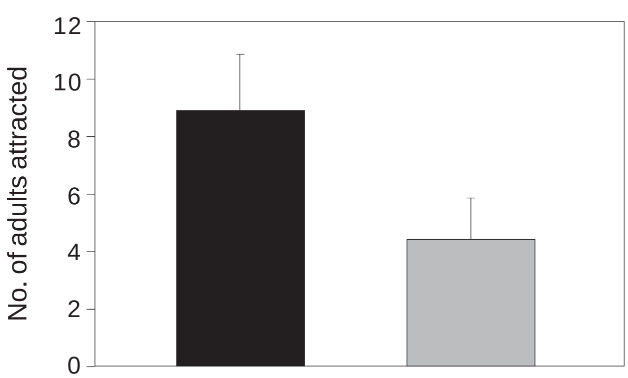


Fig. 5. Attraction of SFB to polar fraction of microwave-assisted extraction in hexane of pak-choi plants (P < *0*.001).

Production of safer tomatoes in protective shelters

The increased use of pesticides poses several socio-economic and environmental threats to producers as well as consumers. It is a growing concern of the policymakers too. Hence, various alternative pest management tactics have been advocated and adopted to reduce the intensive use of pesticides and produce safer vegetables. Growing vegetables under protective structures is one such measure to protect them from pests, which is becoming more common today, especially for leafy vegetables in peri-urban vegetable production areas. These protective structures may be either semi-permanent nylon nethouses or temporary nylon net-tunnels erected over newly planted vegetable plots. More permanent structures that utilize transparent but sturdy rainproof plastics are used mainly for fruit vegetables such as tomatoes, sweet peppers and cucumbers, which are longer duration crops. However, due to the lack of knowledge of the growers on the pests and diseases occurring in these protective structures, and due to their defective plans to keep away the pests from these structures, pesticide use for vegetables is only slightly less than in the open field. In order to learn of pest problems inside these structures and how to overcome them with minimal use of pesticides, AVRDC executed a project on production of safer tomatoes during 2002–2004 in the hot-wet season under plastic houses.

Starting in the summer season of 2002, we initiated research on production of safer tomatoes under plastic houses during summer, when supply of this vegetable is very low and prices are high. The study was taken in plastic houses of 25 × 6.5 m. Each house had a semi-circular top covered with UV-protectant clear plastic. In the center of the semicircular top, a 30-cm portion along the entire length was left free of plastic cover but closed using 32-mesh nylon net. This was done to facilitate ventilation and reduce build-up of heat inside the plastic house. The ventilation facility was made rainproof by erecting a transparent plastic shade 15 cm high and 50 cm wide over the top. The longitudinal side walls were covered with two layers of 32-mesh nylon netting with a spacing of 10 cm between the nets at the soil level and narrowed gradually until closed at 1.6 m above soil level. One end of the tunnel was closed with a single layer of 60-mesh nylon netting and at the other end we installed double doors, utilizing 60-mesh netting.

Bacterial wilt disease (BW) caused by soil-borne pathogen *Ralstonia solanacearum*, whitefly-transmitted geminiviruses (WTG) vectored by *Bemisia tabaci*, and flooding are major limiting factors during the summer season. To overcome BW, we used tomato seedlings grafted onto BW-resistant eggplant rootstock (EG 203). We used imidacloprid and acetamiprid, a new group of neonicotinoids, to reduce vectors of geminiviruses. For combating black leaf mold, caused by *Pseudocercospora fuligena*, we sprayed plants with mancozeb and benomyl.

The crop was transplanted in three 22 × 1.5 m plots inside each plastic house. The first crop of tomato (line CLN 2026D) grafted on BW-resistant eggplant was transplanted on 5 July 2002. The crop was raised using standard cultural practices, including timely application of fertilizers, weeding, pruning, and trellising of vines for easy management and harvest. Yellow sticky paper traps were used to monitor incidence of whitefly. When insect populations increased, we sprayed insecticides. When black leaf mold first appeared, we excised infected tomato leaves; however, when infection spread, we sprayed fungicides. Fruits were harvested and evaluated for marketability and incidences of blossom end rot and common armyworm (*Spodoptera litura*). At the first two harvests, we sampled the marketable fruits and immediately sent for analysis of pesticide residues at the Taiwan Agricultural Chemical and Toxic-substances Research Institute (TACTRI).

We harvested 1.30 kg of blemish-free marketable fruit (13.00 t/ha) compared with 0.59 kg/m^2 of unmarketable fruit through 12 harvests from 27 August to 06 November 2002, which was statistically significant (Table 8). We lost 0.32 kg/m^2 to blossom end rot and 0.20 kg/m^2 to unexpected *S. litura* damage. Around six weeks after transplanting, we started noticing infection of WTG. The infection increased gradually and by mid-harvest period practically all plants to varying degrees were damaged by WTG, which made us use WTG-resistant varieties in 2003. Flooding and BW were not a problem. Black leaf mold was present throughout the season but was kept under check by fungicide. *S. litura* came inside probably due to oviposition of this moth on the nylon net that lines the ventilation facilities at the top of the house.

The initial pesticide residue analysis was performed on the crop sprayed with imidacloprid, benomyl, and mancozeb on 4 October and harvested on 17 October 2002. Residues of imidacloprid, benomyl, and mancozeb were 0.11 ppm, 0.11 ppm, and below the detectable limit of 0.10 ppm, respectively. The maximum residue limit (MRL) for the three pesticides on tomato in Taiwan is 0.5, 1.0, and 2.5 ppm, respectively, for imidacloprid, benomyl, and mancozeb. A second analysis was conducted on 28 October. Residues of acetamiprid were 0.06 ppm; the tomato crop was sprayed with the labeled amount of this chemical seven days earlier. The MRL for this chemical on tomato in Taiwan is 0.06 ppm. It is concluded that protecting tomato crops with judicious use of pesticides does not necessarily leave hazardous amounts of pesticide residues and harvested crops can be considered safe to eat.

In 2003, two types of tomatoes, fresh market (FMTT904) and cherry (CHT1313) were cultivated; both types are resistant to WTG and moderately tolerant to BW. They were used in three treatment combinations: FMTT904 alone, FMTT904 grafted on EG203, and CHT1313 grafted on EG203. The crop was transplanted in three 22 × 1.5 m plots inside each 25 × 6.5 m plastic house. In each of the three plastic houses, one 22-m-long row of each treatment was transplanted on 8 May 2003. The crop was raised using standard cultural practices as explained earlier. In addition to the biotic and abiotic constraints mentioned earlier in 2002, midway through the season, tomato vines showed symptoms of magnesium deficiency in 2003. Blossom end rot, caused by the deficiency of calcium, was a serious problem. To overcome this, we sprayed calcium chloride twice during June. Among the diseases, southern blight (*Sclerotium rolfsii*) was found frequently and late blight (*Phytophthora infestans*) occasionally. We sprayed etridiazole and flutolanil in rotation whenever disease symptoms were visible. For bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*), we sprayed kasugamycin + copper oxychloride twice during July. Symptoms of black leaf mold (*Pseudocercospora fuligena*) were not present during 2003, although this disease was a problem in 2002. One week after the final sprays of acetamiprid, thiodicarb, kasugamycin and copper oxychloride, we sent marketable size fruit samples to TACTRI for analysis of pesticide residues.

Fruits were harvested five times between 14 July and 20 August. The results of quality of harvested fruits and pest damage are summarized in Table 8. The marketable yield of FMTT904 grafted on EG 203 was significantly higher than unmarketable yield. The same held true for non-grafted FMTT904. It is also notable that non-grafted FMTT904 plants yielded 1.6 times more marketable yield than grafted FMTT904 plants.

In cherry tomato, the marketable yield of CHT1313 grafted on EG203 was significantly higher than unmarketable yield. The only visible pest damage to harvested fruits was that of *S. litura*, larvae of which initially fed on foliage but later bore inside fruits. The damage was very minor and occurred in fruits harvested on 5 August in all three plots of one plastic house and one plot of another plastic house. Blossom end rot caused major damage to fruits and was responsible for overwhelming portions of unmarketable fruits. A few fruits were lost to cracking damage. These results show that it is possible to produce marketable tomato fruits during hot and rainy summer months using minimal pesticides.

The residues of pesticides we used were far below the maximum permissible limit. On FMTT904, acetamiprid residue was 0.05 ppm (maximum permissible limit, 1.0 ppm), thiodicarb, 0.04 ppm (maximum permissible limit, 1.0 ppm), and on CHT1313, 0.09 ppm of each insecticide. Application of these insecticides do not pose a health hazard to consumers if the crop raised inside the plastic houses is harvested one week after the pesticide application date. Copper oxychloride residues on FMTT904 and CHT1313 tomatoes were 0.82 and 1.82 ppm, respectively. Other chemicals were below detectable limits. We have repeated this experiment during summer of 2004 before closing the project.

In 2004, we only cultivated fresh market tomato line FMTT904. The crop was transplanted on 5 May 2004, in three 22 × 1.5 m plots inside each 25 × 6.5 m plastic house. The crop was raised using standard cultural practices as explained earlier. To overcome BER, we sprayed calcium chloride once during June. Among the diseases, southern blight was found frequently and we sprayed etridiazole and flutolanil in rotation whenever disease symptoms were visible. For *S. litura*, we sprayed chlorfenapyr + permethrin during May. Fruits were harvested five times between 8 July and 19 August.

The results of quality of harvested fruits are summarized in Table 8. The marketable yield of FMTT904 was significantly higher than unmarketable yield. The only visible pest damage to harvested fruits was that of *S. litura*. The damage was very minor and occurred in fruits harvested on 5 August in two plots of only one plastic house. Blossom end rot was responsible for overwhelming portions of unmarketable fruits. These results reinforced our earlier finding that it is possible to produce marketable tomato fruits during hot and rainy summer months using minimal pesticides.

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Table 8. Yield and marketable quality of tomato fruits grown under plastic houses.[1]

Year	Variety	Parameter	Yield (t/ha)	t-value	*P* > T
2002	CLN2026D[2]	Marketable	13.00		
		Armyworm damage	1.99	6.692	0.022
		Blossom end rot	3.24	9.319	0.011
		Unmarketable[3]	5.93	5.364	0.033
2003	FMTT904[2]	Marketable	12.47		
		Armyworm damage	0.01	8.168	0.015
		Unmarketable	6.07	4.053	0.056
	CHT1313[2]	Marketable	32.52		
		Armyworm damage	0.01	16.093	0.004
		Blossom end rot	0.12	16.090	0.004
		Unmarketable	0.21	16.156	0.004
	FMTT904				
		Marketable	20.26		
		Armyworm damage	0.04	10.104	0.001
		Unmarketable	3.49	8.375	0.014
2004	FMTT904	Marketable	19.74		
		Armyworm damage	0.01	16.279	0.001
		Unmarketable	2.77	14.698	0.001

[1] Transplanted 8 May 2003 and 5 May 2004.
[2] Plants were grafted onto eggplant EG203 rootstock.
[3] Includes small-sized fruits and those damaged by common armyworm (*Spodoptera litura)* or blossom end rot.

Bacteriology

Pre-evaluation scheme for forming local integrated management packages to control tomato bacterial wilt

Bacterial wilt (BW) caused by *Ralstonia solanacearum* is a major constraint for tomato production in the hot and humid tropics and subtropics. The pathogen is soil-borne, can survive in soil for a long period, has a wide host range, and can be transmitted via water, soil, and seedlings. All these properties make the disease difficult to control.

Planting BW-resistant materials has been the main strategy for disease control; this involves either planting a tomato variety that resists the disease or grafting tomato scions onto disease-resistant rootstocks of tomato or eggplant. However, resistance to BW in tomato can be location- or strain- specific. It is not clear whether resistance to BW wilt in eggplant has similar properties.

A mixture of urea and slaked lime has also been reported to control BW on tomato; however, the efficacy can be soil dependent. Therefore, the objective of this study is to design a pre-evaluation scheme and to subsequently conduct an on-farm trial to test the usefulness of the pre-evaluation in designing local integrated management packages.

Our approach was first to understand the local strain profile and then use representative strains for selecting suitable planting materials. Local soil samples were used to determine the efficacy of a soil amendment, which consisted of urea and lime for controlling BW. Then an on-farm trial was conducted to test various combinations of control methods based on the results of pre-evaluation tests.

A tomato production site located at Chunglin, Hsintzu, Taiwan, was selected as the case study site; a local survey recently found that BW was the most important disease in the area. Fifty-two BW strains were collected from symptomatic tomato plants in the locality in 2001. Each strain was inoculated onto three differential varieties, i.e., L390 (susceptible), L180-1 (moderate resistant), and Hawaii 7996 (H7996; resistant). Strains with known aggressiveness, i.e., Pss190, Pss4 and Pss216, were included for comparison. Data of the final percent wilted plants were used to group the strains by cluster analysis with the average linkage method. One strain per cluster was selected to evaluate a set of tolerant commercial varieties and resistant lines at the seedling stage. Biocidal efficacy of urea and slacked lime was tested on a soil sample collected from the on-farm trial site. The soil was artificially infested with Strain CLss7, which belongs to the local predominant group, with the final density at 10^7 cfu/g soil level, covered as a pile under plastic sheeting and incubated at room temperature for 14, 21 or 28 days. Tomato seedlings (21-days-old with four fully expanded leaves) of L390 were then transplanted into pots containing soils with different incubation time and then grown in the greenhouse under a mean temperature at 28°C. Disease incidence was recorded 21 days after transplanting.

Based on the pre-evaluation results, treatments with different combinations of control methods were tested in an on-farm trial in autumn of 2003. The trial site had a severe tomato bacterial wilt outbreak in the autumn of 2002. The following spring and summer, tomato and other vegetables were cultivated to maintain the high pathogen density. The inoculum density was uniform in the trial site, as 17 out of 20 soil samples randomly collected from the site contained pathogen density ranged from 1.2×10^3 to 5.8×10^4 colony-forming unit (CFU) per gram of dry soil before treatment. The trial was conducted following RCBD with three replications. There were 100 plants per plot with 45-cm spacing. The trial began by applying soil amendment on 14 July, transplanting on 18 August, and recording until 1 December 2003.

The 52 local strains were clustered into three groups based on their aggressiveness (Table 1). Comparing with the three control strains, the local strains are most similar to Pss4, a predominant strain in Taiwan, but with higher aggressiveness on Hawaii 7996. Seedling evaluation results of tested tolerant hybrid varieties and resistant lines are listed in Table 2. All commercial hybrid varieties tested were not resistant to the three local strains. Eggplant line EG203 was the most resistant to all three tested strains. Based on the results, EG203 and Hawaii7996 were selected as eggplant and tomato rootstocks, respectively, and Taichung AVRDC#10 (T-AVRDC10), a popular hybrid variety, was selected to be the tomato variety for the on-farm trial.

Table 1. Aggressiveness profile of *R. solanacearum* strains collected from wilted tomato in Chung-Lin, Hsintzu, Taiwan.

		Mean final percent wilted plants (%)		
Cluster[1]	Strain no.	L390	L180	Hawaii 7996
1	5	98.3	68.3	11.7
2	33	91.4	16.2	13.9
3	14	88.7	43.5	37.5
Pss190		100.0	83.3	75.0
Pss4		100.0	66.7	0.0
Pss216		58.3	8.3	8.3

[1]Clusters of strains were defined by the average linkage method with three clustering criteria (pseudo-t, pseudo-F, and ccc).

A combination of urea and slaked lime provided the most consistent and speedy effect in reducing the pathogen density and disease incidence based on the results of the pot trial (Table 3). Moreover, incubation with a 28-day period had the largest efficacy of treatments. Slaked lime alone reduced disease incidence significantly without having a significant biocidal effect. Therefore, the urea and slaked lime combination combined with a 28-day incubation period was applied for the field trial.

Results of the on-farm trial are shown in Table 4. The grafting treatments significantly reduced disease incidence and had the highest yield. No significant differences in yield and fruit weight were observed among the four grafting treatments. However, fruits from the treatments with eggplant rootstock had significantly higher soluble solids. The effect of soil amendment on disease control was only significant at 21 to 42 DAT in the treatments with non-grafted plants as well as in plants grafted onto tomato rootstock at 105 DAT. Grafting plants onto eggplant root stock EG 203 makes it unneccessary to apply soil ammendments.

The above results indicated that effective treatments in pre-evaluation tests were also displaying significant effect in the field trial. Thus the pre-evaluation scheme is valuable in designing local integrated management packages. Considering disease pressure, fruit quality and economic inputs, local farmers can formulate their own integrated strategy. The effectiveness of the pre-evaluation scheme is being tested at different locations to evaluate their general adaptation potential.

Table 2. Evaluation of tomato and eggplant varieties against 4 strains of *R. solanacearum* at seedling stage.

Variety	Pss4	SaS1-3	SnS1-2	SnS1-7	Mean
L390	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a
Taichung-AVRDC #4	50.0 c	100.0 a	100.0 a	100.0 a	87.5 b
Hualien-AVRDC #5	69.3 b	100.0 a	100.0 a	100.0 a	92.4 ab
Taoyuan-AVRDC #9	69.7 bc	100.0 a	91.7 a	100.0 a	90.3 ab
Taichung-AVRDC #10	72.3 bc	100.0 a	100.0 a	100.0 a	93.1 ab
FMTT553	64.0 bc	100.0 a	97.3 a	97.3 a	89.6 b
Hawaii7996	3.3 d	33.3 b	50.3 b	61.0 b	37.0 c
EG203	6.7 d	12.0 c	4.7 c	0.0 d	5.9 e
EG219	5.3 d	52.7 b	11.0 c	11.0 c	20.1 d

Mean separation in columns by Duncan's multiple range test at $P < 0.05$.

Table 3. Efficacy of soil amendments on reduction of *R. solanacearum* soil density (Rs) and disease incidence (W%: percent of wilted plants at 21 days after transplanting) when different incubation periods (14, 21, or 28 days) were applied.

	14 days		21 days		28 days	
Soil amendments	Rs	W%	Rs	W%	Rs	W%
Urea (825 kg/ha)	6.8[2] b	56.7 a	5.1 b	6.7 c	4.7 b	6.7 b
$Ca(OH)_2$ (3,993 kg/ha)	7.1 ab	16.7 b	6.8 a	26.7 b	6.6 a	6.7 b
Urea (825 kg/ha) + $Ca(OH)_2$ (3,993 kg/ha)	6.3 c	6.7 b	5.4 b	7.0 c	4.8 b	3.3 b
No amendment (check)[1]	7.2 a	70.0 a	7.1 a	53.3 a	7.0 a	60.0 a

[1] The bacterial density in the soil was 7.5 $\log_{10}$(CFU/g of dry soil) before applying the soil amendments.
[2] Data are presented in $\log_{10}$[(CFU/g of dry soil) + 1]], which were mean of three replications, three plates per replication.
Mean separation in columns by Duncan's multiple range test at $P < 0.05$.

Table 4. Effect of different integrated control methods on incidence of bacterial wilt, tomato quality and yield in an on-farm trial.

Scion / rootstock	Soil amendment[1]	Days after transplanting 21	42 (% wilted plants)	105	Soluble solids (°Brix)	Fruit weight (g)	Yield[2] (t/ha)
T-AVRDC10	Yes	12.9 b	51.9 b	88.4 a	-	-	1.8 b
T-AVRDC10	No	36.3 a	78.3 a	92.9 a	-	-	2.0 b
T-AVRDC10 / H7996	Yes	0.0 b	1.7 c	18.4 c	4.9 b	177 a	37.2 a
T-AVRDC10 / H7996	No	2.9 b	14.2 c	47.2 b	4.8 b	166 a	23.3 a
T-AVRDC10 / EG203	Yes	0.0 b	0.0 c	0.9 c	5.2 a	166 a	35.7 a
T-AVRDC10 / EG203	No	0.0 b	0.4 c	2.8 c	5.4 a	160 a	35.8 a

[1] Soil amendment consisted of 825 kg urea and 3,993 kg slaked lime per hectare.
[2] Yield data was calculated during the harvesting period from 61 to 105 days after transplanting.
Mean separation in columns by Duncan's multiple range test at $P < 0.05$.

Evaluation of resistance to bacterial wilt in chili pepper in India, Indonesia, Taiwan, and Thailand

Bacterial wilt, caused by *Ralstonia solanacearum*, is an important disease for pepper production in the hot and wet tropical regions. The disease can cause complete wilting of the plant and thus complete yield loss is possible. The pathogen is soil-borne, can survive in the soil for a long time, and has a very wide host range including several hundred species of plants belonging to 44 families.

Planting resistant varieties is the most efficient way for controlling this disease. AVRDC has identified several varieties that resist a single Taiwanese strain. It is known that resistance to bacterial wilt in tomato could be location-specific and strain-specific. It is not known whether a similar phenomenon exists in pepper. Therefore, the objective of this study is to evaluate the stability of resistance sources to bacterial wilt against different strains and environments present in India, Indonesia, Taiwan and Thailand either by seedling or field screening.

A set of 12 resistant varieties and 1 susceptible variety has been assembled and provided to all collaborators (Table 5). The 12 resistant varieties were selected at AVRDC against Pss71. The screening results of the three Taiwanese strains (Pss71, Pss229 and Pss272) were reported in 2003. Evaluations of two Thai strains (T1178 and T1563) were conducted in May 2004 in Thailand by Ms. Nuttima Kositcharoenkul, Department of Agriculture. The two strains were both biovar 3 and were the most aggressive ones among the 36 tested local strains when inoculated on PBC142 (Pant C-1; a moderately resistant variety) (data not shown). Inoculation was conducted following the same method used at AVRDC. Ten plants per entry were evaluated. Inoculated plants were kept in a greenhouse with mean maximum and minimum temperatures at 37 and 26°C, respectively. Disease incidences were recorded over time until 21 days after inoculation.

Evaluation trials in India and Indonesia were conducted in fields where local *R. solanacearum* populations (predominantly biovar 3 strains) have been maintained for screening purposes. The Indian trial (IN02) was conducted by Dr. Madhvi Reddy, Indian Institute of Horticultural Research, Bangalore. The transplanting date was 27 January 2002 and final recording date of disease incidence was in May 2003. The trial was conducted following RCBD with 2 replications and 3 to10 plants per variety per replication.

The Indonesian trial (INDEW) was conducted by Mr. Asep Harpenas at Purwakarta, East-West Seed Indonesia. The transplanting date was 14 July 2004 and final recording date of disease incidence was on 1 November 2004. The trial was conducted following RCBD with 4 replications and 10 plants per variety per replication. ANOVA and mean comparisons were conducted for those replicated trials. Cluster analysis and correlation analysis were performed using mean final disease incidence. Results of IN02 trial were not included in the cluster analysis due to the absence of one entry.

Variability on the stability of resistance to bacterial wilt among tested varieties was observed (Table 5). For example, resistance in PBC631B was not stable, as the mean final disease incidence ranged from 0 to 83.3%. On the contrary, resistance in PBC384 was more stable with mean final disease incidence ranged

Table 5. Mean percent final wilted plants of pepper varieties in each evaluation trial.

Variety	Pss272	Pss229	Pss71	IN02	INDEW	T1178	T1563	Mean
PBC384	0.0 d	2.8 de	0.0 c	5.9 c	10.0 b	0.0	0.0	2.7
PBC631A	8.3 cd	2.8 de	2.8 c	NT	6.7 b	0.0	0.0	3.4
PBC204	2.8 d	0.0 e	0.0 c	0.0 c	5.0 b	20.0	10.0	5.4
PBC385	27.8 c	2.8 de	0.0 c	0.0 c	15.0 b	0.0	0.0	6.5
PBC473	0.0 d	2.8 de	0.0 c	21.4 bc	0.0 b	40.0	0.0	9.2
PBC066	16.7 cd	8.3 de	2.8 c	14.3 c	7.5 b	20.0	0.0	9.9
PBC535	16.7 cd	33.3 c	0.0 c	25.0 bc	2.5 b	10.0	0.0	12.5
PBC375	2.8 d	2.8 de	0.0 c	25.0 bc	22.5 b	60.0	0.0	16.2
PBC1347	0.0 d	0.0 e	0.0 c	6.7 c	15.0 b	50.0	60.0	18.8
PBC743	22.2 c	8.3 d	2.8 c	61.5 a-c	10.0 b	100.0	0.0	29.3
PBC631B	61.1 b	27.8 c	0.0 c	50.0 a-c	83.3 a	20.0	40.0	40.3
PBC067	69.4 b	86.1 b	25.0 b	92.3 ab	17.5 b	40.0	100.0	61.5
PBC1367 (susc. ck)	97.2 a	100.0 a	94.4 a	100.0 a	100.0 a	60.0	60.0	87.4

Mean separation in columns by Duncan's multiple range test at $P < 0.05$.
NT = not tested.
Note: data were transformed by arcsine for ANOVA and mean comparisons.

only from 0 to 10%. PBC384 and PBC631A were the most stable varieties judging from their small range of final disease incidence and the lowest mean final disease incidence over trials.

Results of cluster analysis grouped PBC067 with PBC1367, the susceptible check. There were no other clear-cut groupings. However, several pairs of varieties were identified to have similar trends of reactions over trials. They were PBC384 with PBC631A, PBC066 with PBC204, and PBC375 with PBC473.

Results of correlation analysis clearly showed that T1178 is a unique strain, as the results did not correlate significantly with all the other trials (Table 6). Repeated trials should be conducted with this strain. Moreover, further studies should be conducted to determine the distribution of strains similar to T1178 in order to decide whether it should be a breeding target.

Without consideration of T1178, results of seedling screenings with Pss272 and Pss229 were significantly correlated with all other trials. Therefore, these two strains should replace Pss71 in routine screening at AVRDC, as they are more likely to select for stable resistance.

In conclusion, the results indicated that PBC384 and PBC631A were the varieties with most stable resistance. PBC631A is a non-pungent pepper, and could be used in sweet pepper breeding. Strains Pss272 and Pss229 could be used at AVRDC for selection of stable resistance to bacterial wilt.

Table 6. Pearson correlation coefficients (n=13) among mean final percent wilted plants of each evaluation trial.

	Pss272	Pss229	Pss71	IND02	INDEW	T1178	T1563
Pss272	1.00	0.91****	0.79**	0.86***	0.81***	0.20	0.68*
Pss229		1.00	0.84***	0.89****	0.62*	0.22	0.74**
Pss71			1.00	0.74**	0.71**	0.31	0.52
IND02				1.00	0.61*	0.53	0.66*
INDEW					1.00	0.20	0.47
T1178						1.00	0.24
T1563							1.00

*, **, ***, **** Signficant at $P < 0.05$, 0.01, 0.001, and 0.0001, respectively.

Mycology

Host plant resistance for control of tomato late blight

Late blight incited by *Phytophthora infestans* is the most damaging foliar and fruit disease of tomato in cool and wet environments. Currently, there are no cultivated tomato varieties that have effective resistance against late blight in Taiwan and many other countries of the world. For this reason, AVRDC initiated a program to identify sources of resistance in wild tomato species and then introgress resistance genes into cultivated tomato. To understand pathogen variation, a total of 183 isolates of the fungus were collected during 1991 to 2001 in Taiwan among which tomato races T1; T1,2; T1,2,3;T1,4; and T1,2,4 have been putatively identified by using differential hosts carrying different resistant genes. Resistance to T1,2 was identified in *L. pimpinellifolium* (L3707, L3708, and others) and *L. hirsutum* accessions (L3683, L3684, LA1033, and others). These resistant accessions were first shown to be resistant to Taiwan populations of *P. infestans* by testing them in the field at differential locations. Nineteen accessions of *L. hirsutum* and *L. hirsutum* f. *glabratum* were identified to be resistant to T1,2 and T1,2,3 (Table 1).

The resistant source L3708 was used as the donor parent and resistance was introgressed into tomato by backcrossing and selection with a tomato race T1,2 isolate. Moneymaker was the parent for the initial cross and first backcross; the second and third backcrosses were carried out with the AVRDC line CLN657-285-0-21-0. Nine BC_3F_6 inbred lines designated CLN2037 (A–I) exhibited high levels of resistance under conditions of artificial inoculation. Thereafter AVRDC also developed five hybrids FMTT791 through FMTT795, using CLN2037 lines as the resistant parent crossed with L4783. These hybrids also exhibited high levels of resistance in the greenhouse. To evaluate the durability of late blight resistance, multi-location trials in Taiwan were conducted beginning in 1995.

Resistance in L3708, its derivatives, and LA1033 held up throughout the 1995 crop season and through most of the season in 1996. Toward the end of the 1996 season a new race (T1,2,3) appeared in Puli that overcame the resistance of L3708 and lines developed from L3708, but did not overcome the resistance of LA1033. In 1997 this pattern was repeated. All tested resistant lines and hybrids held up in trials conducted from 1998 to 2001. However, late in the season of 2002 trial in Hualien, the advanced lines with resistance derived from L3708 showed severe symptoms, but not the parent L3708 itself or LA1033. During 2003, the same result occurred in the Puli and Hsinshe but not in Hualien. However, during 2004, the resistance of advanced lines was overcome in Hualien again (Table 2).

These results indicate that the breakdown of resistance in inbred lines and hybrids was due to the occurrence of new races T1,3 and T1,2,3,4. We suspect that L3708 may possess at least two R genes for late blight resistance, but only one of the genes was introgressed into the advanced lines. Therefore, pyramiding genes from different resistant sources into AVRDC tomato lines may be valuable to develop tomatoes with durable resistance to late blight.

Table 1. Disease severity scores[1] of accessions of wild tomatoes resistant to *Pi*-16 and *Pi*-42.

Line	Species	Pi-16 (Race T1,2)	Pi-42 (Race T1,2,3)
LA0387	*L. hirsutum*	1.67	1.60
LA1352	*L. hirsutum*	1.75	1.00
LA1353	*L. hirsutum*	2.00	1.30
LA1361	*L. hirsutum*	2.00	1.10
LA1363	*L. hirsutum*	1.42	1.20
LA1737	*L. hirsutum*	2.36	1.20
LA1740	*L. hirsutum*	1.92	1.00
LA1775	*L. hirsutum*	1.67	1.80
LA1777	*L. hirsutum*	1.75	2.50
LA2158	*L. hirsutum*	1.58	0.40
LA2159	*L. hirsutum*	1.08	0.30
LA2204	*L. hirsutum*	1.50	0.60
LA2324	*L. hirsutum*	2.09	1.30
LA2556	*L. hirsutum*	2.00	1.90
LA2650	*L. hirsutum*	1.92	0.80
LA2098	*L. h.* f. *glabratum*	1.50	1.30
LA2099	*L. h.* f. *glabratum*	2.46	0.70
LA2128	*L. h.* f. *glabratum*	2.42	1.30
LA2869	*L. h. f. glabratum*	2.25	1.70

[1]Disease severity < 2.50 was rated as a resistant reaction.

Table 2. Disease reaction of resistant sources and resistant lines to *Phytophthora infestans* in Hualien, Hsinshe, and Puli during 2002 to 2004.

	2002			2003			2004		
Entry	Hualien	Hsinshe	Puli	Hualien	Hsinshe	Puli	Hualien	Hsinshe	Puli
L3708	R	R	R	R	R	R	R	R	R
LA1033	R	R	R	R	R	R	R	R	R
Inbred lines[1]	S	R	R	R	S	S	S	R	R
F_1 Hybrids[2]	S	R	R	R	S	S	S	R	R

[1]Nine BC_3F_6 inbred lines derived from L3708.
[2]Five F_1 hybrids derived from CLN2037 line.

Species identification and phylogenetic relationship of *Colletotrichum* species associated with pepper anthracnose in Taiwan

Several *Colletotrichum* species have been reported as agents causing pepper anthracnose. Recently, AVRDC has developed both phenotypic and molecular criteria in order to overcome the difficulty of using morphological characteristics alone in species identification. Molecular characterization using specific-PCR primers has been considered a reliable and efficient tool. However, identification results of Taiwan isolates showed high specificity on *C. acutatum* (Ca) and *C. capsici* (Cc) only. A high degree of morphological variation and inconsistent results from these isolates, which previously were analyzed by using specific-PCR primer CgINT and identified as *C. gloeosporioides* (Cg), indicate that they may be a heterogeneous and complex species. With the recent progress of molecular analysis, some new species with differences in morphology have been reported and segregated from *C. gloeosporioides* sensu lato. Therefore, the objectives of this study were: 1) to understand the phylogenetic relationships of *Colletotrichum* species associated with pepper anthracnose in Taiwan; and 2) to develop specific polymerase chain reaction (PCR) primers for species differentiation that leads to understanding the pathogen profile through accurate species identification.

Because the internal transcribed spacer (ITS) sequences of four Taiwan *Cc* isolates have been sequenced in previous studies, 14 cylindrical conidia type of *Colletotrichum* isolates with diverse characteristics were selected for ITS sequencing in this study. Fungal culture and genomic DNA extraction followed the protocol described in AVRDC Report 2003. The ITS region (including ITS1-5.8S-ITS2) was amplified by PCR using primer ITS4 and ITS5. After 0.7% agarose gel electrophoresis, PCR product was recovered and purified using Perfect prep gel cleanup kit equipment (Eppendorf AG, Hamburg). Sequencing of those PCR products were then carried out on an automated sequencer (model ABI Prism 3730, Tri-I Biotech Inc., Taiwan). Sequencing data including four previous *Cc* isolates were analyzed and transformed to multiple sequence files using BioEdit version 7.0.1. Then a phylogenetic tree was generated based on the neighbor-joining method according to the Jukes-Cantor model through the use of MEGA version 2.1.

The result of sequence analysis revealed significant DNA divergence in the ITS1 region, which could be valuable for species delineation. High DNA homology was found among isolates of *Ca* and *Cc* species while higher divergence was found in previously identified *Cg* species. Two ITS1 types were identified in the *Cg* group, each type having its own unique sequence. Only one of these two types matched with the sequences specific to PCR primer *Cg* INT. This result explained why the primer *CgINT* cannot be extensively used for species identification of *Cg* group. Surprisingly, some *Cg* isolates exhibited closer phylogenic relationships to *Cc* although they had major differences of conidial shape. They were separated into two distinct clades (Fig.1). Those isolates were further characterized for growth rate, casein hydrolysis activity, colony and conidial morphology. Isolates with different ITS1 type were also apparently different in several morphological traits (Table 3).

Therefore, two putative *Cg* types based on morphological and cultural characteristics and molecular evidence were classified. *Cg* type 1 was identified as *Cg* isolates that matched the morphological description defined by Sutton in 1992 and showed specificity to primer *CgINT*. However, the isolates of *Cg* type 2 showed the following differences compared

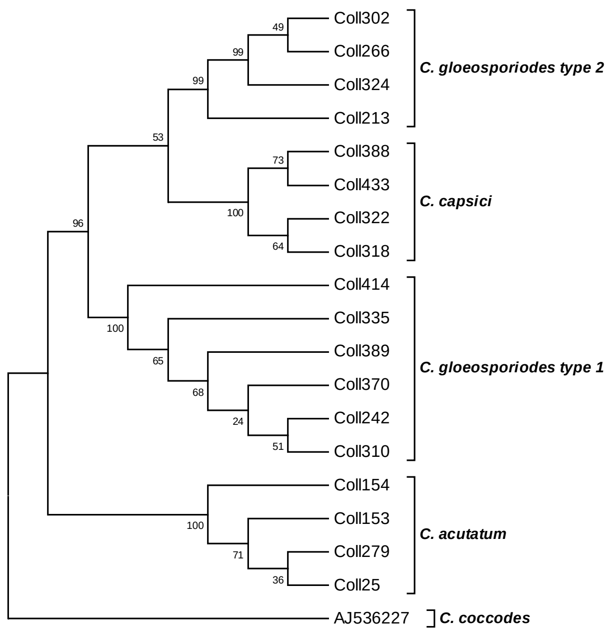


Fig 1. Phylogenic relationship of pepper anthracnose isolates *Colletotrichum* species collected in Taiwan based on neighbor-joining (NJ) analysis of the ITS region according to Jukes-Cantor model.

Percentages of NJ analysis of 600 bootstrapped data set that support specific branches are indicated at the respective nodes. Four distinct phylogenetic groups were identified while a sequence AJ536227, ITS of *C. coccodes* obtained from NCBI, was used as out-group.

to *Cg*. First, they usually grew slower and showed cream to orange reverse color on PDA plating. Second, they had wider conidia often with hilum-like conidial bases and irregular appressoria. Third, they harbored apparent ITS1 sequences. Based on the phenotypic evidences and DNA homology of ITS, Cg type 2 was identified as *C. boninense* (Cb), which was recently identified and segregated from *C. gloeosporioides* by Moriwaki et al.. A specific PCR primer (*Cg*2f: 5'-ccgtcccctgaaaa-3') was designed from ITS 1 region for the identification of this species.

In this study, four *Colletotrichum* species associated with pepper anthracnose have been identified. The phenotypic and molecular characteristics of these four species are summarized in Table 3. Criteria described in AVRDC Report 2003 were successfully used for identifying *Ca* and *Cc*. However, *Cg* and *Cb* were not easy to distinguish since they produced similar shape of conidia. PCR identification using a species specific primer is considered a reliable tool to differentiate them.

Molecular tools showed that they could increase the accuracy of species identification even for types that showed morphological variation or sporulation reduction due to long-term preservation. A total of 252 Taiwan *Colletotrichum* isolates collected from peppers and maintained at AVRDC from 1992 to 2004 were identified through the above mentioned procedures.

Table 3. Comparisons of putative *Colletotrichum species* associated with pepper anthracnose.

Characteristics	*C. acutatum*	*C. boninense*	*C. capsici*	*C. gloeosporioides*
Mycelium color	White to gray	White	White to gray	White to dark gray
Perverse colony color	Orange-pink or dark olive	Cream, yellow, or orange	Dark brown	Black, gray, white or pink
Presence of acervuli	Nil	Sometimes present	Often present	Sometimes present
Conidia shape	Fusiform of cylindrical, most with acute end	Cylindrical with obtuse end, often with a hilum-like conidial base	Falcate with acute apex	Cylindrical with obtuse end
Conidia size(µm)	15.1(12.8–16.9) × 4.8(4.0–5.7)	14.9(14.2–16.0) × 6.5(6.0–7.1)	23.9(21.8–28.4) × 4.8(4.4-–5.4)	15.6(14.9–16.8) x 4.7(4.3–4.9)
L/B ratio	3.1	2.3	5	3.3
Appressorium	round to ovate	ovate, sometimes with shallow lobe	Nt.	ovate to irregular in shape with lobes
Growth rate at 28°C (mm/day)	5.3 (4.0–6.0)	9.0 (8.0–11.0)	7.3 (5.8–8.6)	13.3 (10.4–15.0)
Protease activity	Most with strong	None	None	None, with one exception
ITS1 length	181 bp	190 bp	177 bp	171 bp
Specific primers	CaINT2/ITS4	Cg2f/ITS4	CcINT2/ITS4	CgINT/ITS4
Remark		Designated as *Cg* type 2 before		

A total of 160 *Ca* isolates, 45 *Cc* isolates, 31 *Cg* isolates and 16 *Cb* isolates were accurately identified. These results confirmed that *Ca* was the predominant species causing pepper anthracnose in Taiwan during 1992 to 2004. Although *C. coccodes* has been reported as a causal agent of pepper anthracnose, it has not previously been identified in Taiwan. Identification and characterization procedures can be further improved using advanced molecular biotechnology.

Virology

Studies on tomato leafcurl geminiviruses

Tomato (yellow) leaf curl disease, caused by tomato (yellow) leafcurl geminiviruses (ToLCV or TYLCV) is one of the major production constraints of tomato in the tropics and subtropics. Varieties with stable resistance are not available, mainly because of the genetic diversity of the virus and the narrow genetic base of host plant resistance so far used by breeders worldwide. AVRDC has been addressing this problem systematically in that various host plant resistances and their stability are being identified and tested, and the genetic diversity of the geminiviruses across different locations assessed.

Geographic distribution

Leaf samples from symptomatic tomato, chilli. eggplant, okra, and weeds were collected from 15 countries in Asia, Central America and Africa and tested by polymerase chain reaction (PCR) for the presence of geminiviruses.

The presence of geminiviruses on tomato was confirmed in Bangladesh, Cambodia, Viet Nam, Thailand and Mali (Table 1). For the first time we detected ToLCV on field-grown tomato in China, (Guangxi province) where a high incidence leafcurl disease has recently been observed. We also reported a first record of ToLCV in Ethiopia. This virus will be cloned and sequenced to determine its genetic relationship with other tomato-infecting geminiviruses on the African continent.

A geminivirus was also detected from peppers in India and Laos. An interesting finding was the presence of geminivirus on eggplant in Vietnam and okra in Mali (Table 1).

Geminivirus was not found on pepper in Barbados, tomato and pepper in the Ivory Coast and Tanzania, nor pepper in Korea, Mali and Taiwan. More samples need to be collected and tested to confirm absence of geminiviruses on peppers in the Ivory Coast, Barbados and Mali. It is possible that the local geminiviruses, even those from tomato, as is the case with the Taiwan tomato leafcurl virus, do not infect peppers.

Table 1. Geminivirus survey of major solanaceous crops, other crops and weeds in 2004.

Country	Host	Sample no.	Positive sample no.	(%)[1]
Bangladesh	Tomato	8	8	(100)
Barbados	Pepper	43	0	
Cambodia	Tomato	1	1	(100)
China	Tomato	2	2	(100)
Ethiopia	Tomato	17	14	(82)
Guatemala	Tomato	115	49	(43)
India	Pepper	11	3	(27)
Ivory Coast	Tomato	4	0	
	Pepper	3	0	
Korea	Pepper	1	0	
Laos	Tomato	1	0	
	Pepper	1	1	(100)
Mali	Tomato	139	52	(37)
	Pepper	8	0	
	Okra	16	6	(38)
Taiwan	Tomato	81	64	(79)
	Pepper	14	0	
	Cabbage	1	0	
Tanzania	Tomato	50	0	
	Pepper	2	0	
	Weed[2]	2	0	
Thailand	Tomato	8	2	(25)
Vietnam	Tomato	11	11	(100)
	Eggplant	1	1	(100)
Total	Tomato	437	203	(46)
	Pepper	83	4	(5)
	Okra	16	6	(38)
	Cabbage	1	0	
	Eggplant	1	1	(100)
	Weed	2	0	0

[1]Polymerase chain reaction using the degenerate primer pair PALlv1978B/ PARlc715H.

[2]*Amaranthus* sp., *Solanum nigrum.*

Molecular characterization and diversity of exotic geminiviruses

Six tomato geminiviruses from the Philippines, El Salvador, Mexico, Sudan and Uganda, one pepper geminivirus from Sri Lanka and one geminivirus from the common weed *Ageratum* sp. from India were cloned and sequenced this year. Great molecular diversity was observed (Table 2). The geminivirus from

Sri Lanka was found to be a new geminivirus, which is distinct from the Sri Lankan tomato geminiviruses previously identified by AVRDC in the same location. This virus also contained a satellite DNA-beta. The tomato geminiviruses from Mexico were found to be bipartite and having >95% sequence homology with Tomato mottle virus (ToMoV)-[Florida] in both DNA-A and DNA-B.

The tomato geminivirus from El Salvador was identified as a strain of Tomato chino La Paz virus, which was reported previously from Baja California. The virus did not have DNA-beta or DNA-B.

The tomato geminivirus from Uganda was a distinct new geminivirus; its closest sequence similarity (81%) was with the South African cassava mosaic virus. The Sudan tomato geminivirus was found to be a distantly related (91% sequence homology) strain of the Tomato leaf curl Sudan virus identified in 2001 by other researchers. This brings the number of different tomato geminiviruses in Africa to eight different species.

Genetic diversity of DNA-beta

The genome composition of whitefly-transmitted begomoviruses is either monopartite (DNA-A only) or bipartite (DNA-A and DNA-B). Some begomoviruses also contain DNA-beta, a satellite DNA, which contains the geminivirus stem loop structure and the conserved nonanucleotides TAATATTAC. This satellite is believed to be involved in symptom induction/ expression.

Twelve DNA-beta, including eight from tomato, two from *Ageratum* sp., and one each from *Zinnia* sp. and *Cucurbita maxima* were detected by PCR, by using an abutting primer pair. PCR-amplified DNA products of all but one DNA-beta (TW 1 To) were sent to S.E. Bull (John Innes Centre, UK) for sequencing. The size of the DNA-beta ranged from 667–1383 bp. (Table 3). The sequence homology of these 12 DNA-betas was lower than 89% (Fig. 1) and there was no relationship with the corresponding DNA-As (Fig. 1). It was generally believed that DNA-beta only occurs in monopartite geminiviruses. Our work has shown, however, that bipartite geminiviruses can also contain DNA-beta. The exact role of these satellites vis à vis symptom expression in tomato needs to be further investigated.

Genetic diversity of the Taiwan tomato leafcurl virus

Eight geminivirus isolates were collected from farmer's fields in the main production areas in five counties in Taiwan. The DNA-A was cloned and sequenced according to standard methods.

The presence of DNA-beta was determined by using a beta specific primer pair, Beta 01/Beta 02. The DNA-A sequence homology for six of the isolates with the type strain (TW1-Taiwan), which was originally isolated from Tainan county, was high, ranging from 94–98% (Table 4). This indicates that the six isolates are very closely related strains of the type strain. However, two isolates collected from Hsinchu, i.e., Hsinchu 3 and Hsinchu 1, showed only 81 and 77% sequence homology with the type strain, respectively.

Table 2. Geminivirus cloned and sequenced in 2004.

Country (location)	Crop[1]	Clone	DNA type[2]	Virus with highest sequence similarity (Gene Bank accession)	Sequence similarity (%)
India (Hebbal)	A	IMAC	A[3]	*Ageratum* yellow vein Sri Lanka virus (AF314144)[4]	91
Philippines (San Leonardo)	T	BL1	A	Tomato leaf curl Philippines virus (AB050597)	94
Sri Lanka (M. Illuppallama)	P	LK13	A[3]	Tomato leaf curl Sri Lanka virus (AF 274349)[4]	84
EL Salvador (Opico)	T	SalV1	A	Tomato chino La Paz virus-[Baja California Sur](AY339619)	94
Mexico (Ya'axtian)	T	Mex3	A	Tomato mottle virus-[Florida] (L14460)	98
"	"	"	B	Tomato mottle virus-[Florida] (L14461)	97
Sudan	T	Sud1	A	Tomato leaf curl Sudan virus (AY044137)	91
Uganda	T	Ug11	A	Tomato leaf curl Mayotte virus (AJ865341)	83

[1] A = *Ageratum* sp.; T = tomato; P = pepper.

[2]A = DNA-A; B = DNA-B.

[3]These viruses also contain DNA-beta (1.3 Kb). All other viruses do not contain DNA-beta.

[4]Identified by AVRDC.

Table 3. DNA-beta isolated from geminivirus-infected plant hosts in Asia.

Code	Country (location)	Crop	Genome of helper virus[1]	Symptom[2]	Size (bp)
BD To	Bangladesh (Gazipur)	Tomato	b	c	1383
IN To	India (New Delhi)	Tomato	b	c	1369
LA To	Laos (Savannakhet)	Tomato	m	c, y	1348
NP To	Nepal (Jhapa)	Tomato	m	c	1350
LK To	Sri Lanka	Tomato	m	c	1371
TW1 TN	Taiwan (Tainan)	Tomato	m	c	898
TW1 Central	Taiwan (Changhua)	Tomato	m	c	1350
TW1 North	Taiwan (Hsinchu)	Tomato	m	c	965
MY Ag	Malaysia (Klang, Johore)	*Ageratum*	NT	vy	1348
LK Ag	Sri Lanka	*Ageratum*	m	vy	1351
TH Zi	Thailand (Pattaya)	*Zinnia*	m	c	1354
MY Cu	Malaysia (Selangor)	*Cucurbita maxima*	NT	yM	667

[1]b = bipartite; m = monopartite; NT = DNA-A present, but not tested for DNA-B.
[2]vy = vein yellowing; c = leafcurling; y = yellowing; yM = yellow mosaic.

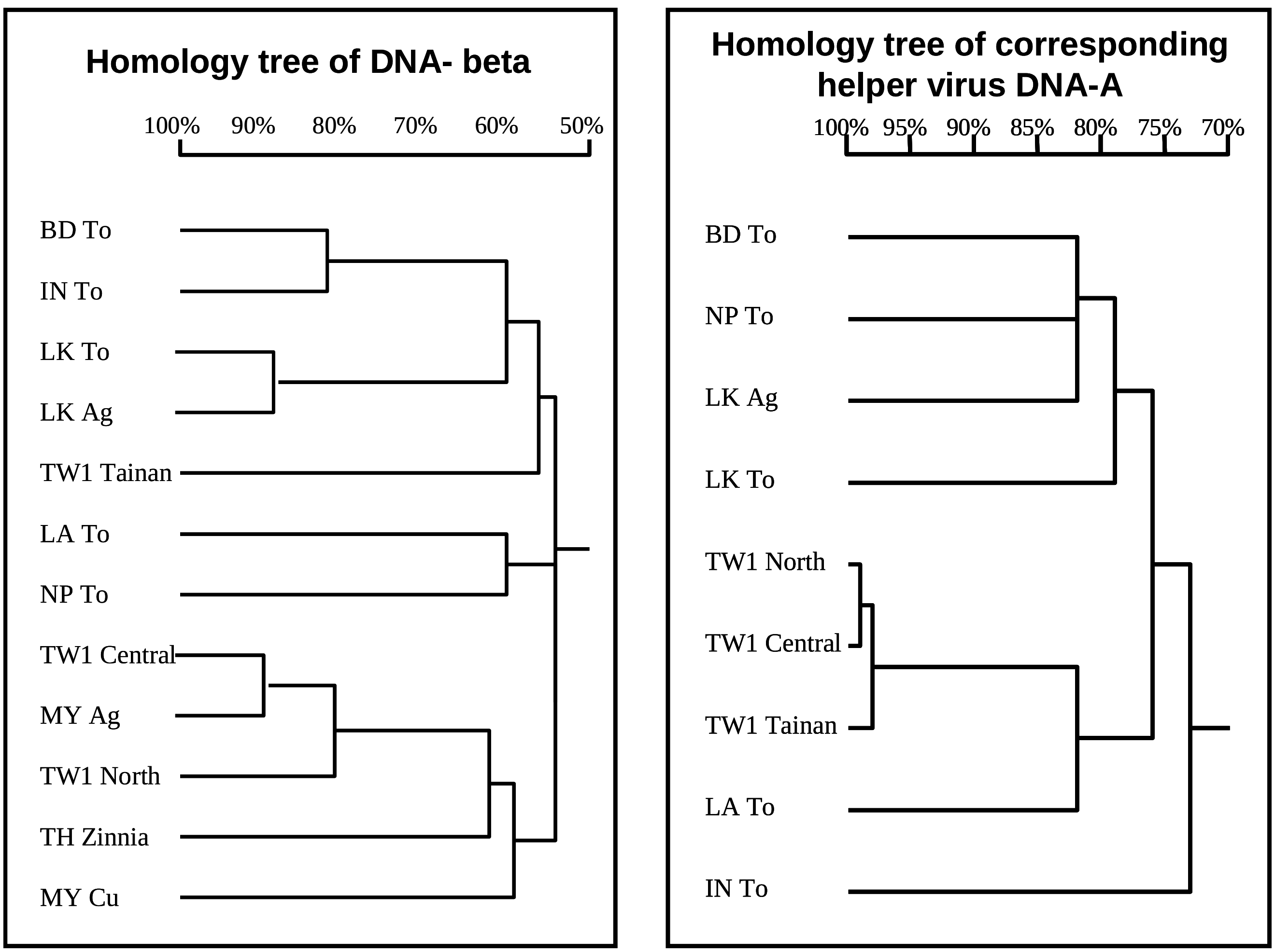


Fig. 1. Homologies of selected DNA-beta and the DNA-A of the corresponding helper viruses.

Table 4. Complete DNA-A nucleotide sequence identities (%) of ToLCV-TW isolates and selected other geminiviruses.

	Hsin-chu 3	Hsin-chu 1	Hsin-chu 2	Tao-yuan	Chang-hua	Tainan	Taitung	Hualien 1	Hualien 2	AYVV-TW/ Hualien
TW3/Hsinchu3	100	76	82	81	81	81	81	81	82	93
TW2/Hsinchu 1		100	77	76	77	77	77	77	77	77
TW1/Hsinchu 2			100	99	99	98	95	96	94	78
TW1/Taoyuan				100	99	98	95	96	94	78
TW1/Changhua					100	98	95	96	94	78
TW1/Tainan						100	96	96	94	78
TW1/Taitung							100	97	94	78
TW1/Hualien 1								100	94	78
TW1/Hualien 2									100	78
AYVV-TW/Hualien										100

One tomato geminivirus collected from Hsinchu area (TW-Hsinchu 3) was found to be a recombinant geminivirus. Sequence comparisons and alignments showed that the nucleotide region from 2047–2733 (= 687 bp) showed 92% sequence identity with the ToLCV-TW1/Hualien 2, whereas the remaining sequence showed highest sequence identity (99%) with Ageratum yellow vein virus (AYVV)-TW/Hualien (Fig. 2). This virus is additional evidence for the high genetic diversity of tomato geminiviruses caused by recombination.

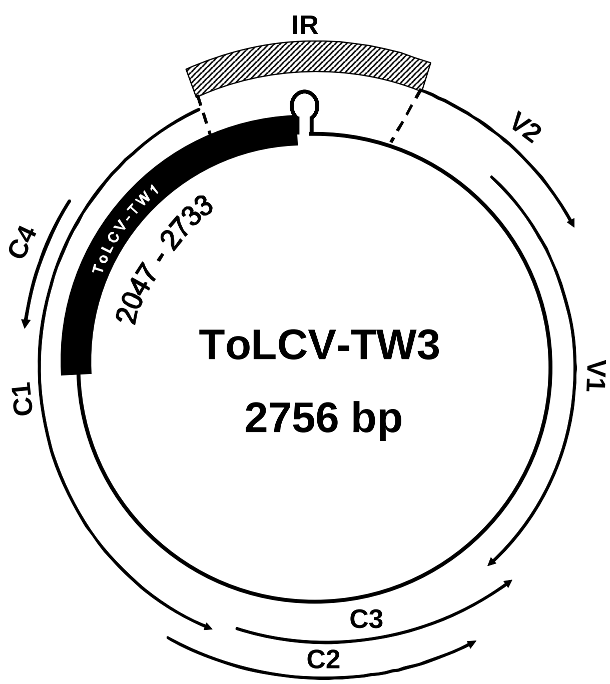


Fig. 2. Genome organization of ToLCV-TW3, a recombinant geminivirus of ToLCV-TW1/Hualien and Ageratum yellow vein virus-TW/Hualien.

Specific primers will be developed and a survey conducted to determine how widely spread these two new tomato geminiviruses are in Taiwan. It will also be interesting to find out whether the *Ty-2* resistance gene present in the newly developed tomato lines for Taiwan will also hold up against these three new tomato geminiviruses, especially the recombinant geminivirus which originated from tomato but whose main part of the genome (2069 bp) is that of AYVV.

On-farm evaluation of tomato leaf curl virus disease control measures in Taiwan

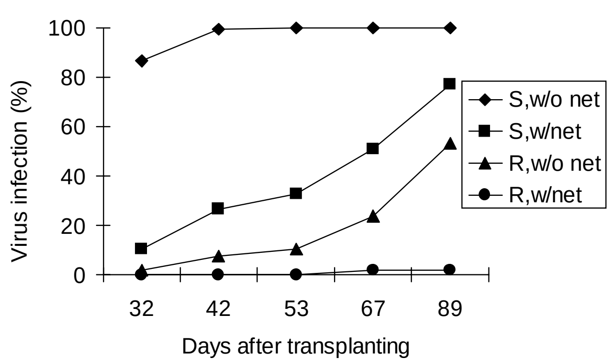
Yield losses due to tomato leaf curl disease are reported to range from 55–75%. Seedling protection by nets as well as alternate weekly insecticide applications have often been recommended, but their efficacy not clearly demonstrated. In this trial, four control measures, including a ToLCV-tolerant variety (FMTT904 F_1, indeterminate fresh market, with *Ty-2* resistance gene in the heterozygous condition), a field nethouse (7.5 m × 7.5 m × 2.4 m high, 60-mesh), seedling protection (60-mesh), and insecticide application were evaluated for their effect on virus infection and marketable yield.

Seeds were sown on 4 March 2004 and transplanted to the AVRDC field in April. The field layout was a split plot design with three replications. Mainplot factors included field nethouse and insecticide spray, and subplot factors included variety and seedling protection. For each combination, 20 plants per plot were planted in double rows with 50 cm spacing between plants. The insecticide treatment consisted of weekly application of alternate imidacloprid 9.6% EC (2000X dilution), binfenthrin 2.8% EC (1000X dilution), methomyl 90% WP (1500X dilution) and pymetrozine

25% WP (1500X dilution). Leaves were collected at 32, 42, 53, 67 and 89 days after transplanting (DAT) for the detection of ToLCV by nucleic acid hybridization using a 1.4-kb digoxigenin-labeled DNA-A probe specific for ToLCV-Taiwan (TW-1). Leaf samples were also collected from two tomato plants for nucleutide sequencing. Fruits were harvested weekly from 53 to 88 DAT.

The virus causing leaf curl symptoms in the AVRDC experimental field was confined to be ToLCV-TW-1. ToLCV incidence increased in both varieties over time. In the open field, mean ToLCV incidence (10 and 48%) in the resistant line at the first and last harvest, respectively, were significantly lower than in the ToLCV susceptible line (FMTT33) where it was 100% at both harvest dates.

Under the nethouse, mean ToLCV incidence in the resistant line was nil and 2.5% respectively at first and last harvest compared to 33 and 77%, respectively, in the susceptible line (Fig. 3). Mean marketable yield of the resistant line was significantly higher than that of the susceptible variety (Table 5). Nethouse and seedling protection considerably reduced ToLCV infection and increased yield (Fig. 3, Table 6). The effect of insecticide on ToLCV infection and yield was however not significant (Table 7). Seedling protection did not significantly affect ToLCV infection and yield in the open field but did significantly increase yield in the nethouse.



S = susceptible line FMTT33; R = resistant line FMTT904
W/o net = open field; w/ne = field nethouse (60-mesh)

Fig. 3. Percent virus infection in ToLCV resistant vs. susceptible tomato varieties planted under the net and in the open field.

It is concluded that the use of a tolerant variety or protection by a field nethouse (which may or may not be economical), is a better and safer measure to control tomato leaf curl disease under Taiwan vector and virus pressure in the spring season rather than weekly applications of insecticide.

Table 5. Effect of variety and seedling protection on marketable yield.[1]

Treatment	Marketable yield (t/ha)		
	Protection	No protection	Difference
Resistant (FMTT904)	32.7	29.4	3.3^{NS}
Susceptible (FMTT33)	17.6	14.6	3.0^{NS}
Difference	15.1**	14.8**	

[1]Average of two nethouse treatments, two insecticide treatments and three replications.
^{NS}, *, ** Nonsignificant and signficant at $P < 0.05$ and 0.01, respectively.

Table 6. Effect of field nethouse and seedling protection on marketable yield.[1]

Treatment	Marketable yield (t/ha)		
	Protection	No protection	Difference
Field nethouse	39.5	32.3	7.2**
Open field	10.9	11.8	–0.9^{NS}
Difference	28.6**	20.5**	

[1]Average of two insecticide treatments, two varieties, and three replications.
^{NS}, *, ** Nonsignificant and signficant at $P < 0.05$ and 0.01, respectively.

Table 7. Effect of insecticide spray and seedling protection on marketable yield.[1]

Treatment	Marketable yield (t/ha)		
	Protection	No protection	Difference
Insecticide	27.2	24.9	2.3^{NS}
No insecticide	23.2	19.2	4.0^{NS}
Difference	4.0^{NS}	5.7^{NS}	

[1]Average of two nethouse treatments, two varieties, and three replications.
^{NS}, *, ** Nonsignificant, and signficant at $P < 0.05$ and 0.01, respectively.

Characterization of ChiVMV in pepper

Chili veinal mottle virus (ChiVMV) is the most important and prevalent virus on peppers throughout tropical and subtropical Asia. Based on differential host plant (*Capsicum* sp.) reactions of the various ChiVMV isolates, the virus seems to occur as strains. The objective of this study was to find a more effective way to identify and differentiate these strains.

Confirmation of biological strains of ChiVMV

As part of the BMZ/GTZ-funded chili project "Development of locally adapted multiple disease-resistant and high-yielding chili (*Capsicum annuum*) cultivars for targeted countries in Asia (India, China, Thailand, Taiwan, and Indonesia)," the diversity of pathogens, including that of ChiVMV, in the targeted countries is very important. More than 100 different *Capsicum* sp. were initially evaluated for their usefulness as strain differentials by symptom observation and detection of virus by ELISA following mechanical inoculation with eight Taiwan isolates.

Four strains were previously identified (*2002 AVRDC Report*). Based on their reactions on six selected *Capsicum* hosts, the Taiwan ChiVMV isolates could now be classified into five strains: strain 1 (isolates 3380 and 1037), strain 2 (isolate 3389), strain 3 (isolate 3525), strain 4 (isolate 3384) and strain 5 (isolates 714, 3215, 3488) (Table 8).

Molecular characterization of ChiVMV

The full-length ChiVMV genomic RNAs of eight Taiwan isolates were sequenced. The virus was maintained in *Nicotiana glutinosa*. Viral RNAs were extracted from virus-infected *N. glutinosa* by Rneasy Plant Mini Kit (Qiagen, Inc., Hilden, Germany) and cDNAs were synthesized using specifically designed primers. The cDNAs were amplified by PCR using the previously described primer pair (1)- Oligo(dT)/ CVMV-1037Pol, as well as designed primers. The PCR-amplified DNA products of the Taiwan ChiVMV isolates were cloned and sequenced and the completed genomic RNA sequence assembled and analyzed.

The genome length of the Taiwan ChiVMVs was 9.7 Kbp. Sequence comparisons showed that the sequences of the eight Taiwan ChiVMV isolates are highly homologous, showing >98% nucleotide sequence identities with each other (Fig. 4). Sequence alignments

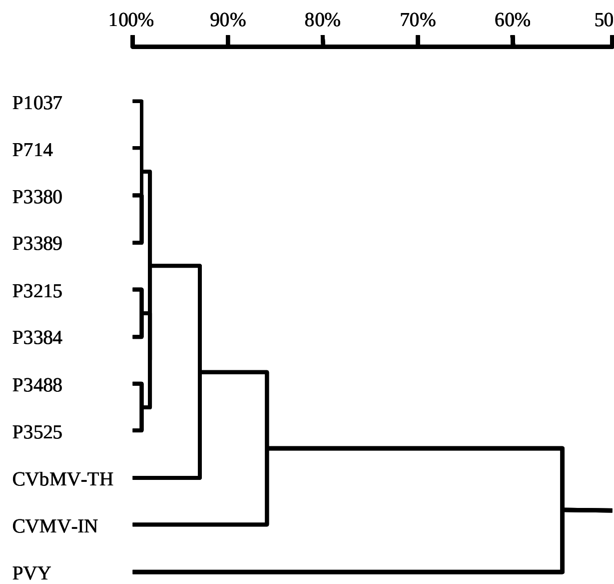


Fig. 4. Homology tree of full length genomic RNA sequences of Taiwan ChiVMV isolates with respect to exotic ChiVMV reference isolates from Thailand (CVbMV-TH) and India(CVMV-IN) and potato virus Y (PVY).

Table 8. Reactions of Taiwan ChiVMV isolates on selected differential *Capsicum* sp. hosts.

Line	3380, 1037	3389	3525	3384	714, 3215, 3488
VC16 a No. 3-2-1-1-2-1-1	R	R	R	R	R
VC240-1-1-1-3-2	R	R	R	R	S
PBC148A-1-1-1-1-1	R	R	R	R	S
VC31a-1-1-3	R	R	R	S	S
PBC142A-1-1-1-2-2	R	R	R	S	S
VC5a-1-1-1-1	R	R	S	S	S
PBC365-1-1-1	R	S	S	S	S

R = resistant, no virus detected by ELISA.
S = susceptible, that is, clear symptoms of virus (mosaic, mottle, or leaf deformation) detected by ELISA.

indicated that the nucleotide differences were distributed throughout the genome and are not localized in one particular genomic region. However, alignment of the eight Taiwan ChiVMV sequences with chili vein banding virus (CVbMV) from Thailand and chili veinal mottle virus (CVMV) from India (GenBank Assc. No. AJ237843), both considered local isolates of ChiVMV, showed less than 91% and 86% nucleotide sequence homology, respectively.

Because of their high sequence homology it may be difficult to distinguish Taiwan isolates by specific primers. It will, however, be possible to distinguish the Indian, Thai, and Indian ChiVMV strains from Taiwan strains by specific primers, selected from the heterogeneous regions.

Characterization of CMV resistance in pepper

One pepper accession (code: CCVR) was found to be resistant to the severe Taiwan strain of cucumber mosiac virus (CMV) P 3613. To study the mechanism of its resistance, healthy scions of CCVR were grafted onto CMV-inoculated rootstocks of VC 27 (susceptible to all CMV isolates) and PBC 370, which shows partial resistance (systemic latent infection, no symptoms, virus restricted to vascular tissue virus detectably by ELISA) to three pepper CMV isolates, i.e. AN (from India), P 3613 (from Taiwan) and RS 30 (from Thailand).

The symptoms in the rootstocks are shown in Table 9. The grafted CCVR scions developed clear mosaic symptoms when grafted onto rootstocks inoculated with RS 30 and AN isolates. However, when grafted onto P 3613-infected rootstocks, the CCVR scions developed local ringspots in some of the leaves, even though it is resistant to P 3613 (no virus, no symptoms, and negative in ELISA) when directly inoculated mechanically.

Table 9. Symptoms[1] of line CCVR grafted onto rootstocks inoculated with different CMV isolates.

Line	Isolate	Rootstock inoculation	Scion CCVR grafting	Inoculation
VC 27	AN	M	M	M
	P 3613	M	RS	-
PBC 370	AN	sl	M	M
	P 3613	sl	RS	-
	RS 30	sl	M	-

[1] M = mosaic; sl = systemic latent infection (no symptoms, but virus detected by tissue printing and ELISA); RS = ringspot; - no symptoms, no virus detected by ELISA.

The virus, which is present in the infected rootstock in high concentration, must have moved via the phloem into the “resistant” scion. It is assumed that a high virus load is transmitted this way and the plant defense mechanism obviously is not able to fully cope with the high dose of inoculum. Virus occasionally escaped from the phloem, as shown by positive tissue prints, inducing a hypersensitive resistant reaction, i.e., ringpots, in some of the leaves. The virus was however prevented from moving further within the plant.

Three kinds of partial resistance to CMV in distinct *Capsicum* accessions have been previously identified: restriction of virus establishment in the host-cells, restriction of virus multiplication throughout the whole plant, and restriction of long-distance within plant movement. Resistance to the long-distance movement of CMV is a common resistance mechanism in *Solanaceous* crops. However, a hypersensitive response against CMV, such as the one reported here, has never been observed. It is assumed that the resistance mechanism of line VC 246 versus certain CMV isolates, which was detected in related studies, seems to be different from the ones previously described and warrants further attention.

Contact: Sylvia Green

Crop and Ecosystem Management

Year-round vegetable production under shelters with furrow and drip irrigation systems

Fertilization and irrigation are standard management practices for vegetable production. Farmers need to improve their efficiency in these practices so as to maximize profits. Excessive fertilization is not only costly to farmers, but may also harm the environment. Water is becoming too scarce to waste in crop production, even in the humid tropics, and particularly in the dry season.

AVRDC has initiated a project on drip irrigation to address this problem. Compared to furrow irrigation, drip irrigation uses less water, improves yield and quality of vegetables, promotes efficient use of fertilizers, and reduces the risk of ground water contamination. Although drip irrigation of vegetables has been studied extensively and numerous literatures are available elsewhere, studies on drip irrigation water requirements for most vegetables in the tropics during the wet and dry seasons are few. The objectives of this study were to 1) develop and adapt micro-irrigation technologies for year-round vegetable production; and 2) compare water and fertilizer use efficiencies of vegetables under furrow and drip irrigation systems.

Three crop sequences were established under three rain shelter treatments; these were irrigated using furrow and drip irrigation systems. The crop sequences were 1) tomato–cabbage, 2) cucumber–yardlong bean, and 3) chili pepper–pak-choi. The shelters were 1) single bed, 2) double bed, and 3) open field (no shelter). The field study was conducted during the hot-wet season for the first crops (tomato, cucumber and chili pepper) followed by a second planting (cabbage, yardlong bean and pak-choi) during the hot-dry season. The total duration period of the field study was 6 months (May to October).

The field experiment was designed using a split-split plot arrangement with four replications. The main plots were vegetable crops while shelters and irrigation systems were assigned as subplots and sub-subplots, respectively. Using this field design, each crop consisted of 6 treatment combinations (3 shelter types × 2 irrigation methods).

The basic components of the microirrigation (drip) system consisted of a 10-ton water storage tank with a sink-pump (0.5 kg/h), a filtration system, water distribution system with main and sub-main lines made of PVC tubes, a check valve, controller, pressure gauge, and fertilizer injectors. Irrigation water was delivered via drip tubing (Netafim) at a constant pressure and flow rate of 25 ml/min/emitter. Water flow from the tank was controlled by a check valve. Irrigation frequency was based on soil moisture tension maintained at –20 kPa at 15–30 cm depth.

Furrow irrigation consisted of applying water through the furrows between raised beds until water infiltrated the soil profile and wet the whole bed at field capacity. Irrigation scheduling was based on maintaining the soil moisture at field capacity.

Crops were grown on raised beds that were 6 m long, 30 cm high, and 2.4 m wide with bed top width of 1.0–1.2 m. All crops were planted on double rows per bed. Cultural practices used for each crop were as follows:

Tomato. Grafted transplants were used in this trial. Seeds of eggplant rootstock EG203 and tomato scion TLCV15 were sown on 25 March 2004. Grafting was accomplished on 14 April and grafted seedlings were transplanted on 17 May 2004. Plants were spaced 50 cm in rows spaced 1 m apart, resulting in 26,666 plants/ha. Under furrow irrigation, basal fertilizer was applied using organic fertilizer (4N–1.7P–3.3K) at the rate of 120 kg/ha. This was followed by a band application of compound fertilizer (15N–6.5P–12.5K) at the rate of 60 kg/ha with three subsequent sidedressings of the same fertilizer rate (except the third sidedressing) at 2 and 5 weeks after transplanting and after the first harvest. Total fertilizer application for furrow irrigated tomato was 360N–135.5P–273.9K kg/ha. Drip irrigated tomato received half of the fertilizer applied for furrow irrigated tomato. Basal organic fertilizer (4N–1.7P–3.3K) was applied at the rate of 60 kg/ha followed by a band application of compound fertilizer (15N–6.5P–12.5K) at the rate of 30 kg/ha. The remaining fertilizer was applied in weekly fertigation rate of 108N–46.4P–89.6K kg/ha using soluble fertilizer formulation. For drip-irrigated tomato, the total fertilizer application was 198N–85.1P–164.3K kg/ha.

Leaf samples were collected at 45 days after transplanting for NO_3-N sap analysis using the Cardy nitrate meter. Data were collected on yield per plant, fruit number, marketable fruit yield, and water and fertilizer use. The experiment was terminated on 15 August 2004 after the last harvest sample was collected.

Cucumber. Seeds of cucumber cv. 'New Crunch-398B' from Evergrow Seed Co. were sown in plastic pots (6 × 7 cm) on 3 May 2004. Seedlings at 4-leaf stage were transplanted into field on 18 May 2004. Plant spacing was 50 cm within rows spaced 1 m apart, resulting in 26,666 plant/ha. The fertilizer rate and application method for furrow-irrigated cucumber was similar with that used for furrow irrigated tomato. The total fertilizer application for furrow-irrigated cucumber was 360N–135.5P–273.9K kg/ha. Total fertilizer applied for drip-irrigated cucumber was 270N–116.1P–224.1K kg/ha. NO_3-N in plant sap was determined from leaf samples 25 days after transplanting by similar method used for tomato. Data were collected on yield per plant, fruit number, marketable yield and water and fertilizer use. The trial was terminated on 23 July 2004.

Chili pepper. Grafted plants were used for this trial. Seeds of chili pepper line 9852-54 for rootstock were sown on 25 March 2004. Grafting was performed on 24 April 2004 using scions of chili pepper cv. 'Delicacy 05193'. Grafted seedlings were transplanted in open field and rain shelters on 19 May 2004. Plant spacing was similar to that of tomato. Total fertilizer application for furrow-irrigated chili pepper was 420N–141.9P–298.8K kg/ha. Drip-irrigated chili pepper received a total fertilizer rate of 264N–113.5P–291.1K kg/ha. NO_3-N in plant sap was determined from leaf samples 45 days after transplanting using similar method for tomato. Other data collected were plant yield, fruit number, marketable yield and water and fertilizer use. The trial was terminated on 30 October 2004 after the last harvest sample was collected.

Cabbage. Following tomato, seeds of common cabbage cv. 'Sharfoung' from Known-You Seed Co. were sown in seedling PE-pots (6 × 7 cm) on 4 August 2004. Seedlings were transplanted in 3-row beds one month (3 September 2004) after sowing. Plant spacing was 50 cm between rows and 50 cm between plants equivalent to plant population of 38,300 plants/ha. Furrow-irrigated plots received a total fertilizer rate of 180N–77.4P–149.4K kg/ha, respectively. Drip-irrigated crop received half of the same fertilizer applied for furrow irrigated crop. NO_3-N in plant sap was determined from leaf samples 35 days after transplanting using similar method for tomato. All other parameters were determined similar to other crops. The field trial was terminated on 5 November 2004.

Yardlong bean. After the cucumber crop was harvested, seeds of yardlong bean cv. 'Kaohsiung Green Pod' were directly sown in 2-row beds on 29 July 2004. Two plants per hill were maintained 5 days after seedling emergence. Plant spacing was 1.0 m between rows and 50 cm between plants resulting in a plant population of 26,666 plants/ha. The furrow- and drip-irrigated plots received similar fertilizer rates applied for cabbage. Data were collected on NO_3-N in leaf samples 25 days after sowing as well as number of pods and pod yield. Water and fertilizer use efficiencies were also determined after the field trial was terminated on 5 November 2004.

Pak-choi. Short-maturing leafy vegetable pak-choi was planted after chili pepper. Seeds of pak-choi cv. 'Green-leaf' from Known-You Seed Co. were sown on 22 October 2004 and transplanted on 5 November 2004. Plants were spaced 15 cm (rows) and 10 cm (plants within rows) equivalent to plant population of 170,000 plants/ha. The furrow-irrigated crop was fertilized with urea at the total rate of 46N–0P–0K kg/ha while the drip-irrigated crop was applied with 18N–6P–14.9K kg/ha. Plant sap analysis for NO_3-N was determined 3 weeks after transplanting. Plant yield, water and fertilizer use were determined at the end of the field trial on 22 November 2004.

Results

Tomato. Shelters had no significant influence on the number of marketable fruits and yield (Table 1). However, tomatoes grown under the double-bed shelter produced lower number of fruits and marketable yield compared to the single-bed shelter and open field. The effect of irrigation method was not significant (P >0.05). Plots under furrow irrigation produced slightly more marketable fruits than drip-irrigated plots. There was no significant interaction between shelter and irrigation method in all yield parameters.

The effect of shelter and irrigation on NO_3-N uptake (content) in leaf and petiole was not significant; however, there was a tendency for higher NO_3-N uptake in open field compared to shelters (Table 2). Total plant NO_3-N under drip irrigation was significantly higher than furrow irrigation, indicating increased fertilizer use efficiency..

Although crops grown with drip irrigation had lower number of fruits, marketable yield was similar. Water use per plant was significantly reduced (>50%) under drip irrigation (Table 5). With drip irrigation, water use per plant was 29.7 L compared to 62.5 L under furrow irrigation. This indicates 52.5% water use efficiency in drip irrigation (Table 5).

Cucumber. The effects of shelter on cucumber yield and fruit number were significant (Table 1). Vines grown under the single-bed shelter produced the highest number of fruits and total yield. Fruit size under shelters (data not shown) was larger than those in the open field. The effect of irrigation method was also significant for number of fruits, but not for marketable yield. Drip irrigation resulted in significantly higher number of fruits compared to furrow irrigation (Table 1). The interaction between shelter and

Table 1. Marketable fruit number and yield of tomato, cucumber and chili pepper as influenced by shelter and irrigation method during the hot-wet season, 2004.

Crop	Shelter	Irrigation	Fruits (000/ha)	Yield (t/ha)
Tomato	Open	Drip	544	20.2
		Furrow	550	21.6
		Mean	547	20.9
	Single bed	Drip	545	21.2
		Furrow	602	22.7
		Mean	573	21.9
	Double bed	Drip	452	18.7
		Furrow	433	16.7
		Mean	443	17.7
		Drip mean	514	20.0
		Furrow mean	528	20.3
Cucumber	Open	Drip	197	31.6
		Furrow	193	32.7
		Mean	195 b[1]	32.1 b
	Single bed	Drip	256	44.7
		Furrow	224	42.0
		Mean	240 a	43.4 a
	Double bed	Drip	228	38.0
		Furrow	188	34.4
		Mean	208 b	36.2 b
		Drip mean	227 a	38.1
		Furrow mean	201 b	36.4
Chili pepper	Open	Drip	5210	37.0
		Furrow	4534	31.0
		Mean	4872	34.0 b
	Single bed	Drip	6053	43.0
		Furrow	5741	42.0
		Mean	5897	42.5 a
	Double bed	Drip	4331	31.0
		Furrow	3538	24.0
		Mean	3934	27.5 c
		Drip mean	5198	37.0 a
		Furrow mean	4604	32.3 b

Tomato, cucumber and chili pepper transplanted on 25 March, 3 May, and 25 March 2004, respectively, at AVRDC.

[1] Mean separation in columns by Duncan's multiple range test, $P < 0.05$.

Table 2. Nitrate nitrogen uptake in leaf blade, petiole and total plant tissues of tomato, cucumber and chili as influenced by shelter and irrigation method during the hot-wet season, 2004.

Crop	Shelter	Irrigation	Leaf	Petiole	Plant
			(NO_3-N, mg/L)		
Tomato	Open	Drip	83.5	490	1518
		Furrow	78.5	380	1395
		Mean	81.0	435	1456
	Single bed	Drip	77.5	555	1627
		Furrow	69.5	428	1223
		Mean	73.5	492	1425
	Double bed	Drip	74.3	455	1414
		Furrow	71.5	390	1288
		Mean	72.9	423	1351
		Drip mean	78.4	500	1520 a[1]
		Furrow mean	73.2	399	1302 b
Cucumber	Open	Drip	70.3	863	1602
		Furrow	56.5	698	1335
		Mean	63.4	780 ab	1468
	Single bed	Drip	76.0	735	1461
		Furrow	60.3	670	1385
		Mean	68.1	703 b	1423
	Double bed	Drip	86.0	870	1675
		Furrow	75.3	795	1497
		Mean	80.6	833 a	1586
		Drip mean	77.4 a	823 a	1579 a
		Furrow mean	64.0 b	721 b	1406 b
Chili	Open	Drip	244	345	2484
		Furrow	253	463	2593
		Mean	249	404	2538
	Single bed	Drip	244	345	2484
		Furrow	231	585	2790
		Mean	238	465	2637
	Double bed	Drip	260	490	2712
		Furrow	426	665	3245
		Mean	343	578	2978
		Drip mean	257	393 b	2560 b
		Furrow mean	303	571 a	2876 a

Tomato, cucumber and chili pepper transplanted on 25 March, 3 May, and 25 March 2004, respectively, at AVRDC.

[1] Mean separation in columns by Duncan's multiple range test, $P < 0.05$.

irrigation method was not significant for all measured parameters.

Among shelters, significant differences in NO_3-N uptake were found in petiole but not in leaf and plant tissue (Table 2). Highest petiole NO_3-N was found in the double-bed shelter and lowest in the single-bed shelter. This was also reflected in the total plant uptake. Between drip and furrow irrigation, significant differences in NO_3-N uptake were observed in petiole, leaf and total plant uptake (Table 2). The drip-irrigated crop was more efficient in N uptake compared to the furrow-irrigated crop. For example, leaf NO_3-N was 38% higher in the drip-irrigated crop. Water use efficiency was also 45.4% more efficient in drip compared to furrow irrigation (Table 5).

Chili pepper. Marketable yield was significantly influenced by shelter and irrigation (Table 1). Marketable fruit yield and number of marketable fruits were highest in the single-bed shelter and lowest in the double-bed shelter. Marketable fruit yield in the single-bed shelter was significantly greater than in the open field and double-bed shelter. Drip irrigation resulted in significantly higher marketable fruit yield than furrow irrigation. There was no interaction between shelter and irrigation method for all yield parameters.

NO_3-N uptake in leaf, petiole and total plant tissues was not significantly influenced by shelter; however, NO_3-N uptake in all samples was highest in the double-bed shelter followed by the single-bed shelter and open field (Table 2). Irrigation method influenced NO_3-N uptake in petiole and total plant tissue. In the case of chili pepper, furrow irrigation resulted in higher NO_3-N uptake than drip irrigation. However, water use was 60.7% more efficient in drip compared to furrow irrigation (Table 5). The interaction between shelter and irrigation method was not significant in NO_3-N uptake.

Cabbage. The effect of shelter on head weight and marketable yield was significant (Table 3). Cabbage grown in the open field had greater head weight and marketable yield than in the single-bed shelters but comparable with double bed shelter. Yield of cabbage under furrow irrigation was significantly greater than under drip irrigation. In terms of NO_3-N uptake in leaf, petiole and total plant tissues, there were no significant differences between shelters (Table 4). NO_3-N uptake was higher in petiole tissue under drip irrigation compared to furrow irrigation. Overall, NO_3-N uptake was higher in drip than furrow irrigation. Drip-irrigated cabbage was 72.1% more efficient in water use than furrow irrigation (Table 5). No significant interaction between shelter and irrigation methods was observed for all measured parameters.

Yardlong bean. The number of pods and marketable yield were significantly influenced by shelter but not by irrigation method (Table 3). Highest number of pods was harvested in the open field and was significantly greater than those in single- and

Table 3. Marketable yield of common cabbage, yardlong bean and pak-choi as influenced by shelter and irrigation method during the hot-dry season, 2004.

Crop	Shelter	Irrigation	Pods (000/ha) or head/plant wt (g)	Yield (t/ha)
Cabbage	Open	Drip	1000	27.5
		Furrow	1200	33.9
		Mean	1100 a[1]	30.7 a
	Single bed	Drip	900	24.2
		Furrow	1200	33.9
		Mean	1050 b	29.1 b
	Double bed	Drip	1000	27.5
		Furrow	1000	29.5
		Mean	1000 ab	28.5 ab
		Drip mean	1000	26.4 b
		Furrow mean	1100	32.4 a
Yardlong bean	Open	Drip	2270	48.4
		Furrow	2287	50.3
		Mean	2279 a	49.4 a
	Single bed	Drip	1784	38.0
		Furrow	1614	36.3
		Mean	1699 b	37.2 b
	Double bed	Drip	1493	31.4
		Furrow	1490	32.2
		Mean	1492 b	31.8 b
		Drip mean	1849	39.3
		Furrow mean	1797	39.6
Pak-choi	Open	Drip	97	19.3
		Furrow	116	25.0
		Mean	107	22.2
	Single bed	Drip	103	22.5
		Furrow	121	24.7
		Mean	112	23.6
	Double bed	Drip	98	19.7
		Furrow	105	21.6
		Mean	102	20.7
		Drip mean	99 b	20.5 b
		Furrow mean	114 a	23.8 a

Yardlong bean directly sown on 29 July 2004; cabbage and pak-choi transplanted on 3 September and 5 November 2004, respectively, at AVRDC.
[1] Mean separation in columns by Duncan's multiple range test, $P < 0.05$.

double-bed shelters. Marketable pod yield was also significantly higher in open field than in shelters. No difference in number of pods and marketable yield was observed between single- and double-bed shelters. The effect of irrigation method on number of pods and marketable yield was not significant. There was no interaction between shelter and irrigation method on number of pods and marketable yield. The lower yield under shelters was attributed to lower light intensity which limited growth. Plants under shelters were generally shorter and smaller than those in the open field. Water use by yardlong bean was 75.3% more efficient under drip irrigation compared to furrow irrigation (Table 5).

Table 4. Nitrate nitrogen uptake in leaf blade, petiole and total plant tissues of cabbage, yardlong bean and pak-choi as influenced by shelter and irrigation method during the hot-dry season, 2004.[1]

Crop	Shelter	Irrigation	Leaf	Petiole	Plant
			—— (NO_3-N, mg/L) ——		
Cabbage	Open	Drip	285	415	1964
		Furrow	263	349	1685
		Mean	274	382	1824
	Single bed	Drip	296	498	2111
		Furrow	263	375	1825
		Mean	280	437	1968
	Double bed	Drip	320	454	2104
		Furrow	301	400	1813
		Mean	311	427	1958
		Drip mean	300	455 a[1]	2060
		Furrow mean	275	375 b	1774
Yardlong bean	Open	Drip	190	280	688
		Furrow	220	375	886
		Mean	205	328	787 b
	Single bed	Drip	225	240	767
		Furrow	180	335	784
		Mean	203	288	776 b
	Double bed	Drip	215	445	1048
		Furrow	210	395	925
		Mean	213	420	986 a
		Drip mean	210	322 b	834
		Furrow mean	203	368 a	865
Pak-choi	Open	Drip	440	900	1820
		Furrow	660	740	2360
		Mean	550	820	2090
	Single bed	Drip	483	827	1860
		Furrow	723	840	2043
		Mean	603	833	1952
	Double bed	Drip	497	903	1920
		Furrow	517	750	1797
		Mean	507	827	1858
		Drip mean	473 b	877	1867
		Furrow mean	633 a	777	2067

Yardlong bean directly sown on 29 July 2004; cabbage and pak-choi transplanted on 3 September and 5 November 2004, respectively, at AVRDC

[1] Mean separation in columns by Duncan's multiple range test, $P < 0.05$.

Significant differences in NO_3-N between shelters were only obtained in whole plant samples and not in leaf and petiole tissue (Table 4). Total plant NO_3-N uptake was highest in the double-bed shelter. The difference between irrigation methods was significant only in petiole NO_3-N where furrow irrigation was higher compared to drip irrigation.

Pak-choi. The effect of shelter on yield of pak-choi was not significant, but irrigation method influenced both the marketable yield and plant weight. Yield and average plant weight was higher (23.8 t/ha and 114 g/plant, respectively) under furrow irrigation compared to 20.5 t/ha and 99.0 g/plant, respectively under drip irrigation (Table 3). Among shelters, differences in NO_3-N were not significant for all plant parts (leaf blade, petiole and whole plant).

The effect of irrigation method on NO_3-N in leaf blade was significant (Table 4). The furrow-irrigated crop resulted in higher NO_3-N in leaf blade than the

Table 5. Water use, water use efficiency (WUE), and total fertilizer applied in vegetable crops grown under drip and furrow irrigation during hot-wet and hot-dry seasons, 2004. Data are mean of 3 rain shelter types.

Crop	Irrigation	Irrigation water use (L/plant)	Drip WUE (%)	N–P–K applied (kg/ha)
Tomato	Drip	29.7	52.5	198–85.1–164.3
	Furrow	62.5	-	360–135.5–273.9
Cucumber	Drip	34.1	45.4	270–116.1–224.1
	Furrow	62.5	-	360–135.5–273.9
Chili pepper	Drip	39.3	60.7	264–113.5–291.1
	Furrow	100.0	-	420–141.9–298.8
Cabbage	Drip	24.4	72.1	180–77.4–149.4
	Furrow	87.5	-	90–38.7–74.7
Yard. bean	Drip	24.7	75.3	180–77.4–149.4
	Furrow	100.0	-	90–38.7–74.7
Pak-choi	Drip	1.1	61.7	46–0–0
	Furrow	2.9	-	18–6–14.9

Tomato, cucumber and chili pepper were transplanted on 25 March, 3 May, and 25 March 2004, respectively, for testing during the hot-wet season at AVRDC. Yardlong bean was directly sown on 29 July 2004; cabbage and pak-choi were transplanted on 3 September and 5 November 2004, respectively, for testing during the hot-dry season at AVRDC.

drip-irrigated crop, but the differences in petiole and total plant NO_3-N were not significant. Efficient water use was observed consistently for drip irrigation in pak-choi. Water use was 61.7% more efficient in drip compared to furrow irrigation (Table 5). Although yield under drip irrigation was lower than furrow irrigation, water and fertilizer use was reduced and more efficient in drip than in furrow irrigation.

In summary, the influence of shelter and irrigation method on yield and nutrient uptake varied with vegetable crops. Drip irrigation did not benefit tomato across shelters. NO_3-N uptake tended to be poor under shelters where levels in leaf, petiole and whole plant samples were lower than those in open field. However, NO_3-N uptake is generally higher in drip than under furrow irrigation indicating better efficiency.

In cucumber, yield is favored by single-bed shelters and drip irrigation. NO_3-N uptake was also high in the double-bed shelter and in drip irrigation. For chili pepper, yield response to shelter was similar to that in tomato where the highest yield was obtained from the single-bed shelter, while the double-bed shelter produced the lowest yield. In contrast, drip irrigation favored yield of chili pepper, but not tomato. Although NO_3-N uptake was high under shelters, plant uptake in general was lower in drip than in furrow irrigation.

Some of the second crops (cabbage, yardlong bean and pak-choi) grown under open field conditions produced higher yield compared to crops grown under shelters. Between the two shelter types, crops grown in double-bed shelters generally produced lower yields than under single-bed shelters, except in the case of pak-choi. Furrow irrigation seemed to favor yield of leafy vegetables (cabbage and pak-choi), whereas, yardlong bean was benefited by drip irrigation. NO_3-N uptake was not consistent in crops as influenced by shelter and irrigation method, but there was a tendency for lower uptake under drip irrigation.

Low yields and nutrient uptake of crops under shelters can be attributed to low light intensity due to shading. Under shelters, solar radiation was reduced by 58–60% during cloudy days and by 62–67% on sunny days. In comparing single- and double-bed shelters, decreased yields in the double-bed shelter can be explained by low light intensity and mutual shading effect of crops in double beds. Light intensity in the double-bed shelter was 2–5% less than in the single-bed shelters. Other factors that may contribute to low yield under double-bed shelters are restricted air flow, relatively high temperature, and humidity.

In comparing drip and furrow irrigation, decreased yield under drip irrigation for some crops can be attributed to reduced fertilizer application. All crops under drip irrigation received approximately half the fertilizer rate that was applied under furrow irrigation.

This study shows that water use by vegetable crops can be reduced considerably with drip irrigation. In all crops, water use in drip irrigation was 45–75% less than furrow irrigation and yields achieved under drip irrigation were comparable with furrow irrigation. Furthermore, nutrient uptake was more efficient in drip-irrigated vegetables.

Chili pepper rootstocks for production of grafted chili pepper during the hot-wet season

Production of chili pepper during the hot-wet season in the lowland tropics is limited due to the influence of adverse biotic and abiotic factors. Among these are high temperatures, flooding, and the incidence of soil-borne diseases including bacterial wilt (BW) and *Phytophthora* blight (PB). Previous studies at AVRDC indicated that there are promising lines/ accessions of chili with high yield potential and high tolerance to waterlogged soil conditions and diseases. These lines, which included selections from *Capsicum annuum*, *C. baccatum*, *C. frutescens* and *C. chacoense*, showed high tolerance to flooding damage with survival rates exceeding 45%. Such lines are suitable for production in flood-prone areas or for use as rootstocks for chili pepper production during the hot-wet season when market prices are favorable for increased economic returns.

This study was conducted to evaluate the most promising lines of chili as rootstocks for chili pepper production during the hot-wet season. Scion plants of the commercial hot pepper cv. ‘Delicacy 193’ (*C. annuum*) were grafted onto rootstocks of *C. annuum* (21 lines) and *C. frutescens* (2 lines). Grafted and non-grafted transplants were planted in open field on 19 May 2004 in plots laid out using RCBD with three replications. Plants were spaced 40 cm apart in twin rows on raised beds. Sixteen plants were set in each plot, which measured 1.5 m × 4.0 m, giving an overall plant density of 26,667 plants/ha. Plants were grown using AVRDC standard cultural practices.

Prior to first harvest, plants were sampled for measurement of plant height, rootstock and scion diameter, leaf, stem, fruit, and root weights. Incidences of BW and PB were also recorded. The number and size of fruits were determined from all harvests. From these measurements, total and marketable fruit yields were determined. Using these plant characters and yield parameters, a correlation test was performed to understand the relationships among the measured traits.

The correlation test showed that some traits were positively and significantly correlated (Table 6).

Differences in disease infection (BW and PB) were significant among rootstocks accessions (Table 7). Disease-infected plants varied from 2.1% (CCA2777A and PBC066) to 52.1% (PBC385). More than 60% of the lines had disease incidences of less than 10%. These lines performed better than the currently recommended rootstock Toom-1. Based on disease rating, it can be concluded that several chili lines are promising for use as rootstocks in hot pepper production during hot-wet season. Outstanding lines which provide disease resistance are CCA2777A, PBC066, CM334, PBC067, PBC204, and PBC743. All these lines belong to *C. annuum* and showed less than 5% disease infection.

Significant differences in the number of fruits and marketable yield were observed among rootstock lines (Table 8). However, variations in fruit size were not significant. The highest number of fruits was produced from scion plants grafted onto Toom-1 rootstock and lowest from plants grafted onto PBC385 rootstock.

In terms of both marketable yield and resistance to soil-borne diseases, rootstocks PBC066, CM334 and PBC743 were most outstanding. Scion plants grafted onto these lines produced yields that exceeded 30 t/ha and comparable with yield from plants grafted onto Toom-1. These lines have great potential for increasing yield of chili pepper during the hot-wet season.

Table 7. Characteristics of chili lines as rootstocks for grafted chili production during the hot-wet season.

Rootstock	Species	Stress tolerance[1]	Infected plants (%)[2]
97-7195-1	*C. annuum*	BW, flood	8.3 abc[3]
9852-54	*C. annuum*	BW, flood	20.8 a-d
C04751	*C. frutescens*	flood	6.2 abc
C05665	*C. annuum*	BW, flood	12.5 abc
C05696	*C. annuum*	BW, flood	35.4 cd
CCA2777A	*C. annuum*	PB	2.1 a
CCA3336	*C. annuum*	PB	8.3 abc
CCA42A	*C. annuum*	PB	29.2 a-d
CM334	*C. annuum*	PB	4.2 abc
PBC066	*C. annuum*	BW, flood	2.1 a
PBC067	*C. annuum*	BW, flood	4.2 ab
PBC1347	*C. annuum*	BW, flood	8.3 abc
PBC1367	*C. annuum*	flood	8.3abc
PBC204	*C. annuum*	BW, flood	4.2 ab
PBC375	*C. annuum*	BW, flood	6.2 abc
PBC384	*C. annuum*	BW, flood	8.3 abc
PBC385	*C. annuum*	BW, flood	52.1 d
PBC473	*C. annuum*	BW, flood	10.4 abc
PBC535	*C. annuum*	BW, flood	18.7 abc
PBC631-A	*C. annuum*	BW, flood	6.2 abc
PBC631-B	*C. annuum*	BW, flood	33.3 bcd
PBC743	*C. annuum*	BW, flood	4.2 abc
Toom-1 (ck)	*C. frutescens*	BW, flood	31.2 a-d
Non-grafted	*C. annuum*	susceptible	18.7 a-d
Mean			14.3

Transplanted 19 May 2004 at AVRDC.
[1] BW = bacterial wilt; PB = *Phytophthora* blight.
[2] Only BW and PB infections were noted.
[3] Mean separation by Duncan's multiple range test ($P < 0.01$).

Table 6. Pearson correlation (n=24) of measured traits prior to first harvest in summer.

Source	Plant height (cm)	Rootstock diam. (mm)	Scion diam. (mm)	Leaf (g)	Stem (g)	Root (g)	Fruit (g)	Plant (g)
Plant height	1.00	0.16	0.41*	0.61**	0.57**	0.52**	0.23	0.44
Rootstock stem diam. (mm)		1.00	0.08	0.08	0.07	0.16	0.04	0.06
Scion stem diam. (mm)			1.00	0.45*	0.34	0.14	0.22	0.32
Leaf (g)				1.00	0.92**	0.45	0.70**	0.88**
Stem (g)					1.00	0.41	0.80**	0.94**
Root (g)						1.00	0.18	0.32
Fruits (g)							1.00	0.95**
Plant (g)								1.00

Transplanted 19 May 2004 at AVRDC.
*, ** Significant at $P < 0.05$ and $P < 0.01$, respectively.

Table 8. Yield performance of chili (hot pepper) cv. 'Delicacy 193' grafted onto chili rootstock lines during the hot-wet season.

Rootstock	Species	Marketable fruits (000/ha)	Marketable yield (t/ha)	Fruit size (g)
97-7195-1	*C. annuum*	3,274 a-d[1]	25.8 a-e	8.0
9852-54	*C. annuum*	3,300 a-d	27.3 a-d	8.3
C04751	*C. frutescens*	3,557 ab	29.3 ab	8.2
C05665	*C. annuum*	2,433 b-f	17.6 c-f	7.1
C05696	*C. annuum*	2,250 def	17.2 ef	7.6
CCA2777A	*C. annuum*	3,188 a-d	27.6 a-d	8.7
CCA3336	*C. annuum*	2,620 a-f	25.5 a-e	10.1
CCA42A	*C. annuum*	2,382 def	18.8 c-f	7.7
CM334	*C. annuum*	3,506 abc	30.7 ab	8.7
PBC066	*C. annuum*	3,499 abc	33.6 a	9.6
PBC067	*C. annuum*	1,910 ef	15.9 ef	8.3
PBC1347	*C. annuum*	3,185 a-d	25.7 a-e	8.1
PBC1367	*C. annuum*	2,657 a-f	22.0 bf	8.3
PBC204	*C. annuum*	2,239 def	18.5 c-f	8.3
PBC375	*C. annuum*	2,988 a-e	25.1 a-e	8.4
PBC384	*C. annuum*	3,021 a-e	23.6 a-e	7.8
PBC385	*C. annuum*	1,602 f	12.6 f	7.9
PBC473	*C. annuum*	2,670 a-f	22.2 b-f	8.3
PBC535	*C. annuum*	2,320 def	18.6 c-f	8.0
PBC631-A	*C. annuum*	2,973 a-e	24.5 a-e	8.2
PBC631-B	*C. annuum*	2,734 a-f	20.9 b-f	7.7
PBC743	*C. annuum*	3,547 abc	30.2 ab	8.5
Toom-1 (ck)	*C. frutescens*	3,773 a	33.0 a	8.7
Non-grafted	*C. annuum*	3,247 a-d	27.7 abc	8.5
Mean		2,870	23.9	8.3

Transplanted 19 May 2004 at AVRDC.
[1] Mean separation by Duncan's multiple range test ($P < 0.01$).

Evaluation of chili rootstocks for grafted sweet pepper production during the hot-wet and hot-dry seasons

Sweet pepper (*Capsicum annuum*) production during the hot-wet and hot-dry seasons in the lowland tropics is constrained by high temperature, flooding, and diseases. AVRDC has developed grafting technology for tomato production during the hot-wet season that is being adopted by a growing number of farmers in Southeast Asia. Similar technology is being developed for sweet pepper production to enhance yield and improve quality. Since 2002, several chili pepper lines from a wide collection including wild species were identified to have tolerance to flooding. In 2003, screening was expanded with the goal of identifying chili pepper lines for production in flood-prone areas or for use as rootstocks for sweet pepper production during the hot-wet season, when market prices are profitable. Generally, lines tolerant to flooding in 2002 consistently maintained tolerance in 2003. Selected lines from *C. baccatum* (4), *C. frutescens* (2) and *C. chacoense* (2) were most tolerant to flooding damage, each with survival rate greater than 45%.

Using promising lines, 23 accessions were selected for this study to evaluate outstanding lines as rootstocks for sweet pepper production during the hot-wet (summer) and hot-dry (autumn) seasons. Seeds of chili rootstocks were sown on 20 August 2003 for autumn season and 14 May 2004 for summer season. Seeds of commercial sweet pepper cv. 'Andalus' (used as scions) were sown on 25 August 2003 for autumn and on 20 May 2004 for summer seasons. Grafted transplants were planted in 32-mesh nethouse on 25 September 2003 for autumn season and on 21 June 2004 for summer season. The experiment was designed in RCBD with three replications. Plots were 1.5 m × 4.0 m in size. Plants were spaced 40 cm apart in twin rows with a density of 16 plants per plot (26,667 plants/ha). Plants were grown using standard cultural practices including silver mulching covered with rice straw, bamboo staking, and IPM practices.

Prior to first fruit harvest, plant samples were collected for measurement of plant traits including plant height, rootstock and scion diameter, number of roots (>15 cm long), and disease incidence (%). At harvest, the number of fruits, fruit size and fruit yield were determined. Using these parameters, a correlation test was performed to understand the relationships among the measured traits.

Significant correlations were detected between plant traits during summer and autumn seasons. In the summer season, plant height, stem diameter (rootstock and scion), fruit number, size and yield were positively and significantly ($P < 0.01$) correlated to each other (Table 9). The same traits were not significantly correlated to root number and were negatively correlated with disease incidence. There was a highly significant positive correlation between fruit number, fruit size and fruit yield. Results of autumn season trial indicated significant ($P < 0.01$) positive correlations between plant height, root number, fruit number, fruit size and yield (Table 10). Rootstock diameter was significantly correlated to root number, fruit number, fruit size and yield, whereas the correlations between scion stem diameter and all other traits were not significant. Most traits were negatively correlated with disease incidence indicating that resistance to disease within these lines may be enhanced by taller plant height, larger rootstock stem diameter, and higher root number. These results are consistent with the previous year's findings where significant differences were detected among the accessions for flooding tolerance and a wide range of morphological and production traits.

Significant differences in sweet pepper yield were observed among rootstocks both in the autumn and summer growing seasons (Table 11). The mean yield in the fall season was 100% higher than the summer season. Except for the three accessions, differences in yield between autumn and summer growing season were highly significant. Yield during the autumn season ranged from 20.5 t/ha for accession CO4751 (*C. chacoense*) to 49.2 t/ha for accession PBC631-A (*C. annuum*), whereas, in the summer season, yield ranged from 4.3 t/ha for accession PBC204 (*C. annuum*) to 34.7 t/ha for Toom-1 (*C. annuum*). Yield during the summer season was highly variable among accessions. Most of the *C. annuum* rootstocks performed equally well in terms of yield with the common rootstocks (9852-54 and Toom-1) in the autumn season. Among the promising chili rootstock accessions for autumn planting were PBC631-A, PBC1376, PBC067, PBC1347 and PBC204. In the summer, none of the accessions out yielded the common rootstock Toom-1, but 10 accessions have yields that are not significantly different with Toom-1. Promising accessions for summer production included C05696, C05692, PBC743, PBC384 and C04765 (Table 11).

Differences in fruit size were significant in the summer season, but not during the autumn season (Table 11). As with yield, mean fruit size was larger (104.3 g) in the autumn than in summer season (60.6 g). Differences in fruit size between autumn and summer seasons for all accessions were all highly significant. Except for C04751 in the autumn, most of the

Table 9. Pearson correlation of measured traits in summer observations.

Source	Plant height (cm)	Rootstock stem diam. (mm)	Scion stem diam. (mm)	Root no. (>15 cm)	Disease incidence (%)	Fruit no. (x1000)	Yield (t/ha)	Fruit weight (g)
Plant height (cm)	1.00	0.62**	0.77**	0.37	-0.27	0.86**	0.85**	0.74**
Rootstock stem diam. (mm)		1.00	0.62**	0.21	-0.13	0.53**	0.54**	0.38
Scion stem diam. (mm)			1.00	0.26	-0.05	0.66**	0.67**	0.69**
Root no. (>15 cm)				1.00	-0.32	0.39	0.45*	0.54
Disease incidence (%)					1.00	-0.36	-0.33	-0.15
Fruit no. (x1000)						1.00	0.99**	0.87**
Yield (t/ha)							1.00	0.92**
Fruit weight (g)								1.00

Transplanted 21 June 2004 at AVRDC.
*, ** Significant at $P < 0.05$ and 0.01, respectively.

Table 10. Pearson correlation of measured traits in autumn observations.

Source	Plant height (cm)	Rootstock stem diam. (mm)	Scion stem diam. (mm)	Root no. (>15 cm)	Disease incidence (%)	Fruit no. (x1000)	Yield (t/ha)	Fruit weight (g)
Plant height (cm)	1.00	0.57**	0.36	0.53**	-0.39	0.81**	0.84**	0.83**
Rootstock stem diam. (mm)		1.00	0.19	0.57**	-0.36	0.49*	0.54**	0.53**
Scion stem diam. (mm)			1.00	0.38	0.02	0.03	0.07	0.09
Root no. (>15 cm)				1.00	-0.51*	0.54**	0.57**	0.49*
Disease incidence (%)					1.00	-0.72**	-0.71**	-0.57**
Fruit no. (x1000)						1.00	0.99**	0.87**
Yield (t/ha)							1.00	0.92**
Fruit weight (g)								1.00

Transplanted 25 September 2003 at AVRDC.
*, ** Significant at $P < 0.05$ and 0.01, respectively.

accessions belonging to *C. annuum* had comparable fruit size with the common rootstock and non-grafted check. Average fruit size of rootstock accessions belonging to *C. baccatum*, *C. chacoense*, and *C. frutescens* was smaller than the common rootstock and non-grafted check (Table 11). For summer planting, four accessions are promising in terms of fruit size: PBC743, PBC384, C05692 and PB1347. Average fruit size of these accessions approaches that of Toom-1.

In summary, this study showed there are promising lines of chili rootstock for production of grafted sweet pepper during the hot-wet and hot-dry seasons. Most of these lines performed equally well with AVRDC recommended rootstocks Toom-1 and 9852-54. However, none of accessions outyielded the recommended rootstocks in the summer growing season, but 12 accessions were comparable with Toom-1.

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Table 11. Performance of sweet pepper grafted and non-granted onto chili and sweet pepper rootstocks for yield characters during the hot-wet (summer) and hot-dry (autumn) seasons.

		Yield (t/ha)			Fruit weight (g)		
Rootstock	Species	Autumn	Summer	Difference	Autumn	Summer	Difference
C0 4200	*C. baccatum*	27.9 c[1]	19.4 c-h	8.5^{NS}	95.0	54.2 b-f	40.8**
C0 4388	*C. chacoense*	30.9 bc	10.5 g-i	20.4**	90.9	56.6 b-f	34.3**
C04751	*C. chacoense*	20.5 c	20.5 c-g	0.0^{NS}	78.7	63.9 a-d	14.8^{ns}
C04765	*C. frutescens*	30.9 bc	28.8 abc	2.2^{NS}	101.6	65.4 a-d	36.2**
C05665	*C. annuum*	41.6 ab	27.9 a-d	13.7**	102.7	62.8 a-d	39.9**
C05692	*C. annuum*	37.3 abc	32.0 ab	5.3**	101.2	66.2 a-d	35.1**
C05696	*C. annuum*	47.7 a	30.3 abc	17.3**	109.4	64.9 a-d	44.6**
PBC066	*C. annuum*	45.1 a	5.6 i	39.5**	108.8	47.3 ef	61.5**
PBC067	*C. annuum*	48.0 a	16.9 e-h	31.1**	104.1	55.2 b-f	48.9**
PBC1347	*C. annuum*	47.9 a	25.3 a-e	22.6**	109.2	65.3 a-d	43.9**
PBC1376	*C. annuum*	48.8 a	14.2 f-i	34.5**	108.1	54.0 c-f	54.1**
PBC204	*C. annuum*	47.9 a	4.3 i	43.6**	108.2	45.7 f	62.5**
PBC375	*C. annuum*	40.6 ab	17.0 d-h	23.6**	103.3	54.9 b-f	48.4**
PBC384	*C. annuum*	46.8 a	28.9 abc	18.0**	105.2	66.6 a-d	38.6**
PBC385	*C. annuum*	47.9 a	22.9 b-f	25.0**	105.2	58.7 b-e	46.5**
PBC473	*C. annuum*	44.5 a	26.7 a-e	17.8**	110.7	64.9 a-d	45.8**
PBC535	*C. annuum*	45.8 a	20.5 c-g	25.3**	108.8	61.9 a-d	46.9**
PBC631-A	*C. annuum*	49.2 a	24.0 a-f	25.2**	108.0	64.0 a-d	44.0**
PBC631-B	*C. annuum*	47.3 a	9.0 hi	38.2**	106.3	53.4 def	52.9**
PBC743	*C. annuum*	48.0 a	30.4 abc	17.6**	109.8	67.2 abc	42.6**
97-7195-1	*C. annuum*	48.7 a	23.4 b-f	25.3**	111.2	62.0 a-d	49.3**
9852-54 (ck)	*C. annuum*	46.5 a	32.7 ab	13.7**	102.4	67.4 ab	35.0**
Toom-1 (ck)	*C. frutescens*	45.1 a	34.7 a	10.4**	108.4	73.2 a	35.3**
Non-grafted	*C. annuum*	40.8 ab	20.6 c-g	20.2**	105.3	58.4 b-f	46.9**
Mean		42.7	21.9	21.0	104.3	60.6	43.6

Summer and autumn trials were transplanted on 21 June 2004 and 25 September 20003, respectively, at AVRDC.

^{NS}, *, ** Nonsignificant, and signficant at $P < 0.05$ and 0.01, respectively.

[1] Mean separation in columns at $P < 0.01$ by Tukey-Kramer test of significance.

Nutrition

Antioxidant capacities and daily antioxidant intake from vegetables consumed in Taiwan

Epidemiological studies have demonstrated the beneficial effects on human health from consumption of vegetables and fruits. The kinds and quantities of vegetables consumed by people vary greatly, depending upon culture, preference, and availability. Per capita vegetable consumption in Taiwan is among the highest in the world. The antioxidant composition and capacity of vegetables relative to vegetable intake data are important to understand the health implications of various dietary patterns. The objective of this study was to assess the antioxidant capacities of common vegetables consumed by the Chinese population in Taiwan using three different free radicals (ABTS, DPPH and superoxide) and to investigate the dietary antioxidant intake from vegetables based on collected data from a food consumption survey conducted earlier by AVRDC.

The selection of the vegetables (Table 1) was based on household consumption survey conducted by AVRDC throughout Taiwan. This survey, which was based on 24-h recall, included 1,457 households during 1998 –1999.

Fresh vegetables were purchased from local markets in southern Taiwan. Samples consisting of approximately 2 kg of edible portion for each vegetable were collected, washed, cut, and mixed well. Exactly 20 g of cut samples were homogenized with 80 mL of deionized water and 20 g for 80 mL of methanol, respectively, in a homogenizer, centrifuged at 15,000 rpm for 10 min at 10°C, divided into several 1.5 mL volume in microtubes, frozen at –70°C immediately for subsequent antioxidant activity (AOA) analysis. Three AOA methods were used and mentioned earlier in *AVRDC Report 2002*.

AOA values of vegetables

The AOA values of vegetables for the six assays and overall AOA ranking are listed in Table 1. The overall rank was made using the average of all assays. The ranking of vegetables for each assay, though different, showed similar trends. Vegetables ranked in the top five in one or more AOA assays. These vegetables included sweetpotato leaf, ginger, amaranth, spinach, eggplant, pak-choi, leafy Chinese cabbage, tomato, Welsh onion, and kangkong. Among these, sweetpotato leaf and ginger were in the top five vegetable lists in every assay. Sweetpotato leaf showed the greatest AOA by ABTS and DPPH methods, whereas ginger and spinach are the vegetables with highest SOS activity. Most green leafy vegetables exhibited high AOA by ABTS and DPPH methods, where five of the top seven by overall ranking were green leafy types. It is noteworthy that eggplant, tomato, and Welsh onion had high SOS activity but relatively low AOAs by ABTS and DPPH methods. The lowest-ranking vegetables for AOA were wax gourd, loofah, cucumber and bottle gourd.

Regarding the extraction solvents, methanol-soluble antioxidants exhibited greater AOA by ABTS method for the vegetables tested; in contrast, the water extracts of 18 vegetables out of 27 showed higher AOA values by DPPH method. For SOS, 17 vegetables showed greater activity with water extracts versus methanol extracts. However, vegetables with DPPHw > DPPHm are not necessarily the same as those with SOSw > SOSm. The greatest AOA values by each method were all found from methanol extracts of vegetables.

Correlation coefficients between AOA values determined from six assays were all significant. The highest correlation coefficient was obtained with AOA values by ABTSm and DPPHm ($r = 0.955$, $P < 0.001$). On the other hand, AOA values by SOSm and DPPHw ($r = 0.400$, $P = 0.041$) and AOA values by SOSm and DPPHw ($r = 0.444$, $P = 0.021$) had statistically significant but lower correlation coefficient.

AOA intake from vegetables

In Table 2, the average antioxidant per capita intake from vegetables on the basis of AOA values by ABTS method were calculated to be 2014 µmol TE/day for methanolic antioxidants and 750 µmol TE/day for aqueous antioxidants. Sweetpotato leaf, leafy Chinese cabbage, bamboo shoot, and spinach together contributed 46% to the daily intake of methanol-soluble antioxidants; whereas, sweetpotato leaf, spinach, white

Table 1. Antioxidant activity[1] (AOA) of common vegetables[2] in Taiwan and overall AOA rank.[3]

Scientific name	Common name	AOA Rank	ABTSm TE	ABTSw TE	DPPHw TE	DPPHm TE	SOSw AE	SOSm AE
Brassica oleracea	Cabbage, white	20	1.60	0.80	1.45	0.70	0.3	ND
Bambusoideae spp	Bamboo shoot	17	3.28	0.52	0.39	0.20	8.5	5.9
Luffa cylindrica	Loofah	26	0.86	0.25	0.12	0.29	ND	ND
Raphanus sativus	Radish	15	3.21	3.50	2.42	0.38	6.6	ND
Lactuca sativa	Heading lettuce	23	1.75	0.50	0.90	0.20	0.0	ND
Ipomoea aquatica	Kangkong	14	4.75	0.35	0.94	0.53	18.2	11.3
Ipomoea batatas	Sweet potato, green leaf	1	28.33	15.49	12.12	19.40	24.7	118.9
Brassica campestris	Leafy Chinese cabbage	7	10.71	3.94	3.03	3.56	6.8	9.2
Spinacia oleracea	Spinach	4	10.30	5.10	7.90	5.25	31.9	ND
Brassica campestris	Chinese cabbage	19	2.40	1.05	1.25	0.65	0.0	ND
Daucus carota	Carrot	18	2.85	0.31	0.51	0.41	9.2	5.8
Cucumis sativus	Cucumber	25	1.40	0.24	0.21	0.14	1.7	ND
Allium fistulosum	Welsh onion	13	6.15	1.64	1.47	0.43	6.8	13.2
Lagenaria siceraria	Bottle gourd	24	1.62	0.51	0.20	0.10	3.7	ND
Brassica oleracea	Cauliflower	8	7.57	2.11	2.59	2.52	17.7	4.6
Benincasa hispida	Wax gourd	27	0.21	0.18	0.58	0.03	ND	ND
Lycopersicon esculentum	Tomato	10	3.41	3.20	0.98	0.81	13.0	28.0
Apium graveolens	Celery	22	2.05	0.45	0.65	0.35	4.0	0.8
Momordica charantia	Bitter gourd	9	7.80	1.92	1.62	3.65	9.7	4.0
Amaranthus spp	Amaranth, green	3	14.07	3.58	4.02	10.35	16.6	9.8
Vigna unguiculata	Yardlong bean	11	9.10	1.66	1.57	3.81	8.0	3.7
Phaseolus vulgaris	Kidney bean	12	10.30	1.50	1.60	4.40	5.7	ND
Zingiber officinale	Ginger	2	15.31	11.04	6.40	6.16	32.4	131.0
Solanum melongena	Eggplant	5	7.12	3.77	1.29	4.15	18.9	62.5
Zizania latifolia	Water bamboo	21	2.22	0.82	0.76	0.41	4.9	ND
Vigna radiata	Mungbean sprouts	16	8.41	1.12	1.27	0.54	5.8	0.8
Brassica campestris	Pak-choi	6	10.84	3.17	3.52	4.62	12.9	0.8
	Mean		6.58	2.55	2.21	2.74	9.9	15.2
	SD		6.08	3.45	2.70	4.18	9.2	34.2
	Min		0.21	0.18	0.12	0.03	ND	ND
	Max		28.33	15.49	12.12	19.40	32.4	131.0

[1] Values are means, n = 2, in µmol TE/g or µmol AE/g on fresh weight basis; TE = Trolox equivalent; AE = ascorbate equivalent; and ND = not detectable.

[2] The selection of vegetables was based on a 1998– 1999 survey of 1,457 households in Taiwan. Vegetables are in the sequence of the daily consumption from high to low.

[3] The overall ranking was based on average rank over each AOA assay.

cabbage and radish contributed 57% of AOA from water-soluble antioxidants. In spite of high AOA of amaranth and ginger, their contribution to daily AOA intake was only about 4–5% of the total AOA due to their low consumption. White cabbage, bamboo shoot, and loofah were the most consumed vegetables, however, their overall AOA rankings were 20, 17 and 26, respectively, and their AOA contribution to daily antioxidant intake was only 1–6%.

Compared to Taiwan, the types of vegetables eaten daily were very different in Western countries such as USA. Antioxidants from dry beans and peas contributed 64% of the daily AOA in the USA, followed by lettuce (8%), and tomato (8%). The major antioxidants were quercetin and kaempferol flavonoids in beans and peas, quercetin in lettuce, and carotenoids in tomato.

In Taiwan, antioxidants from leafy vegetables contributed the most to total AOA, especially sweetpotato leaf, leafy Chinese cabbage, spinach, kangkong and amaranth. Their major antioxidants were b-carotene, lutein, vitamins C, E, phenolic acids (such as gallic acid, chlorogenic acid, and ferulic acid) and flavonols (such as quercetin and kaempferol). It seems that Taiwanese people consume more amounts and types of antioxidants. The health benefits of antioxidants derived from different types of vegetables might merit further investigation.

Table 2. Daily AOA intakes[1] from vegetables in Taiwan.

Vegetable	Daily intake (g/person)	Daily antioxidant intake[2] Methanol extractable AOA µmol TE	%	Water extractable AOA µmol TE	%
Cabbage, white	45.5	73	4	66	9
Bamboo shoot	34.8	114	6	14	2
Loofah	25.0	22	1	3	0
Radish	22.2	71	4	54	7
Heading lettuce	21.3	37	2	19	3
Kangkong	20.3	96	5	19	3
Sweetpotato, grn leaf	18.6	526	26	225	30
Leafy Chin. cabbage	15.4	165	8	47	6
Spinach	10.9	112	6	86	11
Chinese cabbage	10.8	26	1	14	2
Carrot	9.9	28	1	5	1
Cucumber	9.4	13	1	2	0
Welsh onion	9.0	55	3	13	2
Bottle gourd	8.9	14	1	2	0
Cauliflower	8.6	65	3	22	3
Wax gourd	8.4	2	0	5	1
Tomato	7.9	27	1	8	1
Celery	7.8	16	1	5	1
Bitter gourd	7.7	60	3	12	2
Amaranth, green	7.0	99	5	28	4
Yardlong bean	6.9	63	3	11	1
Kidney bean	6.4	66	3	10	1
Ginger, old	6.4	97	5	41	5
Eggplant	6.3	45	2	8	1
Water bamboo	5.9	13	1	4	1
Mungbean sprouts	5.7	48	2	7	1
Pak-choi	5.4	59	3	19	3
Total	352.0	2014	100	750	100

[1] The data source of the consumption amounts was developed by a 1998–1999 survey of 1,457 households.
[2] The AOA intakes were calculated based on AOA values by ABTS method.

Sweet potato leaf contributed almost one-third to overall AOA intake from vegetables. Sweetpotato leaves are eaten as a cooked leafy vegetable in many countries and the leaves contain anthocyanins and phenolic acids, and showed anti-mutagenic properties.

Vegetable consumption in Taiwan is one of the highest in the world with a daily per capita intake of about 350–420 g that includes a diversity of species. Several species such as sweetpotato leaves, amaranth, and ginger have high AOA; however, the most consumed vegetables tended to have lower AOA. To increase antioxidant consumption in Taiwan, people should eat more green leafy vegetables or additional vegetables with high AOA. In our recent survey of more than 120 vegetables species for AOA, we found several plant species with very high AOA, such as Chinese cedar and moringa. Given the wide range of AOA among edible plants, there is great potential to increase antioxidant-rich vegetable consumption. Because the AOA of certain species such as Chinese cedar is 100–1000 times greater than common vegetables, even consumption of a small quantity could greatly increase AOA intake.

Comparison of dietary antioxidants, antioxidant powers, and nutritional quality among four *Moringa* species

A strong food-based approach is critical for alleviating nutritional deficiencies in the tropics. Our survey of over 120 species of Asian indigenous vegetables for nutrient contents, antioxidant activities (AOA), and indigenous knowledge of their medicinal uses indicated that moringa (*Moringa oleifera*) was among the most promising species. However, *M. oleifera* is only one of 13 currently known species of moringa. Little is known about the nutrient content, AOA and beneficial properties of the other moringa species.

Moringas are clustered into three species groups according to their morphological differences. The first group that includes four species are slender trees and are principally Asian; the second group is composed of three species and these are the largest moringas with trunks shaped like bottles or elephant feet; the third group is comprised of six species, and these are tuberous shrubs trees confined in a few African countries. In the study, the AOA and nutrition potential of four *Moringa* species were explored: *M. oleifera* and *M. peregrine* of Group 1, and *M. stenopetala* and *M. drouhardii* of Group 2. *M. stenopetala* is the most economically important species after *M. oleifera*. Among moringas, *M. drouhardii* has the most pungent odor similar to mustard oil, and *M. peregrine* has the widest habitat range and the only one among the slender tree species grown outside of Asia.

Seeds of the four *Moringa* species (Table 3) were sown in November 2000 and transplanted to the AVRDC field in April 2001. One to two kilograms of leaflets from each tree were sampled during 2003–2004. No senescing leaflets were included in the study. Fresh leaflets extracted in water or methanol were stored at –70°C and subjected to AOA analyses. Dried leaflet samples were analyzed for dry matter, protein, calcium, and iron contents. Frozen leaflets at –70°C were used for measuring vitamin antioxidant contents and other nutritional components. The in vitro digestion assay involves simulated gastrointestinal enzymes including pepsin and pancreatine, with subsequent measurement of the soluble/permeable iron or antioxidant molecules released by the digestion.

Table 3. The four *Moringa* species used in this study.

Species	Part consumed	Tree type	Origin
M. oleifera	Leaf, stem, seed	Slender	India
M. peregrina	Leaf, stem	Slender	Arabia, Red Sea
M. stenopetala	Leaf, stem	Bottle	Kenya, Ethiopia
M. drouhardii	Leaf, stem	Bottle	Madagascar

Antioxidant activities (AOA)

Ranges of AOA. Moringa leaves showed high antioxidant capacity in all four of the antioxidative mechanisms: scavenging of superoxide, ABTS and DPPH radicals, and inhibition of lipid peroxidation. The AOA values were the lowest for ILPm (52 TE/g) and highest for ABTSm (411 TE/g) on a dry weight basis, which was around 1,300–10,280 TE/100 g on a fresh weight basis (Fig. 1). These values were 1–5 times higher compared to oxygen radical absorbance capacity (ORAC) values based on fresh weight (FW) of selected high AOA vegetables and fruits including kale (1,770 TE/100 g), spinach (1,260 TE/100 g), prunes (5,770 TE/100 g), raisins (2,830 TE/100 g), and blueberries (2,400 TE/100 g).

Ranking by averaged AOA. Among the four species, *M. peregina* had the highest AOA values for all AOA assays except ILPw. Ranked from highest to lowest in terms of average AOA: *M. peregina* had 234 TE/g DW, followed by *M. stenopetala,* and lastly with similar ranks were *M. oleifera* and *M. drouhardii* at 90 TE/g DW. Although *M. drouhardii* ranked lowest, together with *M. oleifera*, it showed the second highest value of SOSw next to *M. peregina*.

AOA methods and water/methanol extractions. Among the four species, the uppermost two AOA values were found in the methanol extract of *M. peregina* by ABTS and DPPH methods, which were about 2.1 times higher compared to water extractable AOA. However, ILP and SOS methods measured higher activities from water extracts. The top ILPw and SOSw values were found in *M. stenopetala* and *M. peregina*, respectively. These results indicated that water extracted antioxidants of moringa were superior to methanol extracted antioxidants in superoxide scavenging and in inhibition of lipid peroxidation, whereas methanol extracted antioxidants exerted stronger capacity in scavenging of ABTS radicals.

AOA by parts. Stem extracts showed only 2–45% of the AOA values of leaf extracts (Fig. 2). Higher

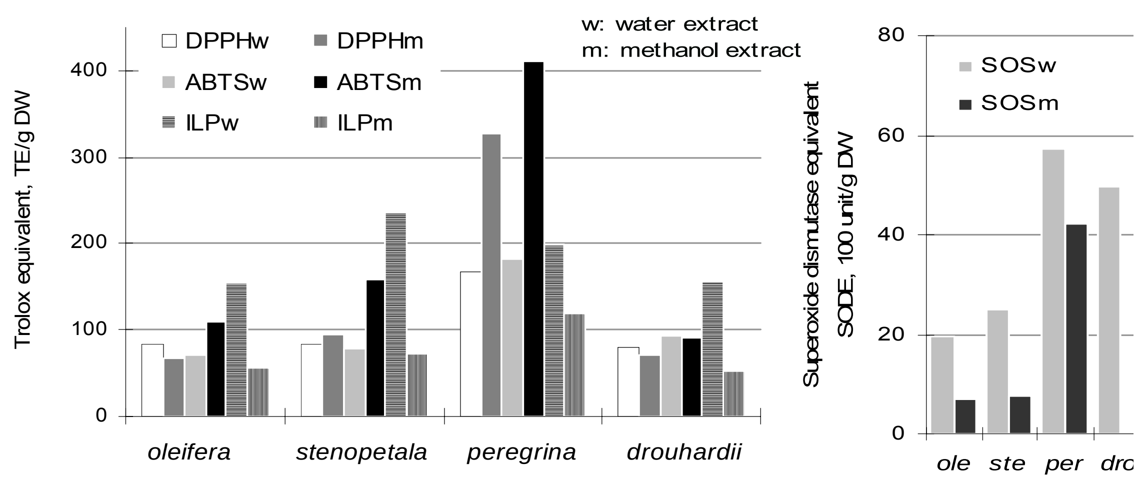

Fig. 1. AOA of water and methanol extracts of four *Moringa* species by four AOA methods. AOA methods followed by subscripts “w” or “m” refer to water or methanol extracts, respectively.

AOA in *M. peregina* stem extract may be due to its higher phenolics content compared with the other three species. Moringa seeds were low in both AOA and phenolics content.

Antioxidant contents

Content ranges. Concentrations of four natural antioxidants (total phenolics and antioxidant vitamins A, C, and E) were measured for the four species. The content ranges on a dry weight basis were 74–210 µmol/g for phenolics, 70–100 µmol/g for ascorbate, 0.7–1.1 µmol/g for β-carotene, and 1.1–2.8 µmol/g for α-tocopherol (Fig. 3). Antioxidant content of moringas are even higher than that of vegetables and fruits known for high antioxidant contents such as: strawberries, which are high in phenolics (330 mg gallic acid (GA)/100 g FW, or ~190 µmol GA/g DW); hot pepper, which is high in ascorbate (200 mg/100 g FW, or ~110 µmol/g DW), carrot, which is high in β-carotene (10 mg/100 g FW, or ~1.8 µmol/ g DW), and soybean, which is high in α-tocopherol (0.85 mg/100 g FW, or ~1.8 µmol/g DW). Moringas are an excellent source of a wide spectrum of dietary antioxidants.

Contribution of AO to AOA. The concentrations of phenolics and ascorbate were about 25–300 times greater than the α-tocopherol and β-carotene contents. In regard to density, phenolics and ascorbate were the dominant antioxidants in moringa and the principal contributors to AOA in both water and methanol extracts. However, only phenolics content showed linear correlation ($R^2 > 0.97$) with methanol extractable

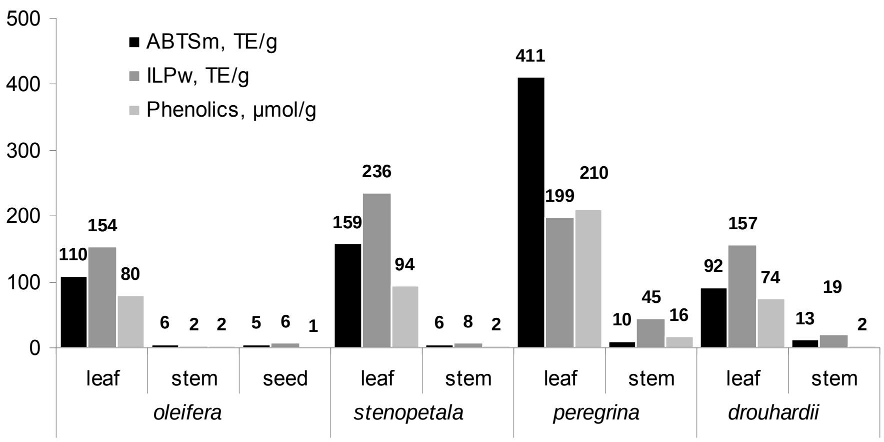

Fig. 2. AOA and phenolic content of leaves, stem and seeds of the four *Moringa* species.

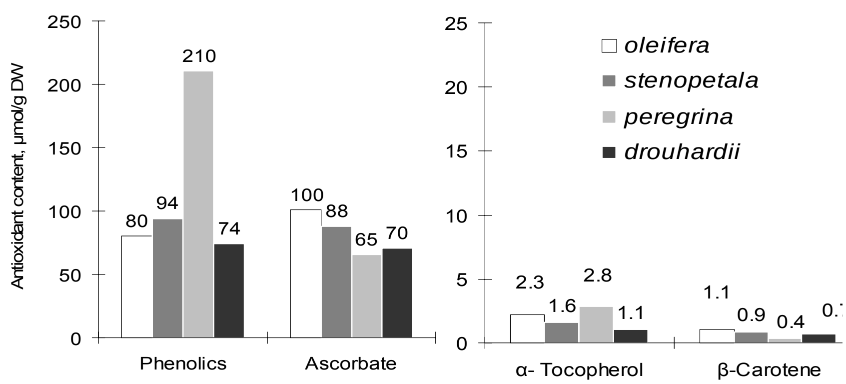

Fig. 3. Antioxidant contents of the four *Moringa* species.

AOA. Ascorbate content was independent of either water or methanol extracted AOA. These results suggest that AOA of methanol extracts could be inferred or estimated from phenolics contents, but not from ascorbate content. This conclusion was supported by the evidence that only 10% of ascorbate content was detected in methanol extract. The aqueous phase may contain enzymes and other bioactive molecules, in addition to ascorbate and phenolics, that could cause synergisms and/or antagonisms among antioxidants. This prevents prediction of AOA activity simply by the summing of the individual antioxidant contents. However, the crude water extracts of vegetables are more like the food matrix and the actual environments for food intake compared to methanol extracts.

High Performance Liquid Chromatography (HPLC) profiles. Antioxidants were extracted from 20 g of mature, fresh leaves of *M. oleifera* in a homogenizer with methanol (1:5, w/v). After heat-acid hydrolysis to breakdown sugar and phenolics linkages, the extract was filtered and then subjected to HPLC analysis. The HPLC eluent was fractionated and collected every minute for 100 min, and then freeze-dried for further determination of ABTS scavenging activity. Based on their optical absorption patterns, the methanol extractable antioxidants were thought to be mainly phenolics. The major antioxidants clusters were shown at RT 3–5 min and 22–52 min (Fig. 4). After heat-acid treatment, the flavonoids such as quercetin (23.6 µmol/g DW) and kaempferol (2.4 µmol/g DW) were detected. Quercetin and its derivatives were the main antioxidants in phenolics in moringa leaves. The peak profiles were changed after acid treatment and this suggests that most of the phenolic compounds in moringa were conjugated with sugars.

Nutritional quality

Among the four species, *M. oleifera* contained the highest amount of β-carotenel and iron, and was the second highest in protein content and α-tocopherol (Table 4). *M. oleifera* grows faster than the other three species in the subtropical low lands in Taiwan, and this species is commonly consumed as a vegetable in South Asia and Africa.

Oligosaccharides and oxalate were reported as anti-nutrient factors in moringa leaves. In this study, stachyose and raffinose were not found in mature leaves of the four species. But, these were detected in young leaves of *M. stenopetala* harvested at different times (0–14 mg/g). Higher amounts of these two galacto-oligosaccharides (22–98 mg/g) were detected in the seeds of *M. oleifera*. Moringa leaves contained much less oxalate (0.99 ± 0.21 mg/g) than spinach (25–45 mg/g). Slightly higher amounts of oxalate (1.37 ± 0.23 mg/g) were measured in young shoots than in mature leaves for ten accessions of *Moringa oleifera*. The data indicated that oxalate and oligosaccharides are not significant anti-nutrient factors in moringa.

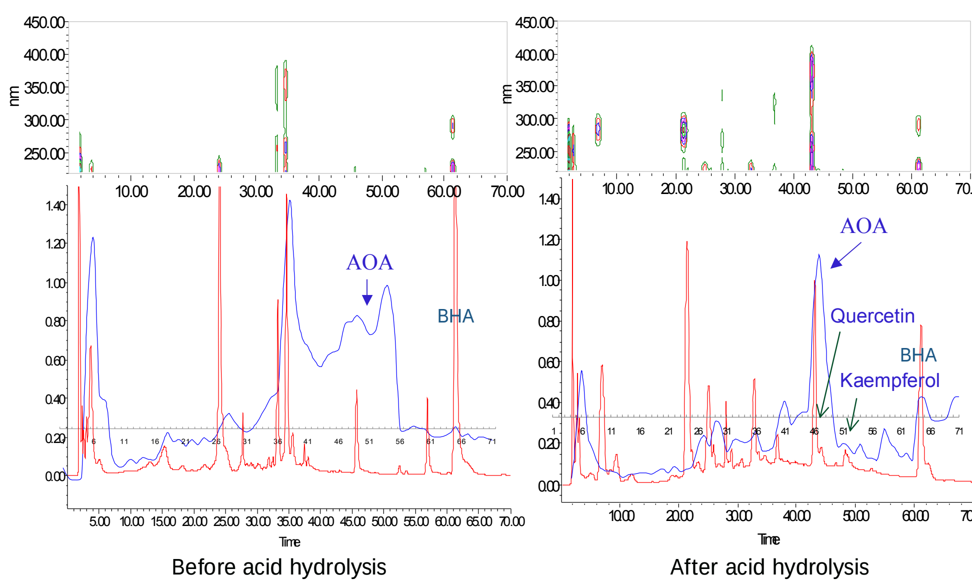

Fig. 4. ABTS activity vs. HPLC profiles of methanol extract of *M. oleifera* leaves before and after heat treatment.

Table 4. Nutrient contents of *Moringa* species leaves based on 100-g fresh weight.

Species	Dry matter	Protein	β-carotene	Ascorbate	Tocopherol	Iron	Calcium
	%	g			mg		
M. oleifera	24	5.7	15	249	25	9.2	638
M. stenopetala	24	5.8	13	400	18	5.4	711
M. peregrina	21	2.9	5	264	28	5.6	458
M. drouhardii	29	5.0	11	388	14	8.7	745

In conclusion, high AOAs (scavenging of superoxide, ABTS and DPPH radicals, and inhibition of lipid peroxidation), antioxidant (β-carotene, ascorbate, α-tocopherols, and phenolics) and nutrient (protein, vitamins A, C, and E, and mineral calcium and iron), and low oxalate contents are common features of the four *Moringa* species. *M. peregina* has the highest level of AOA and *M. oleifera* has the highest nutrient values among the four. The dominant antioxidants in moringa leaves were phenolics and ascorbate. Although moringa contains very high antioxidant vitamins, the α-tocopherols and β-carotene contents cannot be reflected by the AOA values. Qucertin conjugates were the major antioxidants that contributed to their AOA in methanol extract. Moringa, an easily grown perennial, has tremendous potential for increased nutrient and dietary antioxidant consumption.

Contact: Ray-Yu Yang

Diversity in eggplant for superoxide scavenging activity, total phenolics, and ascorbic acid

Eggplant (*Solanum melongena* L.), one of the most important tropical vegetable crops, is grown on over 1.7 million ha worldwide. The crop is adapted to the high rainfall and temperatures that occur during the summer monsoons in South Asia from May–September and is among the few vegetables capable of high yields in hot-wet environments. Therefore, genetic improvement of eggplant varieties for micronutrient content could potentially benefit poor consumers. Eggplant fruit is low in provitamin A content but contains ascorbic acid and phenolic compounds, both of which are powerful antioxidants. The objectives of this study were to assess diversity among *S. melongena* for antioxidant activity as determined by the superoxide scavenging activity (SOS) assay and to estimate the association between SOS, specific antioxidants, and fruit quality.

The study included 33 *Solanum melongena* and two *S. aethiopicum* entries (Table 5). Except for the check commercial hybrid 'Pingtung Long' from Taiwan, all entries are accessions in the AVRDC Genetic Resources and Seed Unit *Solanum* collection. Entries were grown two years in AVRDC fields from February–July 2002 (Year 1) and February–June 2003 (Year 2). Each year, entries were replicated twice and arranged in RCBD. Plots included five plants in Year 1 and ten plants in Year 2. Plants were staked and pruned. Fruits were harvested at commercial ripeness from at least three plants per plot and taken the same day to the laboratory for sample preparation. SOS was measured by the xanthine/xanthine oxidase system. Superoxide is generated from the oxidation of xanthine to uric acid by xanthine oxidase. Superoxide reacts with NBT producing a color change from light yellow to dark purple, which can be measured at 560 nm. Total phenolics content was determined from methanol extracts using Folin-Ciocalteu reagent. Total ascorbic acid was measured based on the basis of coupling 2, 4-dinitrophenylhydrazine (DNPH) with the ketonic groups of dehydroascorbic acid through the oxidation of ascorbic acid by 2, 6-dichlorophenolindophenol (DCPIP) to form yellow-orange color in acidic condition. Data were analyzed on a dry weight basis. SOS, ascorbic acid, total phenolics, sugar content, and dry matter were subjected to analysis of variance for each year and over years with the SAS General Linear Model (GLM) procedure. Entry means were separated by the Waller-Duncan's test (k = 100). Linear correlations between characters were calculated using entry means.

The analysis of variance over years of SOS revealed a highly significant entry mean square, a significant mean square for the year effect, and a nonsignificant mean square for the entry × year interaction (Table 6). These results suggest large genetic differences among entries for SOS, that environmental differences between years influenced expression of SOS, but that the relative differences among entries for SOS were

Table 5. Solanum accessions evaluated for antioxidant activity, antioxidants, and quality traits at AVRDC.

Entry	Accession	Species	Origin	Fruit color	Fruit weight (g)
1	S00196	*S. aethiopicum*	Zambia	orange, uniform	67
2	S00197	*S. aethiopicum*	unknown	orange, uniform	42
3	S00004	*S. melongena*	India	green, mottled	102
4	S00022	*S. melongena*	India	purple, mottled	101
5	S00145	*S. melongena*	Philippines	green, striped	142
6	S00208	*S. melongena*	Iran	purple, striped	156
7	S00254	*S. melongena*	Canada	purple, mottled	205
8	S00256	*S. melongena*	India	green, uniform	47
9	S00257	*S. melongena*	China	purple, mottled	351
10	S00345	*S. melongena*	Turkey	purple, uniform	210
11	S00353	*S. melongena*	Canada	purple, uniform	375
12	S00355	*S. melongena*	India	purple, uniform	195
13	S00385	*S. melongena*	Japan	purple, striped	128
14	S00409	*S. melongena*	China	purple, mottled	409
15	S00610	*S. melongena*	Iran	purple, uniform	392
16	S00624	*S. melongena*	India	purple, striped	69
17	S00633	*S. melongena*	Philippines	purple, uniform	61
18	S00658	*S. melongena*	China	purple, striped	143
19	S00690	*S. melongena*	Bangladesh	purple, striped	43
20	S00718	*S. melongena*	Bangladesh	purple, striped	190
21	S00719	*S. melongena*	Bangladesh	purple, striped	70
22	S00750	*S. melongena*	Bangladesh	green, white and purple, striped	22
23	S00769	*S. melongena*	Bangladesh	purple, striped	119
24	S00777	*S. melongena*	Bangladesh	purple, striped	275
25	S00784	*S. melongena*	Bangladesh	purple, uniform	221
26	S00811	*S. melongena*	Thailand	green, striped	130
27	S00235	*S. melongena*	Turkey	purple, mottled	195
28	S00110	*S. melongena*	Philippines	green, uniform	118
29	S00003	*S. melongena*	Malaysia	green, uniform	90
30	S00017	*S. melongena*	Malaysia	white with purple stripes	26
31	S00062	*S. melongena*	Indonesia	white with green stripes	37
32	S00085	*S. melongena*	Indonesia	green, mottled	132
33	S00092	*S. melongena*	Indonesia	green, uniform	190
34	S00100	*S. melongena*	Indonesia	green, uniform	315
35	Hybrid	*S. melongena*	Taiwan	purple, uniform	125

Table 6. Mean squares from analyses of variance and contrasts of *Solanum* entries evaluated for antioxidant activity, antioxidants, quality factors at AVRDC.

Source	DF	SOS	Phenolics	Ascorbic acid	Sugar	Dry matter	Fiber[1]
Years (Y)	1	7574*	15.29*	28177*	150.2	1.92	-
Replications within year	2	467	1.30	1091	32.1	0.32	2.8
Entries (E)	34	224**	5.43	1069*	88.3	2.97	10.4**
Y × E	34	105	5.46**	600	86.2**	2.32**	-
Error	68	70	0.06	469	40.8	0.67	1.3

NS, *, **Nonsignificant and significant at $P < 0.05$ and 0.01, respectively.

[1] Evaluated in Year 2 only.

consistent between years. Entry means over years for SOS ranged from 26–60% inhibition (Table 7). In general, ranking of entries for SOS was very consistent; for example, of the top ten highest entries for SOS in Year 1, nine entries appeared again in the top ten in Year 2. Entry 31 from Indonesia was the top entry for SOS in both years. SOS was positively correlated with dry matter content and total phenolics content and negatively correlated with fruit weight.

The analysis of variance of phenolics showed a large and significant year effect, a nonsignificant entry mean square, and a highly significant year × entry mean square. The mean total phenolics content over entries for Year 1 was 0.64 g/100 g chlorogenic acid equivalent (dry weight basis) compared to 0.97 g/100 g chlorogenic acid equivalent in Year 2. Furthermore, large entry rank changes were evident for total phenolics content; of the top ten entries in Year 1 only two entries appeared

Table 7. Evaluation of *Solanum* accessions for food quality traits.

Entry	SOS (% inhibition)	Phenolics (mg/100g)	Ascorbic acid (mg/100g)	Sugar (g/100g)	Dry matter (g/100g)	Fiber (g/100g)
1	34 ± 5	1.12 ± 0.10	98 ± 21	32 ± 4	7.9 ± 0.3	13 ± 1.0
2	53 ± 3	1.26 ± 0.25	71 ± 14	30 ± 5	9.4 ± 1.0	18 ± 1.5
3	44 ± 7	1.10 ± 0.20	79 ± 7	29 ± 4	7.1 ± 0.4	15 ± 0.5
4	52 ± 3	1.08 ± 0.15	129 ± 9	29 ± 4	7.9 ± 0.7	10 ± 0.5
5	49 ± 15	0.85 ± 0.15	93 ± 15	27 ± 2	8.7 ± 0.5	11 ± 0
6	36 ± 8	0.84 ± 0.22	62 ± 18	30 ± 2	7.2 ± 0.4	13 ± 0.5
7	30 ± 9	0.81 ± 0.23	83 ± 28	31 ± 3	7.6 ± 0.7	12 ± 0
8	39 ± 5	0.81 ± 0.17	56 ± 14	25 ± 3	7.8 ± 0.3	16 ± 1.5
9	26 ± 16	0.81 ± 0.30	68 ± 22	30 ± 3	7.3 ± 0.7	13 ± 0.5
10	43 ± 2	0.92 ± 0.25	86 ± 17	26 ± 2	7.9 ± 0.8	14 ± 0.5
11	40 ± 6	0.76 ± 0.15	91 ± 10	28 ± 3	7.3 ± 0.4	13 ± 0.5
12	47 ± 4	1.43 ± 0.45	93 ± 6	34 ± 2	7.1 ± 0.4	12 ± 0.5
13	39 ± 3	0.76 ± 0.21	81 ± 15	24 ± 5	8.8 ± 1.0	12 ± 0.5
14	38 ± 4	0.76 ± 0.20	62 ± 10	29 ± 4	6.9 ± 0.6	14 ± 0
15	36 ± 6	0.89 ± 0.19	84 ± 9	27 ± 3	6.1 ± 0.5	13 ± 0.5
16	42 ± 5	0.91 ± 0.17	75 ± 7	28 ± 1	7.7 ± 0.4	12 ± 0.5
17	51 ± 6	1.15 ± 0.38	83 ± 10	26 ± 1	8.2 ± 0.2	11 ± 1.0
18	34 ± 7	0.75 ± 0.17	76 ± 11	33 ± 4	6.8 ± 0.5	11 ± 0
19	43 ± 4	0.74 ± 0.17	90 ± 12	22 ± 2	9.1 ± 0.4	12 ± 1.0
20	32 ± 7	0.92 ± 0.21	120 ± 19	29 ± 2	7.8 ± 0.3	9 ± 1.5
21	45 ± 7	0.98 ± 0.16	90 ± 8	26 ± 5	8.2 ± 0.6	16 ± 0
22	51 ± 7	1.14 ± 0.35	100 ± 5	17 ± 4	9.7 ± 0.3	17 ± 1.0
23	42 ± 7	1.39 ± 0.53	103 ± 5	25 ± 4	9.0 ± 0.5	12 ± 0.5
24	33 ± 7	0.81 ± 0.23	81 ± 14	44 ± 14	7.0 ± 0.4	13 ± 0.5
25	37 ± 4	0.80 ± 0.22	92 ± 13	27 ± 2	7.7 ± 0.2	13 ± 1.0
26	48 ± 4	0.81 ± 0.21	85 ± 13	27 ± 1	9.0 ± 0.4	15 ± 1.5
27	36 ± 5	0.93 ± 0.19	82 ± 17	30 ± 2	7.5 ± 0.8	13 ± 0.5
28	46 ± 3	0.89 ± 0.20	81 ± 4	27 ± 2	8.3 ± 0.7	13 ± 0
29	47 ± 5	0.93 ± 0.16	103 ± 18	28 ± 3	8.3 ± 0.5	14 ± 1.0
30	50 ± 3	1.20 ± 0.16	84 ± 7	21 ± 1	9.0 ± 0.8	19 ± 2.0
31	60 ± 4	1.09 ± 0.10	128 ± 25	18 ± 1	9.5 ± 0.4	17 ± 0.5
32	38 ± 11	1.33 ± 0.29	84 ± 15	28 ± 3	8.1 ± 0.4	13 ± 0.5
33	36 ± 9	0.82 ± 0.21	78 ± 9	26 ± 3	7.6 ± 0.6	15 ± 0
34	40 ± 8	1.25 ± 0.47	82 ± 13	32 ± 1	6.7 ± 0.5	13 ± 0
35	40 ± 5	0.85 ± 0.26	70 ± 14	28 ± 3	7.8 ± 0.6	12 ± 0.5
Waller-Duncan	19	-[2]	50	-[2]	-[2]	2
Grand mean	42 ± 1	0.97 ± 0.04	86 ± 2	28 ± 1	7.9 ± 0.1	13 ± 0.3

[1] SOS = superoxide scavenging.

[2] Mean separations not performed because the entry mean square was nonsignificant.

among the top ten entries in Year 2. The large difference in mean between years and the large interaction indicate a large environmental effect on total phenolics content. We found significant differences among entries in ascorbic acid content as well as a significant year mean square for ascorbic acid content (Table 6). Means of ascorbic acid over the years ranged from 56–129 mg/100 g (dry mass basis) with an overall mean of 89 mg/100 g.

Significant differences among entries were found for fiber content (measured in Year 2 only) but not sugar or dry matter contents. Highly significant year × entry interaction mean squares were evident for sugar and dry matter content (Table 6), the consequence of changes in entry ranking for these characters between years. We detected a highly significant and negative correlation between sugar content and SOS (–0.52**) and dry matter (–0.73**) but a relatively low, strong linear association between sugar content and fruit weight (0.45**).

In this study we have evaluated genetic diversity for SOS activity among 33 *S. melongena* and two *S. ethiopicum* accessions and found about twofold variation for SOS among accessions. It is evident that sufficient genetic variation exists within eggplant to permit plant breeding for increased antioxidant activity. High SOS was not limited to purple-fruited accessions but could be found in some green and white-colored accessions also. Furthermore, the relative differences among entries for SOS were highly consistent over years as shown by the nonsignificant entry × year interaction effect and the similarity of the best performing accessions between years; this was not the case for total phenolics or ascorbic acid content. It is possible that genetic gain from selection for SOS might be larger than selection for total phenolics but further studies are required to determine if this is true. Highly significant negative correlations were found between antioxidant activity and fruit weight, dry weight, and sugar content; consequently it may be difficult to develop large-fruited varieties high in antioxidant activity and sugar content.

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Socio-economics

An analysis of chili food chain for setting research priorities in Asia

Chili is an important vegetable in Asia in terms of area, production, retail value, and people engaged in its production, processing, and marketing. It is cultivated on 4.2 million farms with a total area of 2.7 million ha producing 22.4 million t of fresh output, with a retail value of US$18 billion including fresh and processed chili. The value of its international trade (both import and export) is more than US$5.6 billion, of which US$663 million is in Asia. It provides full-time yearly employment to 4.55 million people at the farm level, and it is expected that similar numbers are engaged in its marketing and processing activities. It generates agricultural business opportunities in rural areas in terms of millions of dollars worth of additional demand for fertilizer, pesticide, and seed.

The social and economic importance of chili justifies research and development efforts on this crop; however, diversity in production and consumption across regions and scarcity of adequate information on each production and consumption system complicates such efforts. This study is an attempt to fill this information gap by providing a comprehensive analysis of issues at various food chain levels in four major chili-producing countries of Asia: China, India, Indonesia, and Thailand. The data for this study were collected from both primary and secondary sources. A comprehensive survey of approximately 2,800 respondents was conducted among farmers, marketing agents, processors and consumers in these countries. It is expected that this analysis will support increased resource allocations for the development of the chili sector, thereby enhancing the competitiveness of the sector and helping millions of chili growing farmers in terms of higher incomes and billions of chili consumers in terms of lower prices all over the world.

Our estimates suggest that about one-third of chili consumed in Asia is in dry and powdered forms while the remaining two-thirds is consumed as fresh vegetable. As much as two-thirds of the chili consumed in South Asia is in dry and powdered forms. In Southeast Asia, except Thailand, chili is mainly consumed fresh.

During the 1990s and early part of this century, chili production, per capita availability, and trade increased in Asia as well as globally. Most of this increase was in fresh chili consumption. This is in line with our demand elasticity analysis, which suggests relatively high elasticity for chili consumed as fresh, and a very inelastic demand for dry and powdered chili. The research implications are that resources allocated for dry powdered chili will mainly benefit consumers in terms of low prices, while some of the benefits of improved productivity in fresh chili will stay at the farm level. Moreover, there is an area for expanding to fresh chili consumption, which can help mitigate micronutrient deficiency.

Recent developments in chili production practices have transformed chili from subsistence to a commercially and economically viable crop. The transformation started with the introduction of improved chili varieties in the form of hybrids and open-pollinated varieties. During 2002, more than one-half of the chili area was planted to improved varieties. Except in Thailand, the share of hybrids among improved varieties dominates (Table 1).

Table 1. Chili variety types (% of parcels) planted in major chili growing countries of Asia.

Type	China	India	Indonesia	Thailand	Overall[1]
Hybrid	90.3	34	77	5	46
Open-pollinated	-	14	5	86	13
Local	9.7	52	18	9	42

[1] Estimated by weighing each country figure with its relative share in total area under chili in four countries.

The development of modern varieties was also ushered with improvements in crop management practices and increases in purchased inputs. An increasing percentage of seed is purchased. Most crops receive fertilizer, manure, and chemical pesticides. Our study showed that 27% of chili fields are treated to prevent soil-borne diseases, 40% are plowed with tractors, 72% have raised beds or furrows, 11% are mulched with straw/sawdust, and another 12% are mulched with plastic (Table 2).

In addition, input use such as fertilizer and pesticide is comparable to other commercial crops and the majority of chili parcels, even in the dry region of India, are irrigated (Table 3). These developments have necessitated chili farmers to be commercially oriented. Our farm characterization analysis of chili farmers suggests that they in fact are better connected with the markets and public sector research organizations than non-chili growing farmers.

The variation of farm management practices across countries provides ample opportunities to study the impact of these practices on chili productivity. The successful adoption of various technologies at one location can be transferred to others. More importantly, chili cultivation in different countries at different times of the year provides an excellent opportunity for regional trade, which is currently at low levels within Asia.

By showing photographs of insects and diseases to farmers, this survey prioritized farmers' perceptions on major insects, diseases and weeds in chili production in each country (Table 4). Mites, caterpillars, and thrips are the most devastating pest types in chili fields, and the fungal diseases *Phytophthora* and anthracnose were generally ranked high. This survey identified other important diseases previously considered as unimportant, such as powdery mildew in India, and *Fusarium* wilt in Thailand. Unspecified viruses were ranked third or fourth among disease priorities. Weeds were of lesser importance across countries.

The important insects and diseases should be given priorities in setting the research and development agenda for chili in the region. Each country should focus on its major disease, and then learn from other countries to control the ones of lesser importance. AVRDC should focus on integrated management diseases approaches, and pyramiding disease resistance through breeding.

The use of chemicals on chili crops is quite high. On average, 19 sprays are applied on a chili crop during its growing season in Asia, with the highest of 47 in Indonesia. Despite the high use of chemicals, yield losses due to insects and diseases did not seem to decrease as perceived by farmers. Indications are that such losses in fact have increased over time. During 1998–2002, average losses due to insects and diseases were 24% each. The highest losses were in India and lowest in China (Table 4). The losses were generally higher in improved open-pollinated compared to hybrid varieties. This is a serious challenge for researchers and policy makers especially in the wake of increased adoption of improved varieties. There is a need to develop integrated pest management strategies to minimize the use of pesticides, or improve the efficacy

Table 2. Farm management practices (% of parcels) on chili in major chili producing countries of Asia.

Management practice	China	India	Indonesia	Thailand	Overall[1]
Purchase seed of local variety	0	24	20	0	14
Purchase seed of improved open-pollinated variety	-	65	44	5	61
Purchase seed of hybrid variety	100	92	66	100	93
Soil treatment in field	36	23	17	19	27
Seed treatment	18	23	53	18	24
Plowing with tractor	4	71	12	68	40
Raised bed or furrow	100	48	96	66	72
Straw mulching	14	7	22	34	11
Plastic mulching	19	1	46	6[3]	13
Organic manure	98	82	79	28	87
Inorganic fertilizer	99	100	100	93	100
Advance method of fertilizer application	61	0	87	68	32
Chemical weeding	100	0.3	23	47	3
Use of pesticide	100	75	100	76	87
Use of fungicide	98	70	95	52	83
Number of harvests	18	3	10	6	9
Crop duration[2]	2w Jan–4w Oct	1w Jul–4w Jan[3] 2w Aug–3w Mar[4]	4w Feb–3w Jun[5] 2w Jul–2w Oct[6]	2w May–2w Dec	-

[1] This was estimated as weighted average of individual country figures using the relative share of each country in the total area of the four countries as weights.
[2] w = week of the month.
[3,4] For local and improved open-pollinated varieties, respectively.
[5,6] For wet and dry seasons, respectively.

of pesticide use. Identification of appropriate pesticide and fungicide to control major insects and diseases and the development of alternative disease management approaches can reduce pesticide use as well as help to reduce yield losses due to insects and other pests. Such identification is urgently needed in Indonesia and India, where the improper use of the same chemical as fungicide and insecticide is very common.

Despite the fact that insects and diseases are serious constraints in chili production, farmers consider yield and output prices to be the most important criteria when selecting varieties. This implies that genetic improvement research on insect and disease resistance will not be useful unless yield and fruit qualities are also considered.

The first and second ranking constraints identified by chili farmers in Asia were insects and diseases. Other high-ranking constraints were low and variable prices (variable prices are also partly related with insect and diseases infestation), market problems (such as high market and transportation costs), and environmental constraints (mainly drought in India and flooding in Thailand and Indonesia). The market agents considered irregular output supplies, high capital requirements, and insufficient storage facilities as major marketing constraints. Our economic analysis showed that high cash costs and high risks involved in chili cultivation are major constraints. Not many chili-growing farmers, however, mentioned cash requirements as a constraint; possibly they were able to overcome this through borrowing. Reduction in chili

Table 3. Input use (unit/ha) on chili in major chili growing countries of Asia.

Input	China	India	Indonesia	Thailand	Overall[1]
Seed rate (kg)	0.4	2.4	1.6	2.47	1.6
Total fertilizer nutrient (kg)	914	385	197	125	563
Manure (t)	23.8	7.0	8.0	2.3	13
Chemical spray	14	17	47	10	19
Pesticide	7	10	21	5	10
Fungicide	5	7	26	5	8
Herbicide	2	-	2	2	2
Chili area irrigated (% of total area)	84	64	79	40	73
Irrigation (number)	3	11	84	41	15
Labor (days)	482	294	369	279	371
Land preparation (%)	11.8	14.0	13.4	12.2	13
Management (%)	47.2	50.6	56.2	54.3	50
Harvesting (%)	22.5	25.2	24.3	25.4	24
Post-harvesting (%)	18.4	10.2	6.1	8.1	13
Full time labor force engaged in Asia (000 number)[2]	1399	1179	260	32	4553

[1] This was estimated as weighted average of individual country input use using the relative share of each country in the total area of the four countries as weights.

[2] This was estimated by multiplying the per-ha labor use with chili area in the respective country and then dividing it by 220 (average working days in a year). The overall figure in the last column is for Asia as a whole and not just for these four countries.

Table 4. Major insects in chili and losses due to insects as perceived by farmers in major chili producing countries.

	Insect rank				Disease rank					Disease losses (%)		Insect losses (%)	
Country	1	2	3	4	1	2	3	4	5	1993–97	1998–2002	1993–97	1998–2002
China	C	M	A	T	PH	AN	VR	BW	FW	8	7	8	7
India	M	T	B	A	PM	AN	VR	LS	DB	48	56	34	43
Indonesia	T	M	A	C	AN	PH	CVMV	CMV	-	11	25	29	29
Thailand	C	T	M	A	AN	FW	CMV	BS	BW	13	24	13	24

Note: Among insects, B = borer (*Helicoverpa armigera*); T = thrips (several species); M = mites (primarily *Polyphagotarsonemus latus*); A = aphids (primarily *Aphis gossypii*); C = caterpillar (leaf-feeding caterpillars such as *Manduca* spp.). Among diseases, AN = anthracnose (*Colletotrichum* spp.); BW = bacterial wilt (*Ralstonia solanacearum*); FW = Fusarium wilt (*Fusarium* sp.); PH = Phytophthora blight (*Phytophthora capsici*); VR = unspecified virus; PM = Powdery mildew (*Leveillula taurica*); CMV = cucumber mosaic virus; CVMV = chili veinal mottle virus; BS = bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*).

cash costs, such as for fertilizer and pesticide may however help small-scale farmers to enter into high-value chili cultivation.

The economic analysis performed in this study across varieties suggests that local, traditional varieties are economically less viable than modern varieties in terms of net return, benefit-cost ratio, and per-unit output cost in all surveyed countries. Open-pollinated varieties were economically a better option in India, while hybrids generated higher returns and lower per-unit output costs in Thailand and Indonesia (Table 5).

Despite the success of research institutes in developing successful open-pollinated varieties in India, farmers' access to these varieties is limited. In contrast, research institutes in Thailand, Indonesia, and China failed to generate economically viable open-pollinated varieties. Therefore in the case of Thailand, farmers have to use whatever is available among open-pollinated varieties, whereas farmers in China and Indonesia will likely opt for hybrids that are expensive but cost-effective. The policy implications are that in India, the distribution mechanism of open-pollinated seed needs to be improved, while in Indonesia and Thailand, the efficiency of research institutes need to be enhanced so that they can generate economically viable open-pollinated varieties for the poor farmers.

Table 5. Benefit-cost ratio for chili variety types in major chili producing countries of Asia.

Item	China	India	Indonesia	Thailand
Hybrid	114 a[2]	76 b	251 a	136 a
Open pollinated	-	107 a	36 c	40 b
Local	113 a	29 c	115b	38 b
Overall[1]	114	56	216	45

[1] This was estimated as weighted average of individual chili type, using the relative share of each type in total area in each country (see Table 80) as weights.

[2] Mean separation in columns by Duncan's multiple range test ($P < 0.05$).

Improvements in crop management practices did not follow the corresponding development in its marketing system. Traditional marketing channels and methods are still being used, and the chili market seems to be less integrated with the main markets, especially in Indonesia and China where a large proportion of output is channeled through local markets or through disposal at the farm level to traders/consumers. The system is not very successful in transmitting consumers' preferences to producers. For example, a relatively large amount of chili output is sold ungraded, suggesting that little attempt is made to satisfy the consumer preferences. Farmers do assign high priority to consumer acceptance of a variety, but are less clear what consumers want; they assign low priority to the color and hotness in India, for example, even though consumers assign high priority for these attributes.

Resource allocation in the priority areas of the chili food chain will not only improve the competitiveness of the sector but also help to encourage socio-economic development by inducing agricultural business activities in rural areas, improving the managerial capacity of farmers and therefore efficiency of resources engaged in agriculture, favoring female gender development, improving micronutrient availability, and enhancing the quality of food consumed.

Opportunities and constraints for safe and sustainable food production in Hanoi

By 2030, it is expected that 60% of Asia's population will reside in cities. The populations of megacities in Indochina, including Hanoi, Ho Chi Minh City, Phnom Penh and Vientiane, are likely to double by 2020. Migration from rural areas will be the main source of this increase in urban populations. As a result of growth in population and incomes in urban areas, the food requirements of cities have enormously increased in recent years, and will continue to do so in the near future. Agriculture and food planners have to think how to best meet these food requirements without stressing resources and polluting the environment. One of the possibilities is to grow food, especially perishable high-value vegetables, in and around cities. In addition to providing food to growing cities, the urban and peri-urban agriculture system may give a respite to migrant agriculture labor by engaging them in the activities they know best and rewarding them with income, especially when they cannot find other jobs in their early stage of migration. It may also help reduce the traffic jams caused by the enormous flow of food into cities from distant areas.

However, the sustainable contribution of urban and peri-urban agriculture systems to urban food security is constrained by technical, marketing and environmental factors. The present study is conducted to evaluate the food production and marketing system of Hanoi with the objectives of assessing the socio-economic and physical environment in which they operate; the human, physical, and institutional resources available in these systems to meet the food demand of Hanoi; and how these resources are utilized in supplying safe food to the city.

In this study, we relied considerably upon secondary data sources, especially from the Hanoi Agricultural Rural Development Department (HARDD) and the Hanoi Statistical Office (HSO). These data cover demographic and occupational structures, economic and climatic conditions, available resources, pollution and environmental factors, agricultural production (including livestock production and aquaculture), food consumption patterns, seasonal prices, and agricultural input-output marketing systems. The analysis of survey data is also presented, which provides an in-depth look of the vegetable production system in Hanoi. Whenever possible, we disaggregated these data by urban and peri-urban regions. The definitions of these regions were derived from the political boundaries of the city. The urban districts within Hanoi were defined as the urban region while the rural districts within Hanoi were defined as the peri-urban region. Districts immediately outside Hanoi were defined as the rural region. These data and analyses not only help us to characterize and differentiate the urban and peri-urban systems, but also to identify the potential growth and limitations of these systems. It is hoped that such evaluation of resources, constraints, and opportunities of the urban and peri-urban agriculture systems will help policy makers to meet the food needs of megacities in general, and of Hanoi in particular, without damaging the natural resource base of urban and peri-urban areas.

Despite a long history of turmoil, human population in Hanoi province has increased by more than 40 times during the last century. Historically, the rate of growth in urban population remained higher than peri-urban, and the difference is growing (Table 6).

Hanoi is blessed with abundant natural resources for agricultural production to meet the increasing needs of its population. For example, fertile agricultural land constitutes an important resource in urban planning of Hanoi. It is comprised of 42,540 ha, or 46.2% of the total geographical area of the city (Table 7). Even in urban Hanoi where demand for commercial use of land is quite high, about 17.7% of the urban land is agricultural (or 4.1% of total agricultural land). In addition to fertile land, Hanoi has moderate weather, abundant water (except during a few dry months), and irrigation and drainage systems favorable for agricultural activities in and around the city. Above all, it has a hardworking and qualified labor force and a network of public institutions supporting agriculture activities in and around the city. The private sector has also become active and is becoming increasingly efficient in providing various agricultural inputs to farmers and taking unprocessed and processed outputs to consumers.

With these resources, however, the city has to import a large amount of food from far distances. Our estimates suggest that about 44% of Hanoi's food requirements are met from domestic production within the city (both urban and peri-urban). This amounts to importing more than 600,000 t of food from other provinces (Table 8). To meet all food needs, about 329 trucks of food have to enter the city every day (assuming each truck carries 5 t), creating adverse consequences on traffic and the environment. Most of these trucks have to come farther than from peri-urban peripheries as these areas barely meet their own requirements.

However, the contribution of urban and peri-urban agriculture in supplying safe and hygienic food on a sustainable basis can be improved with appropriate

Table 6. Trends in population growth in Hanoi during 1918–2001.

	Population (000 persons)				Annual growth rate (%)		
Year	Urban Hanoi	Peri-urban Hanoi	All Hanoi	Urban % of total	Urban Hanoi	Peri-urban Hanoi	All Hanoi
1918	-	-	70.0	20.0	-	-	-
1955	160.0	370.0	530.0	30.2	-	-	6.9
1978	769.7	1692.3	2462.0	31.3	7.1	6.8	–0.1
1996	1150.3	1247.3	2397.6	48.0	2.3	-1.7	2.8
2001	1506.3	1305.8	2812.1	53.6	5.5	0.9	3.2

Sources: HSO (2001), VTGEO (CNST)-UMR CNRS-IRD "REGARDS" (2002).

Table 7. Distribution of land (ha) by use during 1995 and 2001.

	1995				2002					
	Area (ha)			% of city	Area (ha)			Percentage		
	Urban	Peri-urban	Total	area	Urban	Peri-urban	Total	Urban	Peri-urban	Total
Agricultural land	627	43,238	43,865	47.8	1,748	40,791	42,539	4.1	95.9	46.2
- Annual crop land	-	-	40,087	(91.4)	907	37,075	37,982	2.4	97.6	(89.3)
- Grass land	-	-	88	(0.2)	0	100	100	0.00	100.0	(0.2)
- Perennial crop land			266	(0.6)	18	755	773	2.3	97.7	(1.8)
- Water surface	-	-	2,900	(6.6)	774	2,409	3,183	24.3	75.7	(7.5)
- Mix garden	-	-	524	(1.2)	49	452	501	9.8	90.2	(1.2)
Forest land	-	-	6,717	7.3	24	6,604	6,628	0.4	99.6	7.2
Land under industries, roads etc.	-	-	19,306	21.0	4,216	17,474	21,690	19.4	80.6	23.6
Residential land	2,428	9,081	11,509	12.5	2,922	8,864	11,786	24.8	75.2	12.8
Wasteland	-	-	10,410	11.4	946	8,509	9,455	10.0	90.0	10.3
Total (ha)	-	-	91,807	100.0	9,856	82,242	92,098	10.7	89.3	100

Note: Figures in parenthesis are percentage of the total agricultural land in the respective year.
Source: Hanoi Land Office and HSO (2002).

Table 8. Total food production and demand of urban and peri-urban Hanoi during 2001.

	Production (000 t/annum)			Total demand (000 t)			Annual gap (000 t)		
Food items	All Hanoi	Urban	Peri-urban	All Hanoi	Urban	Peri-urban	All Hanoi	Urban	Peri-urban
Cereals	222.3	4.1	218.3	395.5	193.1	200.1	–173.1	–189.0	18.2
Tubers/starch	37.6	0.0	37.6	15.1	9.1	6.0	22.5	-9.1	31.7
Pulses and beans	7.4	0.0	7.0	83.4	44.4	39.1	–76.4	–44.4	–32.1
Fruits	33.6	0.5	33.1	128.4	98.1	34.3	–94.8	-97.6	–1.3
Vegetables	135.6	3.8	131.8	255.7	137.4	118.5	–120.1	–133.6	13.3
Pork and other red meats	38.1	0.8	37.4	78.6	48.5	30.8	–40.4	–47.8	6.6
Poultry meat	83.5	0.2	8.2	18.5	12.2	6.8	–10.2	–12.0	1.4
Milk, eggs, honey	2.9	0.5	2.4	27.3	18.3	9.7	–24.5	–17.8	–7.3
Water food	9.6	1.6	8.0	45.3	28.0	17.9	–35.7	–26.4	–9.9
Total	495.1	11.4	483.7	1124.3	626.6	501.3	–629.3	–615.3	–17.6

Total demand was estimated by multiplying the per capita consumption with population reported.

policies and technologies. There is a strong possibility that the relatively high proportion of the land for agricultural use compared to other cities in Asia, say Manila, will no longer be available in the near future due to its strong demand for commercial use. However, there is a large potential to expand non-plant-based food production, such as livestock and poultry, in peri-urban areas of the city. The economic viability of such a decision, however, should include the environmental costs of these activities. For this purpose, these sub-sectors have to be organized on a commercial basis away from congested populated areas. The feed manufacturing industry should be encouraged, and programs to promote animal health will need improvement, perhaps through the involvement of the private sector.

The urban Hanoi production system seems more efficient in producing vegetables, especially leafy types as depicted by their higher yields (Table 9). On the other hand, the disease and pest pressure, pesticide use, and industrial wastewater use in urban systems are also higher compared to peri-urban and rural systems (Table 10). Therefore, relative profitabilities of urban, peri-urban, and rural systems are not clear. In making such comparisons, the cost of transportation of food from the rural system and its impact on the environment as well as the value of consumers' preference for fresh vegetables from the urban districts should be included. On the other hand, food quality affected by high levels of pollution in the city, the use of wastewater, and relatively large amounts of pesticides applied on vegetables should also be included in the evaluation.

Table 9. Per ha yield (t/ha) of various crops in Hanoi during 2001

Crop groups	All Hanoi	Urban	Peri-urban
Cereals	3.5	3.3	3.6
Starch food crops	8.0	0.0	8.0
Pulses	1.11	1.00	1.11
Annual industrial crops	7.67	-	7.67
Perennial industrial crops	8.77	-	8.77
Perennial fruit crops	13.25	4.92	13.60
Vegetables	17.90	22.04	17.81
Beans	0.41	0.45	0.41

Source: Estimated from the data reported in HSO (2002).

Table 10. Water, disease, and pesticide use situations in Hanoi.

Situation	Urban	Peri-urban	Rural
Experience water shortage (%)	48.3	44.6	51.1
Use wastewater (%)	41.4	18.9	44.9
Source of wastewater (%)			
City drainage	17.2	0.0	1.1
Household	19.0	14.4	43.8
Industry	0.0	1.5	0.0
Combined	5.2	3.0	0.0
Experience flooding (%)	76.8	67.8	61.6
Drainage of excess water (%)			
Pond	25.0	4.0	1.1
Canal	7.1	11.6	29.6
River	25.0	16.1	16.5
Combined	19.7	36.2	24.4
Veg. yield losses due to pests (%)	28	22	21

The other major constraints on the vegetable cultivation in different production systems of Hanoi are flooding, low output prices, problems in marketing, high input costs, shortage of labor, and shortage of water (Table 11).

The most endurable way to enhance food supplies from city sources is to introduce technological innovations in its production and marketing systems both in urban and peri-urban areas to resolve these constraints. Improved crop varieties and superior crop, livestock and fish management technologies can boost their production. Improved vegetable varieties and protective cultivation strategies that facilitate vegetable production in the wet season, when vegetables are in short supply, can reduce seasonality in their supply. Moreover, technologies and policies are required to improve the safety and hygienic conditions of vegetable supplies in the city. Institutional innovations to improve marketing systems should be given special attention not only to supply affordable food to the urban poor, but also to enhance food safety.

Table 11. Constraints to vegetable production (percentage of farmers).

Constraints	Urban	Peri-urban	Rural
Flooding	50.0	35.3	14.2
Low output prices	41.4	69.2	55.7
Marketing problem	41.4	59.7	44.9
High input cost	34.5	46.3	29.6
Labor shortage	37.6	25.3	20.5
Water shortage	20.7	33.3	29.0
Non-availability of credit	10.3	32.8	10.2
Non-availability of seed	5.2	19.4	13.6
Non-availability of fertilizer	0.0	12.4	7.4
Non-availability of pesticide	1.7	12.4	9.1
Land	3.5	3.0	6.8
Others	6.9	10.0	10.8

Hanoi's unique farming characteristics and constraints should be kept in view to develop and introduce new technologies for the urban and peri-urban areas. For example, the small size of landholdings and the farmers' low financial capabilities should be considered upfront. Arrangements to supplement limited manure supplies in urban areas should be made. Home gardens and livestock sheds owned by a large number of farmers can be used to test new vegetable and animal technologies. To protect crops from insect pests and diseases and to prevent the injudicious use of pesticide on vegetable crops, research institutes in Hanoi should develop rapid diagnosis and response systems. To resolve these various constraints of production and marketing, agriculturists, economists, and city planners need to work together.

The involvement of the private sector in the input supply system needs to be strengthened. Most farmers use home-produced seed, or exchange it with neighboring farmers, and few resort to certified seed dealers because of their high seed prices. The low quality of some home-produced seed seriously affects crop productivity. Legal and financial constraints need to be removed in the development of healthy competition in seed and seedling production and distribution, which is expected to lower seed and seedling costs. Encouraging cooperative marketing can also increase farmers' access to certified seed and other input sources and reduce their costs. The availability of improved and affordable feeds for livestock and fish through a competitive private sector can also boost livestock and fish production.

The extension services should be specifically strengthened in the livestock and poultry sub-sectors. The marketing of livestock and poultry products needs investment to make it hygienic. For this purpose, the private sector should be encouraged to invest in the marketing infrastructure, and cooperative marketing programs should be introduced among farmers.

Many farmers face water shortages despite the many rivers that run through the city. They resort to using untreated drainage water, which presents food safety concerns. Moreover, the distribution system is inefficient in the sense that it requires a lot of labor to haul water from irrigation sources to the field. Therefore, water saving technologies need to be introduced and water distribution systems should be improved to enhance access to irrigation water to many more farmers. Scientific planning to bring water to vegetable fields can save lots of labor, which is quickly becoming a binding constraint for agricultural production in the city. On the other hand, an overall watershed management strategy needs to be designed to overcome flooding during the rainy season.

The indiscriminate use of pesticide on crops, especially on vegetables, has serious health and environmental consequences. Moreover, with increasing levels of gas and water pollution, the crop cultivation in the city is threatened with serious contamination problems. With rising incomes and many tourists in the city, the demand for quality and safe food is increasing. Therefore, farmers need to be trained to follow and record the good management practices depicted by various food safety management systems, such as the Hazard Analysis and Critical Control Point (HACCP). Moreover, economically viable technologies should be promoted to reduce the emission of hazardous wastes at the source points.

Contact: Mubarik Ali

Impact of modern vegetable technologies on the development of agribusiness in Bangladesh

Background

Bangladesh has an overwhelmingly agricultural economy. Agriculture accounts for 32% of gross domestic product (GDP), and absorbs 63% of the country's labor force. Food production has more than doubled since independence in 1971, but food security still remains a major development issue. Thus, the government of Bangladesh has called for a departure from "rice-led" growth to a more diversified production base, including vegetables. Diversification into vegetable crops and increasing commercialization can support the development of the agricultural sector for several reasons. Commercialization is characterized by households moving from subsistence systems into semi-commercial and commercial systems (with the main objective of achieving food self-sufficiency), thereby maximizing profits and generating surplus. Often, this is accompanied by an increase in the number of agro-processing, distribution and farm-input provision companies. Subsequently, income and employment opportunities may grow, causing an increase in real wages. But little is known on how commercialization-led income growth is distributed among different social groups, and whether it actually reduces poverty.

Supported by USAID, AVRDC conducted a project in Bangladesh from 1991-2000 with the aim of overcoming constraints in vegetable production through the development and introduction of new varieties and technologies. These technologies included varietal development for tomato, eggplant, chili pepper, okra, radish, red amaranth, Indian spinach, kangkong, cabbage, cauliflower, yardlong bean and bitter gourd. Despite the substantial improvements observed for both adopting and non-adopting farmers (due to spillover effects) on the farm level, commercialization effects could not be validated at that time. Now, with more than a decade after the project was initiated, evaluation of the project's effects beyond vegetable production was highly plausible. The purpose of this study funded jointly by GTZ/BMZ and the Eiselen foundation was to understand the effect of earlier AVRDC research and development activities in Bangladesh on the welfare of the rural population beyond the direct farm level, by analyzing (1) employment and wage effects; (2) commercialization and agribusiness development;

and (3) by focusing particularly on poverty reduction and assessing differential effects on different groups in society.

The study incorporated quantitative and qualitative methodologies, using structured farmer interviews, focus group discussions, key informant interviews, and available secondary data.

The districts of Jessore and Savar were selected as study sites. New varieties and technologies are widespread in both Jessore and Savar. The research team randomly surveyed 172 farm households in the west side of Jessore district, and 163 in the central area of Savar, which is within the Dhaka district. The survey covered farmer characteristics, marketing and input of crop products, and information on socioeconomic status.

The survey data was supplemented with qualitative data collected in focus group discussions held in the rural communities of Jessore and Savar. The discussions were done primarily to learn from the villagers the range of new agribusiness that has developed relative to increasing vegetable production, new job opportunities that have emerged, and the beneficiaries from the increase in agro-industrialization. Ten interviews were conducted each at the nine villages in Jessore (Muktodhaho, Mothura pur, Tirer Hat, Haibut pur, Kadir para, Shahabaj pur, Charamon Khathi, Paltadanga, and Noldanga) and nine villages in Savar (Mushurikriola, Kanda para, Mushuri Kriola, Chauira, Bakurta Hinda para, Kisherchar, Sadapur, Kazi para, and Chakulia). The focus group discussions were conducted with men and women separately.

On the Meta level, ten interviews were conducted with key informants such as community leaders, entrepreneurs, and market middlemen in Jessore, Savar, and Dhaka areas. Of these, four interviews were conducted with vegetable wholesalers, vegetable retailers, and seed retailers; while the other six interviews were with representatives from the Department of Agriculture Marketing in Bangladesh, Bangladesh Seed Merchant Association, seed producers, food processing companies, and Bangladesh Women Entrepreneurs Association. These semi-structured interviews provided information on the impact of increased vegetable production on commercialization and agro-industrialization.

Vegetable production in Bangladesh

Vegetable production in Bangladesh has increased at an average rate of 2.8% over the past 23 years. In some areas of Bangladesh (namely Jessore, greater Dhaka region, and Rangpur and Dinajpur districts), this growth has been tremendous. A change of existing farming practices has taken place, replacing traditional crops as jute, pulses and rice (Fig. 1). However,

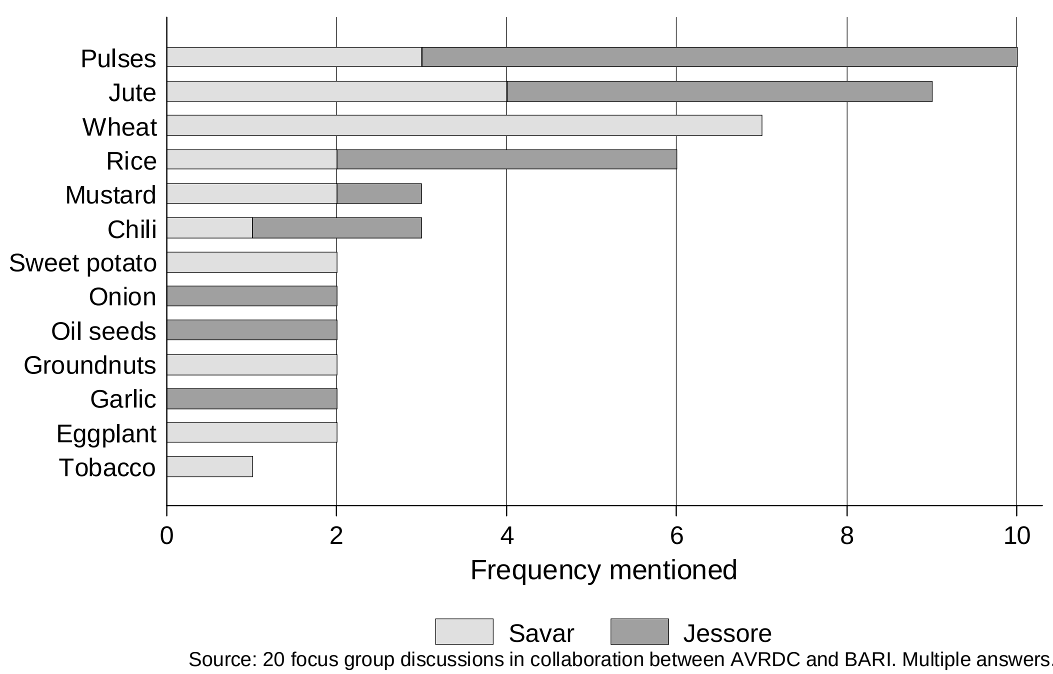


Fig. 1. Frequency rank of crops replaced by vegetables.

horticultural exports from Bangladesh remain negligible, and the supply of horticultural products can barely address the country's domestic requirements.

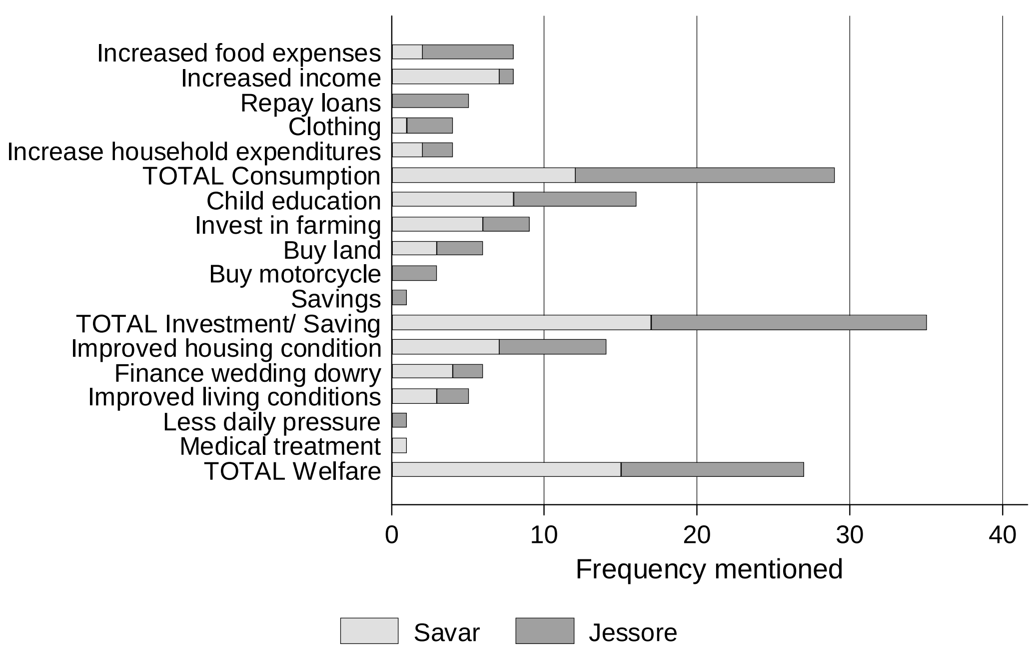
Adoption and access to new vegetable technologies

The government continues to deliver farmers' support systems (irrigation facilities, rural infrastructure, improved technologies and varieties, and others), which have helped Bangladeshi farmers achieve dramatic increases in agricultural production. Eager to increase their production, many farmers (91%) invested in some new vegetable technology over the last five years. Based on the sample, improved open-pollinated and hybrid seed varieties are the most commonly adopted vegetable technologies in Jessore and Savar (72%). The average rate of farmers who adopted an improved technology of the USAID-funded AVRDC project was 43%, and the average share in all technologies adopted was 31%. In terms of farmers' receptiveness to these improved technologies, small-scale farmers, particularly small landowners with large cultivated areas, tend to be late adopters compared with larger farmers.

Employment and wage effects

Increased vegetable production has resulted in large employment effects for the community through (1) new employment opportunities; (2) substitution of family labor for hired labor; and (3) increased wage income. The average hired labor man-days in the cultivation of vegetables is 170 man-days per ha (excluding labor from contracted companies), half of the total labor requirements. Likewise, the total value added in wages is approximately US$400 per ha, 7.5 times higher than valued added through employment in rice. In particular, small-scale farmers benefit from additional employment opportunities. In small-landowning households cultivating small areas, more than half of men and 16% of women seek employment outside their own farm, wherein one-third of these employment opportunities are vegetable-related (Fig. 2).

In Bangladesh, women's participation in the labor force is increasing faster than that of men's and it is estimated that approximately 8 million women are seeking employment. Hired vegetable-based labor in Savar and Jessore continues to be male-dominated, perhaps due to cultural restrictions that women face



Source: 20 focus group meetings in collaboration between AVRDC and BARI. Multiple answers.

Note: Two groups (one each in Savar and Jessore) responded that they did not see any benefits in increased vegetable production.

Fig. 2. Life improvement indicators.

in working outside the homestead (*purdah*). Individual hiring of laborers for production activities is usually male-dominated, except for harvesting activities in Jessore. In Jessore, women are also involved in abstracting and emasculating flowers for seed production. However, focus group discussions highlighted that post-harvest activities, which were not recorded in the farm production survey, are female-dominated and four out of the ten focus groups in Savar and nine in Jessore identified female laborers among the beneficiaries of increasing labor requirements. Women are usually involved in cleaning, washing and grading of harvested goods. Similarly, women are usually responsible for seed production of vegetables. Others have reported a share of hired female labor in vegetable production of 1.2%. Our study found a higher share in Jessore at 17.2% as compared to Savar (1.5%). Jessore has been reported by others to be less conservative. Thus, there appears to be an employment-generating effect of modern vegetable technologies that favors female labor employment to some extent, social and cultural circumstances permitting.

So far, these off-farm employment activities are mainly at the production and post-harvest levels since vegetable processing and the food manufacturing sector are not yet fully developed. While the number of fruit and vegetable industries has grown from 12 in 1986 to 62 in 2000, this number remains negligible and offers employment opportunities only for a very few. Consequently, no household in the sample of this study had paid employment in the processing sector.

Local support industries

Local support industries are benefiting from an expansion of vegetable cultivation both on the input and output side. A higher degree of input commercialization was observed for vegetables as compared to cereals. This is particularly true for all inputs such as seed, inorganic fertilizers, pesticides, farm manure, plastic, nets and bamboo sticks. In general, a higher share of vegetable output is sold on markets as compared to the production of cereals. Vegetable farmers are highly integrated into markets, selling a large share of their products and retaining a small portion for home consumption. This is true for all farmers, whether small or large.

Supermarkets continue to play a minor role in Bangladesh, and most vegetable produce are sold either in the local markets or to wholesalers.

Welfare effects

In general, this study found that the vegetable production has contributed to widespread welfare effects. A comparison of income data between an earlier study and this one leads to the conclusion that ‘late adopters’ have also been able to capitalize on improved vegetable technologies, and in the process have leveled down initial income differences between households. While total household incomes have not changed much compared to the earlier study, a much larger share can now be attributed to vegetable-related farm production.

Nearly all communities agreed that they were benefiting from increased vegetable production (either in terms of enhanced consumption, enhanced investment or saving opportunities, or increased welfare, see Fig. 2). The single most important improvement mentioned was the ability to send children to school, followed by improvements in housing condition. The average school attendance ratio of this sample is much higher than the average for Bangladesh.

However, the farm level data also showed that larger farmers have been able to capitalize more. On average, 90.3% of households experienced an improvement in their life over the past five years, but large farmers reported larger increases in well-being as compared to smaller farmers.

Summary

The current state of vegetable production can continue to expand, spreading to other regions in Bangladesh, if export and processing markets are tapped, and low-cost post-harvest and processing technologies to the agro-processing sector are introduced. Also, there are quality standards demanded by large importers like EU (i.e., EUREPGAP) that must be met by farmers, processors and marketers if export markets are to be tapped. Some current limitations, though, cannot be dealt with by vegetable research and development alone, such as transportation and infrastructure such as cold storage. The availability of quality vegetable seed also remains a major bottleneck.

While this study has shown that increases in vegetable production are leading to broad and widespread welfare increases in target communities, the study has also shown more impact can still be expected, particularly if agro-processing industries and food manufacturing develop further.

Contact: Katinka Weinberger

Domestication of selected African indigenous vegetables in Tanzania—an ex-ante impact assessment

Background

African indigenous vegetables play a highly significant role in food security of the underprivileged in both urban and rural settings. They can serve as primary foods or secondary condiments to dishes prepared from domesticated varieties. They are also valuable sources of energy and micronutrients in the diets of isolated communities. Further, they may serve as income sources and may be marketed or traded locally, regionally, even internationally, and the primary importance of edible wild species during periods of drought and or social unrest or war is well documented. However, the important role of African indigenous vegetables in Tanzania's health sector, diets, and as an income source is threatened through extinction of the genetic resources of these species. Many landraces of vegetables are in the process of being replaced by modern varieties.

The purpose of the study, funded by GTZ/BMZ, was to provide recommendations for enhancing the role of indigenous vegetables (IV) for improved nutrition, healthy diet, and diversified income generation in home garden production and commercial farming systems in Tanzania. The study used a multidisciplinary approach to identify market demand and to analyze values for nutrients that are known to be commonly deficient in the diets of the majority of people in Tanzania. Several of the IV crops that we focused on in this study are those identified by a complementary project "Promotion of Neglected Indigenous Vegetable Crops for Nutritional Health in Eastern and Southern Africa" as target IV crops. There are a variety of indigenous fruits in use and consumed, which are purposely excluded from this study.

Data were collected using both quantitative (household surveys) and qualitative approaches (focus groups). Four regions were covered, namely Arusha, Singida, Dodoma and Tanga, all in northeastern Tanzania and the focus of another research project funded by the same donor, aiming to promote production and consumption of IV crops. In total, 359 households were interviewed based on random selection. The questionnaire comprised of a section on consumption, and a section on production. The consumption section included general consumption aspects of indigenous vegetables, a section of attitude and beliefs concerning the vegetables, and a detailed 24-h food recall. The production section comprised a section on overall food crop production, a section on production of indigenous vegetables, and a section on marketing related aspects of them. Some socio-economic variables were also included. In addition, we identified several large cities for a willingness-to-pay analysis, namely Arusha, Morogoro and Dar es Salaam and 287 randomly selected consumers on local markets participated in these interviews. Based on the consumption survey, amaranth (*Amaranthus* spp.), nightshade (*Solanum villosum*, *S. scabrum*, and related species) and African eggplant (*Solanum* a*ethiopicum* and *S. macrocarpon*) had been identified as the most frequently purchased crops. With the WTP survey, thus, we focused on these three indigenous vegetables to assess traits important for consumers, and consumer's willingness to pay for these traits. A model was estimated to measure the impact of the most relevant explanatory factors on the individual WTP for selected indigenous vegetables, based on contingent valuation. Nutrient content analysis of vegetables was conducted for major vegetables identified in focus group meetings, and the atomic absorption spectrophotometer (AAS) method was applied to determine iron and zinc content and â-carotene content was determined using the high-performance liquid chromatography (HPLC) method.

Nutrient analysis

It appears that several of the analyzed indigenous vegetables in the four districts have good potential as important sources of the three important micronutrients assessed in the current study (Table 12). For example, while the iron contents of spinach (*Spinacia oleracea*) found in most parts of Africa is known to be 1.7 mg per 100 g edible portion, the values observed in this study for amaranth and nightshade are as high as 37 mg. Other noted good sources of iron include spiderflower plant (*Cleome gynandra*) and bitter lettuce (*Lactuca* spp.) (up to about 50 mg per 100 g of edible portion).

Table 12. Iron, zinc and ß-carotene contents of amaranth, nightshade and African eggplant (mg/100 g).

	Fe	Zn	ß-carotene
African eggplant			
Kongwa	2.20	0.120	0.04
Singida	2.45	0.325	0.19
Muheza	2.80	0.176	0.29
Arumeru	2.00	0.218	0.11
Amaranth			
Kongwa	37.05	0.433	3.29
Singida	22.95	0.363	2.70
Muheza			
- variety 1 (common type)	13.55	0.372	3.79
- variety 2 (spiny type)	7.95	0.489	0.86
- variety 3 (broad-leaf type)	5.95	0.885	7.54
Arumeru			
- variety 1 (dark-leaf type)	13.15	0.810	1.71
-variety 2 (broad-leaf type)	8.60	0.534	2.10
-variety 3 (indigenous type)	6.50	0.512	0.13
Nightshade			
Kongwa	8.90	0.261	3.23
Singida	14.55	0.351	1.09
Muheza	6.95	0.205	5.02
Arumeru			
- variety 1 (common type)	15.90	0.374	3.97
- variety 2 (broad-leaf type)	9.75	0.380	1.82

Consumption aspects

Among the rural population, only about one-quarter of all vegetables consumed are indigenous, the remaining are exotic vegetables. Compared to earlier reports from the 1970s the frequency of consumption has declined. However, indigenous vegetable crops continue to be an important contribution to the diet, particularly during the rainy season, when they are readily available. Nearly 80% of households reported that they collected indigenous vegetables during the rainy season. The share of indigenous vegetable consumption in all vegetables is much higher among the poorest quintile of households (40%) compared to among the wealthiest quintile of households (11%) and also the variety in consumption of indigenous vegetables decreases as households become wealthier, while at the same time the variety in consumption of exotic vegetables increases. By valuing collected indigenous vegetables and such produced in local gardens, we found that in the poorest group of households approximately 11% of all food consumed are indigenous vegetables. The average share for all households is only 4.5% (Table 13).

Table 13. Household wealth and value of vegetables consumed.

Wealth	Share in total food value		Per capita value (month)	
index	IV	All vegetables	IV	All vegetables
0	10.6	18.7	1066	2031
1	4.7	14.0	500	1509
2	4.1	11.4	435	1377
3	3.8	11.4	435	1477
4	3.8	11.3	474	1335
5	1.8	7.2	150	1505
Average	4.5	12.5	492	1478

Note: Wealth index was calculated as the sum of values assigned to ownership of radio, chicken, bicycle, mobile phone, electricity.

However, it would be wrong to believe that indigenous vegetables are a purely subsistence crop for poor consumers. After all, approximately two-thirds of all rural households reported that they purchased indigenous vegetables during the dry season. Also, our WTP analysis among urban consumers indicated that there is considerable scope for higher prices. On average, consumers were willing to pay an additional 23% for African eggplant to 34% for amaranth, although this varied strongly across localities (Table 14). In general, the willingness to pay an additional premium on current prices if all desired traits among crops were available was highest in Arusha (where current prices are lowest) and lowest in Dar es Salaam (where current prices are 2 to 3 times higher than in Arusha). The willingness to pay was more strongly influenced by location and crop, than by individual socio-economic characteristics of respondents.

Table 14. Average willingness to pay for one kg of IV crop.

Location	Amaranth		Nightshade		African eggplant	
	TSH	Premium (%)	TSH	Premium (%)	TSH	Premium (%)
Arusha	366	+92	375	+110	333	+98
Morogoro	352	+43	419	+63	491	+33
Dar es Salaam	399	+15	469	+3	598	+6
Average	371	+34	429	+32	516	+23

Consumers demanded very different types (Table 15). For example, consumers in Arusha demand a narrow-leaf, dark green, small sized nightshade variety, while consumers in Dar es Salaam demand a large broad-leaf, green variety. Some of the crops, such as amaranth, are demanded for their medicinal and nutritional value. i.e., it is well known that amaranth is a cure against anemia (and indeed, amaranth showed the highest iron value among all indigenous vegetables analyzed). Indigenous vegetables are also popular because consumers believe that production takes place with low input levels.

Particularly poor households rely in the consumption of indigenous vegetables to fulfill their daily requirements of vitamin A and iron (Table 16). In the poorest households, approximately 50% of all vitamin A requirements and slightly less than one third of iron requirements are consumed through indigenous vegetables. Thus, while indigenous vegetables cannot be considered a panacea for the elimination of micronutrient deficiencies, these results show that IV do have an important role to play in maintaining adequate levels of micronutrient consumption.

Table 15. Summarized results of cluster analysis.

	TYPE I	TYPE II	TYPE III
Amaranth	Dark green	Green	Dark green
	Narrow leaves	Narrow or broad leaves	Broad leaves
	Small-average size leaves	Average size leaves	Average to big size
	Softt texture	Fibrous texture	Fibrous texture
	Neutral taste	Neutral taste	Neutral taste
	No aroma	Some aroma	Some aroma
	Not slimy	Not slimy	Not slimy
Arusha	38.5%	15.4%	46.2%
Morogoro	27.5%	47.1%	25.5%
Dar es Salaam	16.2%	51.4%	32.4%
Nightshade	Green	Dark green	Dark green
	Broad leaves	Broad leaves	Narrow leaves
	Average to big size	Average size	Little size
	Fibrous texture	Soft texture	Fibrous texture
		Cooks within 30 minutes	
	A little bitter	A little bitter	Very bitter to some bitterness
	Not slimy	Not slimy	Not slimy
Arusha	33.3%	16.7%	50.0%
Morogoro	35.3%	23.5%	41.2%
Dar es Salaam	58.6%	27.6%	13.8%
African eggplant	Light green/ yellow	Dark green	Milk white
	Round	Long form	Egg shaped
	Average size	Average size	Average size
		Little bitter	Little bitter
	No aroma		No aroma
Arusha	90.9%		9.1%
Morogoro	19.5%	22.0%	58.5%
Dar es Salaam	18.8%	21.9%	59.4%

Table 16. Contribution of IV to fulfillment of daily Fe, Zn, and ß-carotene requirements of household.

Wealth index	% Contribution of IV to daily household requirements		
	Iron	Zinc	ß-carotene
0	29.5	3.8	53.1
1	22.0	2.6	35.7
2	13.2	1.9	23.7
3	14.6	2.0	24.7
4	10.4	2.8	32.8
5	1.7	0.6	1.7
Average	15.2	2.3	29.0
Average contribution of exotic vegetables	1.5	0.5	3.0

Production aspects

Production of indigenous vegetables is an important activity particularly for small farmers with small plots of land (Table 17). Placing more emphasis on research for these crops as opposed to exotic vegetables will thus benefit the relatively poorer farmers. On average, the production of IV crops contributes to approximately 13% of all household income, valuing both marketed and non-marketed crop (Table 18).

The production of indigenous vegetables is particularly important for small farmers, because the production involves little monetary cost and relies strongly on family labor (Table 19). On average, only 10% of all cost in the production of indigenous vegetables are cash cost, the remaining 90% is family labor valued at the average wage rate. Few other purchased inputs are required. Indigenous vegetables are also important because they allow for an extended harvest period, thus contributing to the food security of the household over a longer period than exotic vegetables, which are usually harvested within a few harvests. Another advantage of indigenous vegetables is their adaptation to abiotic constraints, in particular droughts or heavy rains.

Table 17. Percentage of households engaged in the cultivation of IV crops by district and total cultivated food area.

District	Food crop area quintiles (%)					Average
	1	2	3	4	5	
Arumeru	77	79	67	54	71	70
Kongwa	10	9	10	10	15	11
Singida	53	56	54	39	10	43
Muheza	28	35	32	27	18	28
Average	39	40	40	30	26	35

Note: Farm households were ranked into quintile groups according to their total area under food crop cultivation within each district. Farms in group "1" cultivate smallest areas, while farms in group "5" cultivate largest areas.

Table 18. Share of marketed and non-marketed IV in overall household income.

District	% Non-marketed IV in total income	% All IV in total income
Arumeru	3.8	12.6
Kongwa	8.3	9.2
Singida	7.8	18.5
Muheza	1.8	10.0
Average	5.4	12.6

Table 19. Share of different cost items.

	Share in variable cost (%)					Variable cost
	Labor	Inputs	Marketing	Rent	Total	in total cost
Sweet potato	36.0	0.0	64.0	0.0	100	2.0
Cowpeas	20.9	69.5	9.6	0.0	100	6.2
African eggplant	7.8	74.4	17.0	0.8	100	30.6
Amaranth	48.5	48.4	2.9	0.2	100	24.5
Ethiopian mustard	1.4	89.1	8.5	1.0	100	13.3
Nightshade	9.1	88.7	2.3	0.0	100	20.0
Okra	12.3	34.1	52.8	0.8	100	3.8
Pumpkin	69.6	30.4	0.0	0.0	100	0.4
Average	25.7	54.3	19.6	0.3	100	12.6

Note: Labor cost in variable cost is hired labor, valued at actual wage rate. Total cost includes family labor, valued at 200 TSH per hour, and total variable cost.

While not all indigenous vegetables are marketed, several of them are highly commercialized (Table 20) and further expansion of their production will contribute to a further development of markets and commercialization of the rural economy. However, for small farmers in remote areas to benefit from such a development, improved infrastructure and market access would be required. Since small farmers rely strongly on the production of IV for their livelihood, it is expected that further expansion of commercialization activities would particularly benefit the small farmers. The IV crops that are most important for sale on markets are African eggplant, nightshade, okra, amaranth and Ethiopian mustard.

Table 20. Share of IV produce sold on the market.

Crop	Mean (%)	N
African eggplant	82.2	24
Nightshade	66.6	30
Okra	65.1	58
Amaranth	64.8	50
Ethiopian Mustard	62.6	11
Sweet potato	37.6	12
Pumpkin	32.1	21
Cowpeas	11.4	86
Wild cucumber	4.0	5
Jute mallow	0.0	1
Total	46.3	298

A main constraint for further expansion appears to be availability of high quality seed with resistance to a variety of pests and diseases, and related information on best cultivation practices. The latter will be difficult to develop, since cultivation of IV crops is highly location specific, and much more so than for exotic vegetables.

Seed availability

Three (3) seed companies in Tanzania sell IV crop seed. Among the seed companies interviewed, the share of IV seeds sold is small at probably no more than 10%. In total, around 15 ha in Tanzania is under production of IV seed (Table 21, Table 22). The IV that have been domesticated are: amaranth, African eggplant, Ethiopian mustard, black nightshade, and okra. Most prominent are amaranth and eggplant, but seed for nightshade and okra is also produced.

Table 21. Production of certified indigenous vegetable seed in 2004.

	Company (in ha)			
Vegetable	Alpha	KIBO	East African	Total
African eggplant	2.99	0.40	0.00	3.39
African nightshade	1.98	0.40	0.00	2.38
Amaranth	0.49	0.40	2.02	2.91
Ethiopian mustard	6.96	0.00	0.00	6.96
Okra	0.00	0.40	0.00	0.40
Total	12.42	1.60	2.02	16.04

Table 22. Production of quality declared seed in 2004.

Vegetable	Farmers (no.)	Production (ha)
African eggplant	26	1.62
African nightshade	18	0.93
Amaranth (grain and white)	21	1.42
Okra (pusa sawani)	18	1.29
Total	83	5.26

Approximately 15% of all IV seed used are probably certified seed, while another 8-10% are quality declared seed. Hence, approximately 25% of all IV seed used are either certified or QDS.

Most seed companies regard the market for several IV crops as promising a good potential. There is a good potential for the marketing of seeds especially of amaranth and nightshade, because farmers harvest continuously and thus cannot keep seed, and of okra and African eggplant, because the fruits are eaten. Thus, seed dealers consider that the market for certified seed will increase for these crops if consumers demand IV crops. Also, European seed is relatively more expensive, thus local seeds have a price advantage over imported seeds. In addition, these are fast growing crops that need minimum investment, thus putting only little financial strain on farmers. Seed dealers also perceive that the demand for IV seed is rising and may be rising even further since IV crops are nowadays sold in supermarkets. Consumers also appreciate the nutritional and medicinal value of IV crops.

However, while seed dealers perceive a good growth rate, they are also aware of the problem that there is a big parallel trade in farmers' seed where farmers obtain their seed at no monetary cost. Also, some of the crops such as amaranth and nightshade are not so easy to grow, so farmers may become discouraged. Another constraint for the seed market as a whole is the missing government support for the seed market as a whole. Crops that the dealers perceive as having good potential are cowpea and cassava leaves.

Seed companies were using both base seeds provided by AVRDC and HORTI-Tengeru, the Tanzanian research institute for horticultural crops. There are opportunities for further improvement of the collaboration with AVRDC, such as AVRDC providing improved information packages related to varieties, yields, production aspects, and proper specifications for cultivation.

Summary of research findings

Indigenous vegetables are important both for consumption and production, and in both cases, poor households rely more on these vegetables than more wealthy households. However, in comparison to older literature, the importance of IV for consumption appears to have declined over the years. Nonetheless, several indigenous vegetables are highly commercialized, and some of them can nowadays be found in supermarkets and convenience stores. It appears that there is a good market potential for these crops, both in the high-price segment, as well as in the low-price segment. Commercial seed companies are also recognizing this potential and are entering – albeit cautiously – this market.

In order to tap this potential while also ensuring that small and resource poor farmers can benefit it will be essential that the companion project on "Promotion of Neglected Indigenous Vegetable Crops for Nutritional Health in Eastern and Southern Africa" incorporates the needs of small farmers into their research agenda.

In particular this relates to the selection of improved varieties with traits that are important for small farmers. Indigenous vegetables enjoy the advantage of being produced with relatively small inputs and thus with low capital risk and it is unlikely that farmers would change this production pattern. Thus, selecting varieties that require an intensive input regime will probably be less attractive to farmers. On the other hand, farmers are interested in early maturing varieties that allow for multiple harvesting over a long production cycle. Such traits should be considered when selecting varieties for domestication.

Currently, approximately 25% of IV seed are either certified or quality declared seed. To contribute to the enhanced availability of quality seed, it is recommended to provide farmers with training on how to produce quality seed. The project should consider collaborating more strongly with the existing "Quality Declared Seed" project. In addition, to foster seed companies and increase their share in the production and market of indigenous vegetable seed, it will be desirable to provide seed companies with bigger quantities of base seed and to provide training of employees of seed companies.

Part of the success of the project "Promotion of Neglected Indigenous Vegetable Crops for Nutritional Health in Eastern and Southern Africa" will also depend on stronger promotional activities. While AVRDC-RCA should play a part in providing the required information, not necessarily all activities should be carried out by AVRDC-RCA. Production related information aspects, such as varietal information, yields and cultivation practices, should be packaged and made available to extension personnel and seed companies who may have a greater outreach to farmers. Consumption related information such as medicinal and nutritional properties should also be packaged and made available in an easily digestible form. Opportunities for distributing this information through schools, in supermarkets, or through media such as the radio should be explored. Considering the current number of staff at AVRDC-RCA it should be considered to hire one additional staff for these promotional activities. This information would be of value for the other participating countries, i.e. Rwanda, Uganda and Malawi, as well.

A main constraint for further expansion appears to be the difficulty in obtaining high quality seed and related information on best cultivation practices. The latter will be difficult to develop, since cultivation of IV crops is highly location specific, much more so than for exotic vegetables. A major problem that any priority setting exercise with such a diverse range of crops is the extreme variation in preferences. The companion project has already achieved a formidable task in selecting twelve crops for further research. In order to come to quantifiable output, however, it may be best to focus on a smaller group of crops. Amaranth appears to offer the best opportunities across all study areas. Okra and African eggplant also offer good market potential. If not for their location specificity, both African eggplant and okra offer relatively attractive returns on per ha and per labor h basis. The limitation of nightshade, for instance, is its location specificity which may offer fewer opportunities for market expansion. Ethiopian mustard, while highly attractive in economic terms, is much less demanded by consumers across all four regions and would require intensive promotion activities to increase demand. For nutritional purposes, a focus on amaranth, nightshade, spiderflower and bitter lettuce may be valuable.

In conclusion, the results of this study reveal the importance of indigenous vegetables in resource poor communities and highlight the importance of preserving biodiversity and indigenous knowledge on production and consumption, while improving cultivars and cultivation practices of IV's in Tanzania.

Contact: Katinka Weinberger

Significance of indigenous vegetable consumption and health among school children in Lao PDR, Thailand, and the Philippines

Background and objective

This activity is a component of the ADB funded RETA 6067 "Promoting Utilization of Indigenous Vegetables for Improved Nutrition of Resource-Poor Households in Asia" which aims at promoting indigenous vegetables through pilot school gardens in selected sites of Lao PDR, the Philippines and Thailand. The surveys intend to provide baseline information against which the success of the school garden activity can be assessed at a later stage. Objectives of the school garden activity are: (i) to increase exposure of children and their families to indigenous vegetables, (ii) promote consumption of indigenous vegetables, (iii) increase knowledge about indigenous vegetables, and (iv) increase consumption of micronutrients.

Methods

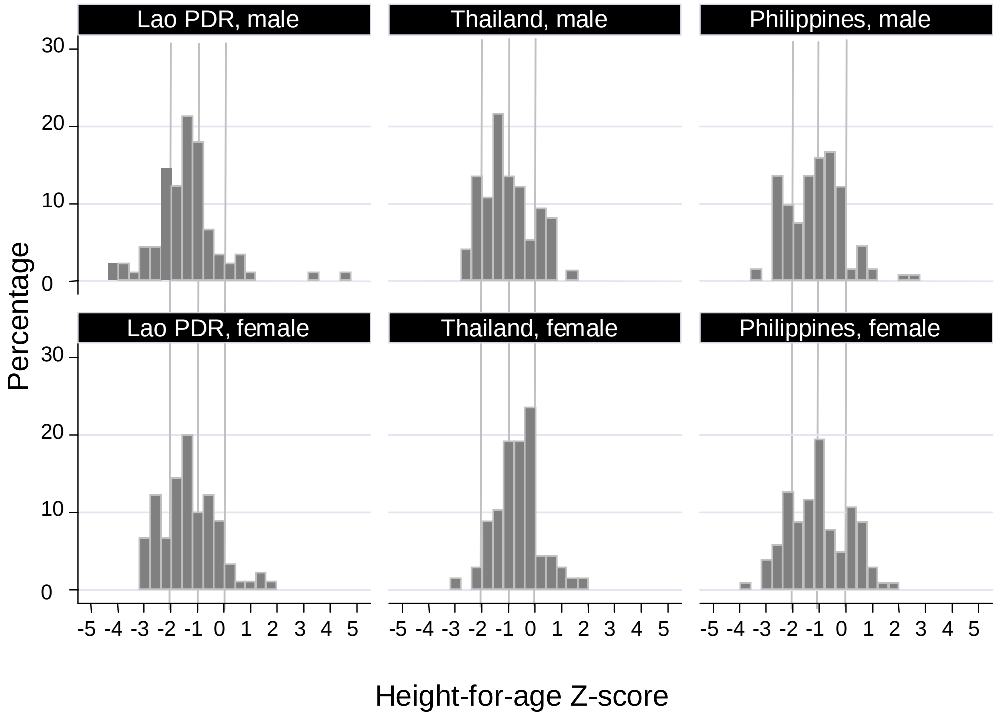
The surveys were conducted between August 2003 and June 2004. In total, 564 children and their households were interviewed, 194 children in Lao PDR, 143 children in Thailand, and 227 children in the Philippines. Children interviewed from the three countries belong to the 9 to 11 age group, and are enrolled under Grades 3 to 5. Sites include schools with a school garden intervention and control schools, located in relative proximity to the intervention schools, with a distance of about 10 to 20 km. Three sites each for the Philippines and Thailand were covered (2 interventions and 1 control), and four in Lao PDR (3 interventions and 1 control). All children of the grades covered under the intervention were included into the sample.

Two different survey forms were administered. Children underwent anthropometric measurements and a blood haemoglobin test, and were interviewed concerning current knowledge on indigenous vegetables. Weight of children was measured using spring scales with light clothing, and height was measured using a measuring tape. Blood haemoglobin was analyzed with a fingertip sample of capillary blood obtained by a physician/nurse using system microlances. The blood was collected in a microcuvette and analyzed by a laboratory the same day. An adult family member, usually the mother (73.2% in Thailand, 88.5% in Philippines, and 77.6% in Lao PDR), was interviewed with a survey form that includes socio-economic and demographic variables, attitude towards and knowledge of IV crops, and a 24-hour food consumption recall.

Child health

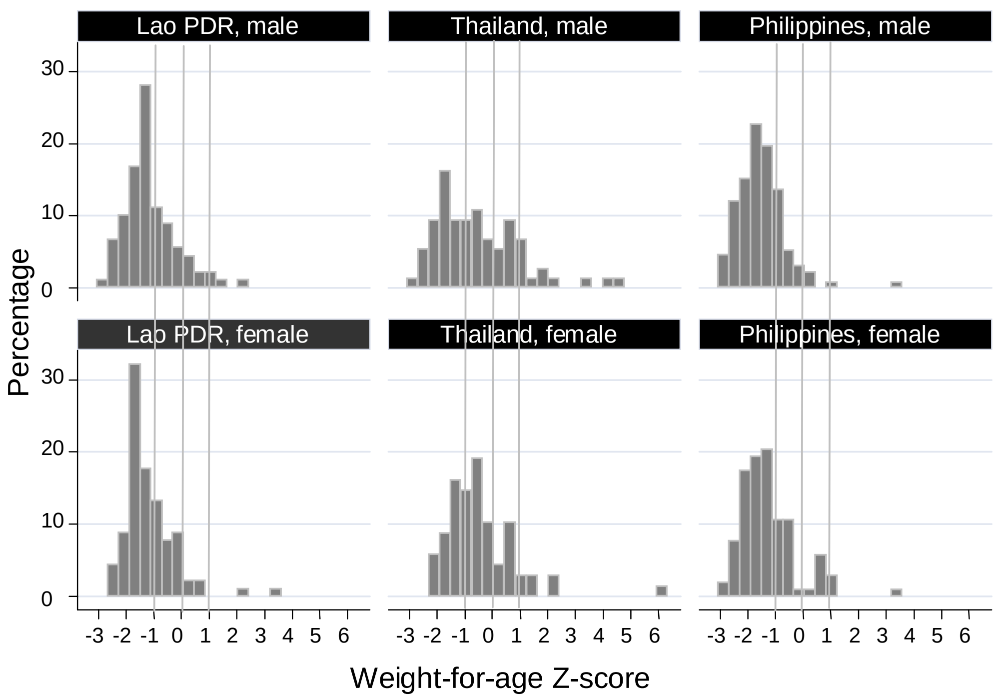
Anthropometric measures. We use Height-for-age and Weight-for-age to identify malnutrition among schoolchildren in the selected sites of Lao PDR, Thailand, and Philippines and compared these to the 1978 NCHS/WHO reference standards (Figures 3 and 4). The average weight for age Z-score in Lao PDR was -1.15, -1.41 in the Philippines and -0.48 in Thailand. The WHO considers a Z-score of below -1 as a cut-off point for mild malnutrition, a cut-off point of below -2 as moderate malnutrition and a cut-off-point of below -3 as severe malnutrition. Thus, in our sample, the average child in the Philippines and Lao PDR was mildly malnourished (Figure 5).

Blood haemoglobin values. Blood haemoglobin measured average values just around the cut-off point for anaemia (<12g/dl) in all three countries; lowest values were measured in Thailand. Percentages of children classified as moderately anaemic in countries surveyed: Philippines, 12.6% ; Lao PDR, 22.2%; and Thailand, 35.2% with a surprisingly high rate for boys at 42.5%. The distribution of blood haemoglobin values is shown in Figure 6.



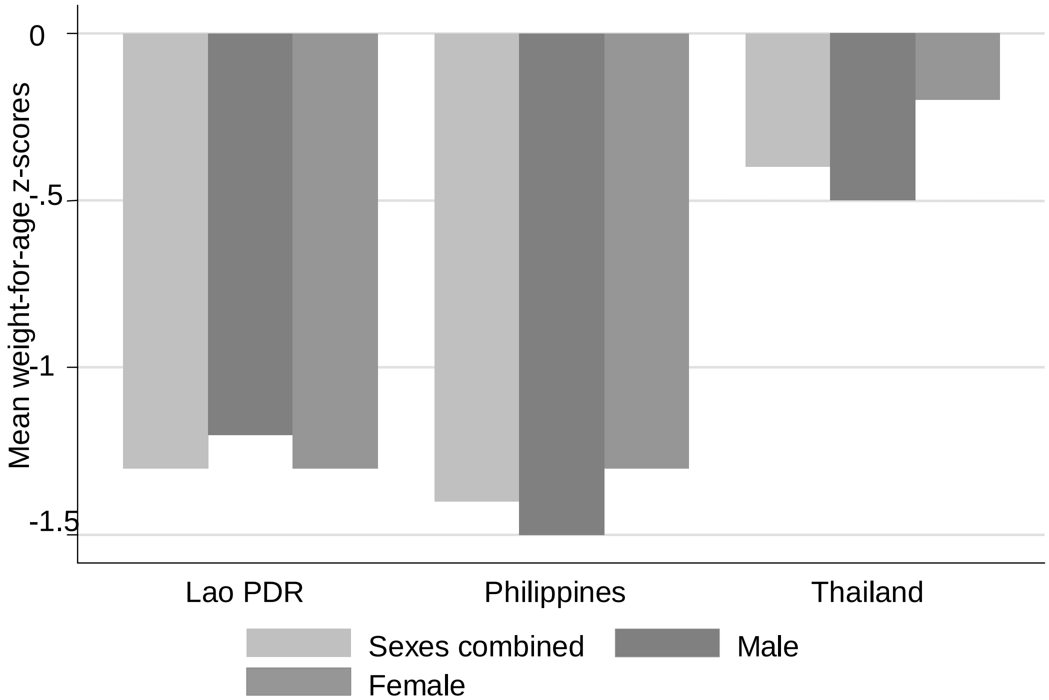
Source: Surveys in collaboration between NARS of respective countries and AVRDC, 2003-2004.

Fig. 3. Histogram for Height-for-age Z-scores by country and sex.



Source: Surveys in collaboration between NARS of respective countries and AVRDC, 2003-2004.

Fig. 4. Histogram for Weight-for-age Z-scores by country and sex.



Source: Surveys in collaboration between AVRDC and NARS of respective countries, 2003-2004.

Fig. 5. Mean Weight-for-age Z-scores by country and sex.

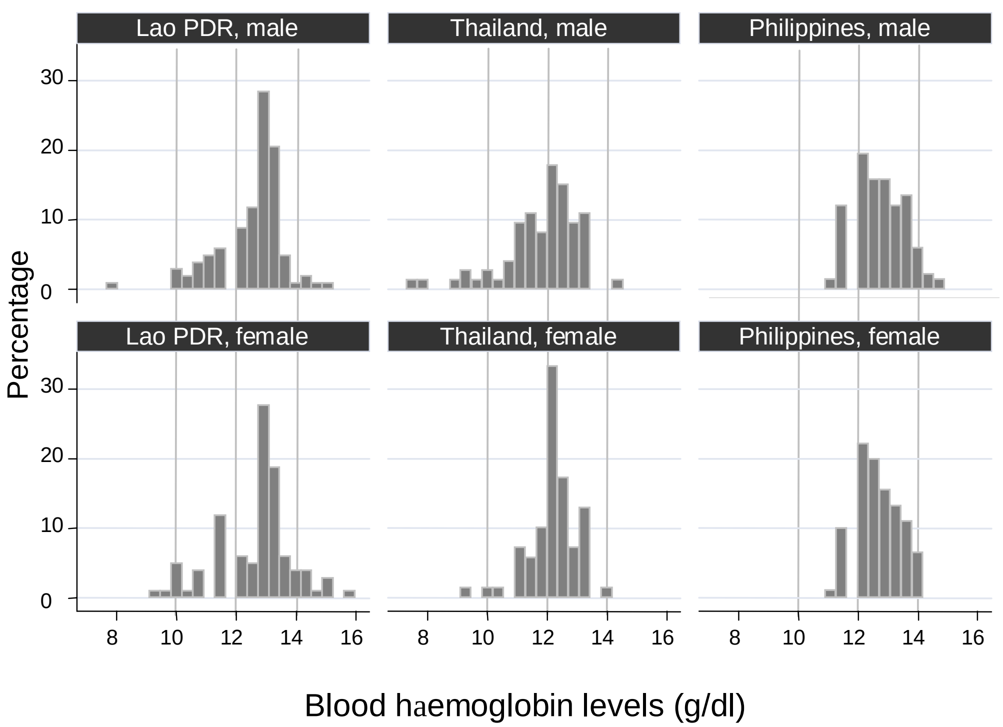


Fig. 6. Histogram for blood haemoglobin levels by country and sex.

Food consumption

Average per capita food expenditure is highest in Thailand at approximately US$50 per capita per month, and lowest in the Philippines at approximately US$20 per capita per months. These differences keep their scale when using the purchasing power parity (PPP) conversion factor into international US$ (Table 23).

Table 23. Selected socioeconomic parameters.

Country/ site	Monthly per capita food expenditure per household	
	(current US$)	(2003 PPP US$)
Lao PDR	27.5	99.9
Thailand	49.8	160.9
Philippines	19.6	88.9

Note: 1 US$ = 0.00013 LAK (February 2004 average)
= 0.01791 PhP (June 2004 average)
= 0.024505 Baht (August 2003 average)

Source: Surveys in collaboration between NARS of respective countries and AVRDC, 2003-2004; 2003 purchasing power conversion factor from Worldbank, 2004.

A comparison of food consumption patterns across the three countries shows that families in Lao PDR and Thailand have a higher frequency of consuming meat and poultry products as compared to the Philippines. This reflects the higher per capita food expenditures in these two countries as compared to the Philippines. Approximately 80% of households in Lao PDR and Thailand consume meat and poultry more than once per week, whereas in the Philippines, the rate is only 40%.

There is a large variation in the propensity of households to grow vegetables in home gardens across countries, as Table 24 shows. Approximately one third of all households in the Philippines never grow vegetables in home gardens, while only 15% of all households in Lao PDR never grow vegetables. Similarly, the share of households growing vegetables in home gardens around the year from Lao PDR is high at 58% than in Thailand (51%) and the Philippines (45%).

Table 24. Households growing vegetables in home garden.

Survey response	Lao PDR		Thailand		Philippines	
	N	%	N	%	N	%
No response	8	-	1	-	0	-
No	29	16	35	25	78	34
Yes, during rainy season	9	5	34	24	47	21
Yes, during rainy and dry seasons	107	58	73	51	102	45
Yes, during dry season	41	22				
Total	194	100	143	100	227	100

Source: Surveys in collaboration between NARS of respective countries and AVRDC, 2003-2004.

Attitude towards indigenous vegetables

Respondent in all three countries underwent a variety of yes/no questions to determine the attitude towards indigenous vegetables. Some interesting aspects emerge (Table 25).

Table 25. Respondents' attitudes and perception toward indigenous vegetables, (yes responses).

Item	Lao PDR		Thailand		Philippines	
	N	%	N	%	N	%
IVs are offered to visitors	155	81	129	90	183	81
Our household consumes IVs during special occasions	86	45	107	75	117	52
Cooking IV more time consuming than other vegetables	39	28	52	23		
The diversity of IVs today is larger as compared to 20-30 years back	48	25	91	66	116	51
We consume more IVs when we are short of money	175	92	89	63	206	91
Exotic vegetables are more nutritious than IVs	60	31	62	44	90	4
I teach my children how to grow IVs	170	88			139	61
Generally, my children like eating IVs	179	93	120	84		

Source: Surveys in collaboration between NARS of respective countries and AVRDC, 2003-2004.

Less households in Lao PDR and the Philippines would offer indigenous vegetables to visitors (80%) than in Thailand (90%). The share of households preparing indigenous vegetables for special occasions is even lower, 45% in Lao PDR and 51% in the Philippines, but 75% in Thailand. In contrast, around 90% of households both in Lao PDR and the parents teaching them is relatively low in the Philippines at only 60%.

Philippines agree that they consume more IV when money is short, while only 63% of households in Thailand agree to this question. Generally, children like eating indigenous vegetables, however the share of

Among children, knowledge of indigenous vegetables, measured as the number of names given, is four to six times higher in Thailand as compared to the Philippines and Lao PDR, and associated knowledge levels are also higher in Thailand, with approximately half of all indigenous vegetables there associated with some medicinal property (Table 26).

The data shows that in the Philippines, where many households do not cultivate vegetables in home gardens and a high rate of children suffer from moderate malnutrition, there is a strong need to conduct in-country training on IV production, utilization and conservation through home-gardening schemes. The data also shows the necessity to become more engaged in campaign work in Lao PDR and the Philippines, to inform rural communities about the value of IV consumption.

Contact: Katinka Weinberger

Table 26. *Frequency counts of IVs identified by children.*

Information	Lao PDR	Thailand	Philippines
Identified vegetables	6.3	15.1	5.4
Identified indigenous vegetables	1.7	12.1	3.0
Identified vegetables with medicinal value	0.1	6.2	0.5

Source: Surveys in collaboration between NARS of respective countries and AVRDC, 2003-2004.

Summary of Research Findings

The analysis shows that home garden vegetable production is more prevalent in Lao PDR and Thailand; however, vegetable production takes place in very scattered form only in Thailand. Households in Thailand usually have higher food expenses per capita as compared to the Philippines and Lao PDR. In Thailand respondents also tend to consume IV more frequently either with visitors, or during special occasions, while in the Philippines and Lao PDR respondents more frequently considered indigenous vegetables to be a crop of choice when households are short of money. Among children, knowledge of indigenous vegetables, measured in terms of the number of names given, is four to six times higher in Thailand as compared to the Philippines and Lao PDR, and associated knowledge levels are also higher in Thailand. In line with household food expenditures, children in Lao PDR and the Philippines on average are mildly malnourished, and nutrition levels are better in Thailand. In contrast, we find a higher prevalence of moderate anaemia among children, particularly boys, in Thailand, and lowest levels of anaemia in the Philippines.

Communications, Training, and Information

Multimedia, electronic, and print publications

The most extensive publication in 2004 was AVRDC Report 2003, which reported the research and development activities of the Center for that year. Another major publication was AVRDC's strategic rolling plan, *AVRDC Mid-Term Plan 2004–2006.* This plan highlighted successful projects, vegetable production and consumption trends, AVRDC's strategic approach, and our program goals for 2004–2006. The Center's new initiatives on organic agriculture, marker-assisted selection, Central Asia networking, and cucurbit breeding, were also described in the plan.

The booklet, *Global Horticulture: Now is the Time for Action,* was produced for dissemination at the Annual General Meeting of the Consultative Group of International Agricultural Research, which was held in Mexico. This illustrative booklet describes the role of horticulture R&D in improving income, nutrition, health and education in the developing world. Using advances in communication technologies, AVRDC is mobilizing a global network of experts to develop technologies that will improve economic opportunities and food security for the poor.

Technical bulletins published in 2004 included two socio-economic studies. *Urban and Peri-urban Agriculture in Hanoi: Opportunities and Constraints for Safe and Sustainable Food Production* is a descriptive summary of the demography, climate, institutions, and physical resources available to produce and market food in Hanoi, Viet Nam. This publication includes an evaluation of the impacts of urban and peri-urban agriculture on food supply, income generation, job creation and environmental pollution. The publication, *Indigenous Vegetables in Tanzania: Prospects and Significance*, provides recommendations for enhancing the role of indigenous vegetables for improved nutrition, healthy diet, and diversified income generation in home garden production and commercial farming systems in Tanzania. Analyses of market demand and human nutritional status are included.

The proceedings of two workshops were published. *Proceedings of the APSA-AVRDC Workshop* is a summary of activities at a workshop jointly held by AVRDC and the Asia & Pacific Seed Association. The proceedings include an overview of AVRDC's major breeding programs, specific research priorities for the future, and lively discussions between representatives of Asia's leading seed association and AVRDC scientists. The proceedings, *Workshop on Application of Molecular Markers to Broaden the Genetic Base of Tomato for Improved Tropical Adaptation and Durable Disease Resistance*, presents the initial results of a GTZ-BMZ-sponsored project which is developing genetic resistance in tomato to bacterial wilt and tomato yellow leaf curl virus, two major diseases in the tropics.

A brochure on eggplant pest control was written and translated into Bengali, Hindi, Oriya, and Gujarati for dissemination to farmers and extension specialists. This brochure, *How to Use Sex Pheromone for Controlling Eggplant Fruit and Shoot Borer*, describes techniques for installing traps baited with sex pheromones to safely trap eggplant fruit and shoot borer, the most important pest of eggplant in Asia. The techniques are effective, economic and completely safe to use.

A sabbatical scientist, Dr. Ray Cerkauskas, wrote 26 International Cooperators' Fact Sheets on pepper disorders and 11 such guides on tomato disorders. These guides included detailed information on identifying and controlling the major diseases of pepper and tomato in developing countries. More guides will be published in 2005.

Numerous scientific findings were published in refereed scientific journals. All AVRDC publications in 2004 are listed in the back of this document.

The Communications and Training Office mailing list currently contains 1941 entries, including 624 libraries in 164 countries. The office printed more than a quarter of a million pages, shot thousands of photos, and handled numerous art requests from Center scientists.

AVRDC Web site and Learning Center

As a research center with a global mandate and an immense number of clientele, information technology is an essential tool for AVRDC's communication and training activities. In 2004, AVRDC added 40 publications to its "virtual library", which consists of all of the Center's publications since 1997. This includes annual reports, books, bulletins, production guides, and over 130 fact sheets. In 2004, 83,600 unique visitors from 123 countries downloaded this information freely and instantly over the Internet. Approximately 485,300 web pages from the AVRDC Web site were downloaded, twice the amount in 2003. Twelve computer-based tutorials have been developed on major vegetable production topics; approximately 10,000 persons accessed these tutorials during 2004.

Training

In 2004, 72 scholars from 16 countries received training in vegetable research and development at AVRDC headquarters in Taiwan (a complete list of trainees can be found in the back of this document). These trainees experienced productive and useful training at AVRDC. All (100%) of the scholars reported that their training would be useful for their work. All stated that they would like to come to AVRDC again for further training and all reported that they would recommend training at AVRDC to their colleagues.

When rating their training experience at AVRDC, using a 1–5 scale with 1 = poor, 2 = fair, 3 = good, 4 = very good and 5 = excellent, students rated the success of their training at 3.84, the quality of their instruction from trainers at 4.44, and the assistance from the Communication and Training Office at 4.34. These ratings are among the highest ever at AVRDC.

ASEAN scholarship training

A multi-year scholarship program has been established to support the training of young scholars from Cambodia, Lao PDR, Myanmar and Vietnam. The Japanese government, through the Association of Southeast Asian Nations (ASEAN), sponsors this program. Two scholars benefited from this training program at AVRDC headquarters during 2004. Hai Thi Hong Truong, educator from Hue University of Agriculture and Forestry, came to AVRDC through this scholarship program and is now studying at AVRDC for her doctoral degree from the University of Hannover in Germany. Her studies focus on identifying molecular markers for tomato geminiviruses and other diseases. Le Thi Thu Huong successfully passed her doctoral examination from the University of Bonn in Germany. She is currently employed in a major FAO project in Viet Nam that is developing and disseminating vegetable production technologies to growers throughout the country.

Research internships, sabbatical scientists, and post-doctoral fellows

A total of 32 researchers from 11 countries (Burkina Faso, Cambodia, China, India, Indonesia, Korea, Lao PDR, Malaysia, Philippines and Thailand and Viet Nam) completed research internships and fellowships. In these 1 to 12-month training programs, researchers developed skills within the fields of biotechnology, genetic resource management, entomology, plant pathology, plant physiology, tomato breeding, pepper breeding, legume breeding, and nutrition.

A sabbatical scientist from Agriculture and Agri-Food Canada, Dr. Raymond Cerkauskas, studied diseases of oriental vegetables and authored many fact sheets regarding disease management for tomato and pepper crops. Another sabbatical scientist, Dr. Teng-yung Feng of Academia Sinica in Taiwan, is conducting gene transformation studies.

Three post-doctoral fellows came to AVRDC for advanced training. Dr. Srinivasan Ramasamy from India is studying gene transformation of *Bacillus thuringiensis* in yardlong bean to control maruca pod borer as well as studying insect pest-plant interactions related to chemical ecology. Dr. Mounira Elbaz from Tunisia is conducting research projects on interactions between plants and pathogens with special emphasis on interactions between tomato and bacterial wilt. Dr. Elaine Graham from the USA is using molecular-based tools to develop genetic resistance of tomato to geminiviruses and other major diseases.

Summer program for undergraduates

AVRDC offers undergraduate training to support university studies and to provide valuable experiences to students who are deciding their futures in the life sciences. For the 29th consecutive year, AVRDC hosted undergraduate students from universities in Taiwan. Thirteen students from six universities in Taiwan were trained in 2004. The students conducted research in a wide range of topics, including plant breeding, plant pathology, entomology, plant physiology, and plant production. They gained experiences in conducting experiments and writing technical reports. All Taiwanese students received training in the English language.

Six students from the University of the Philippines Los Baños came to AVRDC for training in genetic improvement, germplasm management, and crop production. One student from Hampshire College of the USA learned molecular-based plant breeding techniques.

A total of 14 university students, 20 research interns, and 24 AVRDC staff developed greater fluency in the English language through weekly classes. The focus of these classes was to improve the students' abilities in English conversation. Students demonstrated improved communication skills that assisted them in their work at AVRDC.

Dissemination of training materials

Over 40,000 educational documents in Adobe Portable Document Format (PDF) format were downloaded for printing from the AVRDC web site. Thousands of more documents in Hypertext Markup Language (HTML) were accessed and printed. Approximately 100 Vegetable Production Training Manuals and 70 slide sets were disseminated upon request.

Collecting and sharing tropical vegetable information

This subproject is handled by the Center's library. In 2004, the library acquired over 132 new books and over 1,769 serial publications. Subscriptions to 86 journals were renewed.

The library updated the Center's bibliographic databases to facilitate information storage and retrieval. A total of 309 books, 3,060 crop documents, and 34 new serial titles were indexed and added to the library database. This in-house database, which now holds 42,927 bibliographic records and 3,921 journal records, was placed on-line in 2004 and can be readily retrieved by staff and collaborators via computer. A total of 292 journal issues were bound; this hard-copy collection of journals now totals 16,007 volumes.

The library conducts regular searches of literature for vegetable researchers. The results of these searches are categorized by vegetable crop and published as Selective Dissemination of Information (SDI) bulletins. The SDI system was expanded and updated in 2004. Twenty two issues of SDI bulletins and six issues of recent AVRDC Library acquisitions were established on the library web site in 2004. A total of 831 users from 46 countries accessed the SDI services via the internet.

Library staff conducted 40 literature searches of CD-ROM databases and Tropical Vegetable Information Services databases for internal and external users. A total of 552 documents were photocopied and delivered to 131 users in 72 libraries in 17 countries.

International Cooperation

Variety selection is an important component of successful vegetable production. At AVRDC, regional yield trials (RYTs) were conducted to evaluate promising lines under a range of locations for several years. The RYTs serve as one means for transferring AVRDC's research outputs to Taiwan and beyond. In preparation for evaluations in other countries, the following RYTs were conducted to evaluate promising AVRDC lines/varieties in the field under different seasons and locations in Taiwan.

Regional yield trial of ToLCV-resistant fresh market tomato

This trial was conducted to identify promising fresh market hybrids with tolerance/resistance to heat, bacterial wilt (BW), tomato mosaic virus (TMV) and tomato leaf curl virus (ToLCV) for summer production in the lowlands. Based on the results of the Summer 2003 trial, five large-fruited AVRDC hybrids, namely, FMTT904, FMTT906, FMTT907, FMTT957 and FMTT965 were selected for testing in Summer 2004. Check varieties included Hualien-ASVEG No. 5, Taoyuan-ASVEG No. 9, and Taichung-ASVEG No. 10. Trials were conducted from 6 February to 29 June 2004 (with mean day/night air temperatures at 29.3/20.5°C, and a total of 212 mm rainfall) and from 28 July to 31 December 2004 (with mean day/night air temperatures at 29.6/20.7°C, and a total of 718 mm rainfall) at AVRDC headquarters (120°17´E, 23°08´N).

The experimental design was RCBD with four replications. Plants were set in twin rows on raised beds with plants spaced 50 cm apart. Plot size was 5 m x 3 m, and 75 cm between rows. Applications of 90N–38.7P–74.7K–13.7Mg kg/ha of inorganic and 80N–34.4P–66.4K kg/ha of an organic fertilizer with organic matter content of 60% were applied by basal dressing during land preparation. Applications of 30N–12.9P–24.9K inorganic fertilizer were sidedressed two weeks after transplanting, one month after transplanting, and then again every month after that.

FMTT965 gave the highest yield in the spring and summer trials at 45.9 and 97.0 t/ha, followed by FMTT957 at 42.3 and 94.4 t/ha, respectively. These two lines significantly outyielded the check variety Hualien-ASVEG No. 5 (83.5 t/ha) and Taichung-ASVEG No. 10 (80.6 t/ha) in the late summer trial (Tables 1 and 2).

The yield and fruit set in the spring trial was much lower than summer due to the gradually increasing temperature in the latter period of growth and the reduced harvesting frequencies (only three harvests). FMTT904 matured earlier than other test lines. The

Table 1. Regional yield trials of fresh market tomato hybrids at AVRDC, February to June 2004 (spring).[1]

Lines	Days to maturity	Fruit set (%)	Fruit wt. (g/fruit)	Yield (t/ha)	ToLCV (%)	Solids (°Brix)	Acid[2] (%)	Solids/ acid	Color[3] (a/b)
FMTT904	79.4	56.4	151.7	39.1	11.0	5.53	0.48	11.52	2.01
FMTT906	83.5	55.0	150.0	33.4	4.2	5.23	0.44	11.89	2.01
FMTT907	82.8	56.1	161.7	32.6	19.8	5.35	0.43	12.44	2.09
FMTT957	83.1	58.4	140.0	42.3	6.5	5.83	0.50	11.66	1.84
FMTT965	82.0	62.6	141.7	45.9	5.2	5.80	0.39	14.87	1.76
Hualien-ASVEG No. 5 (ck)	84.1	55.8	176.7	42.1	100.0	5.60	0.43	13.02	1.69
Taoyuan-ASVEG No. 9 (ck)	82.7	59.2	168.3	38.8	100.0	5.60	0.47	11.91	1.60
Taichung-ASVEG No. 10 (ck)	81.6	61.3	160.8	38.7	100.0	5.15	0.44	11.70	1.58
Mean	82.4	58.1	156.4	39.1	43.3	5.51	0.45	12.40	1.82
LSD (5%)	3.0	9.4	25.2	9.0	10.5	0.54	0.07	1.58	0.18

[1] Lines sown on 6 February, transplanted on 4 March, and harvested from 21 May to 23 June 2004.

[2] Equivalent of citric acid.

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

Table 2. Regional yield trial of fresh market tomato hybrids at AVRDC, July to December 2004 (summer).[1]

Lines	Days to maturity	Fruit set (%)	Fruit wt. (g/fruit)	Yield (t/ha)	ToLCV (%)	Solids (°Brix)	Acid[2] (%)	Solids/ acid	Color[3] (a/b)
FMTT904	76.3	68.4	147.0	84.4	8.9	4.38	0.44	9.95	2.16
FMTT906	78.4	70.1	160.2	87.5	7.3	4.33	0.43	10.07	2.06
FMTT907[4]	-	-	-	-	-	-	-	-	-
FMTT957	78.5	68.6	176.4	94.4	17.2	4.73	0.47	10.06	1.95
FMTT965	79.4	69.6	166.2	97.0	4.2	4.50	0.45	10.00	1.83
Hualien-ASVEG No. 5 (ck)	77.3	69.3	146.1	83.5	46.4	4.43	0.37	11.97	1.69
Taoyuan-ASVEG No. 9 (ck)	78.1	70.2	138.9	86.8	58.3	4.35	0.37	11.76	1.60
Taichung-ASVEG No. 10 (ck)	78.0	69.7	162.0	80.6	60.9	4.40	0.40	11.00	1.80
Mean	78.0	69.4	156.7	87.7	29.0	4.44	0.42	10.80	1.87
LSD (5%)	1.9	6.3	35.0	9.8	24.1	0.34	0.06	1.43	0.13

[1] Lines sown on 29 July, transplanted on 3 September, and harvested from 19 November to 31 December 2004.

[2] Equivalent of citric acid.

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

[4] The seeds of FMTT907 were not purified in summer trial, therefore the results were not comparable.

incidence of ToLCV for the FMTT lines was low (4.2–19.8% in spring and 4.2–17.2% in summer), whereas 46.4–100% of check varieties were infected and had lower color values. The results of the incidence of ToLCV revealed FMTT lines with stable resistance.

The same lines were evaluated during the same time in I-lan (121°45´E, 24°46´N), Taoyuan (121°18´E, 24°59´N) and Pingtung (120°29´E, 22°39´N) (data not shown). Based on the results obtained in 2003–2004, FMTT957 and FMTT965, both with dark green shoulder and good horticultural traits, were selected and official registration will be sought in 2005 by Hualien District Agricultural Research and Extension Station (DARES) I-lan Branch and Taoyuan DARES, respectively. One of FMTT904 and FMTT906 will be selected for registration by the Seed Improvement and Propagation Station (SIPS) Pingtung Branch in 2005.

Regional yield trial of ToLCV-resistant cherry tomato

This trial aimed to select promising cherry tomato hybrids for summer production. Five ToLCV-resistant red cherry tomato hybrids: CHT1312, CHT1313, CHT1358, CHT1372 and CHT1374, and check Tainan-ASVEG No. 6 were evaluated in AVRDC from 6 February to 24 June 2004 (with mean day/night air temperatures at 28.1/19.6°C, and a total of 210 mm rainfall). The experimental design was RCBD with four replications, two rows per plot, and 50 cm between plants. Plot size was 5 m x 3 m and 75 cm between rows. Applications of 90N–38.7P–74.7K–13.7Mg kg/ha of inorganic and 80N–34.4 P–66.4K kg/ha of an organic fertilizer with organic matter content of 60% were made as basal dressings during land preparation. Applications of 30N–12.9P–24.9K inorganic fertilizer were sidedressed two weeks after transplanting, one month after transplanting, and then again every month after that.

Line CHT1372 gave the highest yield at 54.5 t/ha, followed by CHT1312 and CHT1358 at 53.6 and 53.3 t/ha, respectively, significantly outyielding the check Tainan No. 6 by 89–93% (Table 3). The incidence of ToLCV for four CHT lines was low (2.6–7.8%), whereas 99% of check variety plants were infected. Also, three of the five test lines had better fruit-setting ability than the check variety. The fruit size of CHT1358 was smaller (11.8 g/fruit) but longer than other test lines, and its soluble solid at 6.18 °Brix, was acceptable to the cooperative farmers. The incidence of ToLCV revealed CHT1358 has stable resistance and it will be applied for naming in 2005 by Tainan DARES.

Table 3. Regional yield trial of cherry tomato hybrids at AVRDC, February to June 2004.[1]

Lines	Days to maturity	Fruit set (%)	Fruit wt. (g/fruit)	Yield (t/ha)	ToLCV (%)	Solids (°Brix)	Acid[2] (%)	Solids/ acid	Color[3] (a/b)
CHT1312	86.7	71.9	12.1	53.6	7.3	6.25	0.49	12.76	1.28
CHT1313	87.8	68.9	13.5	49.7	6.3	6.88	0.50	13.76	1.36
CHT1358	86.2	74.8	11.8	53.3	2.6	6.18	0.51	12.12	1.29
CHT1372	86.5	74.6	13.3	54.5	7.8	6.88	0.51	13.49	1.42
CHT1374	88.2	68.4	13.8	47.5	16.1	6.70	0.49	13.67	1.30
Tainan ASVEG No. 6 (ck)	87.1	64.2	10.2	28.2	99.0	6.50	0.47	13.83	1.13
Mean	87.1	70.5	12.4	47.8	23.2	6.56	0.49	13.34	1.30
LSD (5%)	1.2	8.5	1.5	6.9	12.1	0.69	0.04	1.86	0.10

[1] Lines sown on 6 February, transplanted on 4 March, and harvested from 21 May to 24 June 2004.

[2] Equivalent of citric acid.

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

Cherry tomato hybrid released in Taiwan

Based on the results of RYTs, Taiwan's Council of Agriculture released cherry tomato hybrid CHT1201 (Fig. 1) developed by AVRDC on 29 December 2004. It has been officially named as Hualien-ASVEG No. 14. This is the tenth AVRDC improved tomato line and the second with high ß-carotene released by the host country since the Center's inception. Besides being rich in ß-carotene (2.7 mg/100 g), the unique traits of this orange-colored hybrid are its oblong-shape, firm fruit with less cracking, and resistance to tomato mosaic virus and *Fusarium* wilt races 1 and 2.

Fig. 1. Fruits of high β-carotene line CHT1201.

Regional yield trials of vegetable soybean

Ten vegetable soybean lines, including two from AVRDC, three from Tainan DARES, and five from Kaohsiung DARES, were evaluated against three check varieties, Kaohsiung No.1 (KS#1), KS#5 and KS#6 in regional yield trials at AVRDC headquarters in four seasons: Autumn 2002 (3 September–21 November, with mean day/night air temperatures at 31.9/22.6°C, a total of 84 mm rainfall); Spring 2003 (29 January–30 April, with mean day/night air temperatures at 27.5/18.3°C, a total of 88 mm rainfall); Autumn 2003 (1 September–14 November), with mean day/night air temperatures at 32.0/23.2°C, a total of 81 mm rainfall); and Spring 2004 (4 February–6 May), with mean day/night air temperatures at 26.8/17.8°C, a total of 73 mm rainfall). The experimental design was RCBD with four replications. Plot size was 5m x 3 m and spacing was 50 cm between rows and 10 cm between plants.

Test lines showed significant differences in graded pod yields (Table 4). A Kaohsiung line, KVS1175, produced the highest yield in Autumn 2002, Spring 2003 and Spring 2004; it also gave the highest overall mean yield across all seasons at 10.30 t/ha. Another Kaohsiung line, KVS1312 produced the highest yield in Autumn 2003, and gave the second highest overall mean yield across all seasons at 10.16 t/ha. Besides their reliable high yields, these two lines outperformed all check varieties for shelled bean ratio (Table 5), and outperformed KS#1 and KS#6 for 100-fresh-seed weight.

Table 4. Graded pod yield (t/ha) of vegetable soybean lines tested in regional yield trials at AVRDC, autumn 2002 to spring 2004.

Lines	Autumn 2002[1]	Spring 2003[2]	Autumn 2003[3]	Spring 2004[4]	Mean
KVS1175	10.30	10.45	8.39	12.08	10.30
KVS1194	7.57	8.43	8.10	10.78	8.72
KVS1209	5.47	9.48	7.95	12.38	8.82
KVS1249	8.53	9.10	8.23	11.13	9.25
KVS1312	9.37	9.48	9.80	12.00	10.16
TS88-04V	8.70	10.45	7.75	10.30	9.30
TS88-31V	5.70	7.85	8.18	9.40	7.78
TS88-57V	5.67	7.50	7.85	10.50	7.88
GC95004-2-3-1-1	8.87	8.00	8.30	8.85	8.51
GC95016-6	8.07	7.88	6.65	8.15	7.69
KS1 (ck)	6.40	6.58	5.38	6.65	6.25
KS5 (ck)	6.43	7.35	6.33	8.68	7.20
KS6 (ck)	7.83	6.98	6.77	8.78	7.59
Mean	7.61	8.42	7.67	9.97	8.42
LSD (5%)	1.20	1.63	1.16	1.02	

[1] Lines sown on 3 September and harvested 12–21 November 2002.
[2] Lines sown on 29 January and harvested 16–30 April 2003.
[3] Lines sown on 1 September and harvested 5–14 November 2003.
[4] Lines sown on 4 February and harvested 20 April – 6 May 2004.

KS#1 and KS#6 had higher mean percentage of soluble solids than the experimental lines. Among the new lines, GC95004-2-3-1-1 (9.33%), TS88-31V (8.57%), and TS88-04V (8.34%) had higher mean percentage of sugar than others. One of the highest yielding lines, KVS1175, produced dark green pods similar in color to the check varieties (Table 6).

For the yield data of these 13 vegetable soybean lines, the regression of entry mean yields on the environmental index resulted in regression coefficients ranging in values from –0.0128 to 2.6385 (Table 7 and Fig. 2). The large variation in the regression coefficients signifies large differences in the responses of the entries to differences in environmental conditions over the four growing seasons. Overall superior yield performances were shown by A, E, D, and F. Their regression coefficients were comparable and close to one and their deviations from regression are not significant (S^2_d=0). These four entries were the most stable based on Eberhart and Russell's definition of stability (Eberhart and Russell, 1966) with D and F having less response to environmental changes compared with A and E.

Results from this trial showed that KVS1175 and KVS1312 were outstanding for their reliable high yields and desirable quality traits. These two lines are ready to be promoted.

Table 5. Shelled bean ratio (%) and 100-fresh-seed weight (g) of vegetable soybean lines tested in regional yield trials at AVRDC, autumn 2002 to spring 2004.

Lines	Autumn 2002		Spring 2003		Autumn 2003		Spring 2004		Mean	
	Shelled bean ratio (%)	100-fresh-seed wt (g)	Shelled bean ratio (%)	100-fresh-seed wt (g)	Shelled bean ratio (%)	100-fresh-seed wt (g)	Shelled bean ratio (%)	100-fresh-seed wt (g)	Shelled bean ratio (%)	100-fresh-seed wt (g)
KVS1175	57.33	74.33	56.33	87.30	56.00	68.80	60.25	76.25	57.60	76.67
KVS1194	51.00	68.00	54.33	75.30	61.50	71.00	56.00	78.50	55.71	73.20
KVS1209	53.33	63.00	58.00	78.30	58.00	64.80	59.50	76.00	57.21	70.53
KVS1249	51.67	63.00	54.67	72.50	54.75	66.50	56.75	75.50	54.46	69.38
KVS1312	54.67	64.33	54.67	82.50	55.75	70.80	55.75	89.00	55.21	76.66
TS88-04V	54.67	69.00	46.00	72.30	52.25	65.00	45.50	72.00	49.61	69.58
TS88-31V	50.00	63.00	45.00	84.80	53.50	64.30	49.50	88.00	49.50	75.03
TS88-57V	44.00	68.33	47.67	74.30	52.75	76.00	51.00	70.50	48.86	72.28
GC95004-2-3-1-1	52.67	67.67	49.00	90.50	56.25	69.00	49.00	76.50	51.73	75.92
GC95016-6	51.67	72.00	48.00	100.50	53.00	81.30	43.00	76.75	48.92	82.64
KS1 (ck)	53.33	64.67	48.00	68.80	50.25	53.50	48.50	65.75	50.02	63.18
KS5 (ck)	56.00	72.00	53.67	88.50	58.25	75.00	52.25	81.75	55.04	79.31
KS6 (ck)	58.00	76.00	50.33	71.00	53.75	58.00	54.00	78.25	54.02	70.81
Mean	52.95	68.10	51.21	80.51	55.08	68.00	52.38	77.29	52.91	73.47
LSD (5%)	3.37	6.06	2.99	5.17	5.49	6.44	3.06	5.96		

Table 6. Quality analysis of vegetable soybean lines tested in regional yield trials at AVRDC, 2002-2004.

Lines	Autumn 2002			Spring 2003			Autumn 2003			Spring 2004			Mean		
	Protein (%)	Sugar (%)	Color[1]	Protein (%)	Sugar (%)	Color	Protein (%)	Sugar (%)	Color	Protein (%)	Sugar (%)	Color	Protein (%)	Sugar (%)	Color
KVS1175	41.32	8.76	4.81	42.55	6.55	4.00	40.27	7.61	3.85	41.22	10.03	3.32	41.35	8.06	3.72
KVS1194	42.42	8.01	5.76	43.66	6.22	5.02	41.16	7.35	4.95	42.21	8.46	4.80	42.34	7.34	4.92
KVS1209	41.40	8.57	5.31	42.02	6.99	4.61	39.69	7.48	4.14	41.75	8.34	4.06	41.15	7.60	4.27
KVS1249	42.16	8.15	5.39	43.63	7.18	4.80	41.12	7.48	4.56	43.55	8.40	4.72	42.77	7.69	4.69
KVS1312	40.64	7.97	5.03	41.36	7.81	4.72	39.96	8.02	4.07	42.01	8.69	4.64	41.11	8.17	4.48
TS88-04V	38.62	7.86	4.40	40.85	7.43	3.35	38.15	8.19	3.60	41.12	9.39	3.62	40.04	8.34	3.52
TS88-31V	41.28	9.21	3.70	44.27	7.86	4.15	40.12	8.08	3.53	42.56	9.78	4.16	42.32	8.57	3.95
TS88-57V	42.48	7.69	4.74	43.96	5.62	3.85	41.73	6.98	5.31	43.77	7.74	4.40	43.15	6.78	4.52
GC95004-2-3-1-1	37.92	9.10	4.23	40.97	8.01	4.84	36.97	8.77	4.30	39.62	11.20	3.91	39.19	9.33	4.35
GC95016-6	40.16	8.86	4.62	43.03	6.91	4.99	38.58	8.28	4.68	42.56	9.58	5.17	41.39	8.26	4.95
KS1 (ck)	35.35	8.53	4.68	39.51	10.27	3.94	35.10	9.17	4.02	40.30	12.59	3.54	38.30	10.68	3.83
KS5 (ck)	39.81	8.10	3.93	42.87	8.79	3.50	39.52	8.22	4.19	43.10	9.98	3.61	41.83	9.00	3.77
KS6 (ck)	34.49	10.26	4.38	38.55	10.70	3.61	34.92	10.34	3.61	39.51	14.42	3.80	37.66	11.82	3.67
Mean	39.85	8.54	4.69	42.09	7.72	4.26	39.02	8.15	4.22	41.78	9.89	4.13	40.96	8.59	4.20
LSD (5%)	0.85	0.62	0.36	1.41	0.84	0.28	0.66	0.48	0.23	0.75	0.59	0.36			

[1] Pod color rated on 1–6 scale with 1 = very dark green-yellow and 6 = pale green-yellow.

Table 7. Stability parameters of 13 vegetable soybean lines based on Eberhart and Russell's definition.

Line notation	Lines	Mean yield (t/ha)	Regression coefficient (b's)	S^2_d
A	KVS1175	10.43	1.0699	0.0884
B	KVS1194	8.73	1.2726	0.0129
C	KVS1209	8.80	2.6385	0.1864
D	KVS1249	9.14	1.0426	0.0119
E	KVS1312	10.18	1.0360	0.0431
F	TS88-04V	9.45	1.0968	0.3001
G	TS88-31V	7.81	1.1490	0.1984
H	TS88-57V	7.85	1.5448	0.1973
I	GC95004-2-3-1-1	8.58	–0.0128	0.0400
J	GC95016-6	7.58	0.2971	0.0765
K	KS1 (ck)	6.34	0.3532	0.0736
L	KS5 (ck)	7.39	0.9316	0.0041
M	KS6 (ck)	7.63	0.5807	0.0698

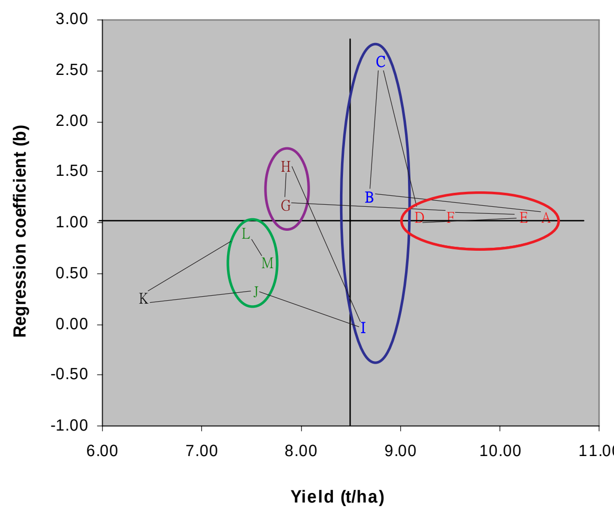


Fig. 2. Relationship between the regression coefficients and mean yields of 13 vegetable soybean lines.

In a separate trial, nine promising lines of vegetable soybean, including two from AVRDC, two from Tainan DARES, and five from Kaohsiung DARES, were evaluated in Autumn 2004 (7 September – 18 November 2004, with mean day/night air temperatures at 30.0/20.9°C, a total of 257 mm rainfall) in AVRDC. Kaohsiung DARES line KVS1195 gave the highest yield at 9.88 t/ha, which significantly outyielded three check varieties by a margin of 47.5 to 88.9% (Table 8). Regional yield trials will be conducted further in 2005–2006.

Another six promising lines of taro-flavor vegetable soybean were also evaluated at AVRDC headquarters in spring 2003 (29 January–1 May; with mean day/night air temperatures at 27.5/18.3°C, a total of 88 mm rainfall); autumn 2003 (1 September–14 November); with mean day/night air temperatures at 32.0/23.2°C, a total of 81 mm rainfall), and spring 2004

Table 8. Yield and horticultural characteristics of vegetable soybeans tested at AVRDC, autumn 2004.[1]

Lines	Days to maturity	Pod no./ 500 g	100-fresh-seed wt (g)	Pod length[2] (cm)	Pod width[2] (cm)	Graded pod yield (t/ha)
KVS1195	73.0	151.0	71.67	4.67	1.30	9.88
KVS1197	73.0	151.7	66.33	4.77	1.30	9.73
KVS1198	73.0	140.7	79.33	5.60	1.40	6.70
KVS1269	73.0	148.0	76.33	4.87	1.37	9.73
KVS1314	72.0	137.0	77.00	5.30	1.40	7.43
TS90-19V	72.0	140.7	87.00	5.23	1.40	4.70
TS90-22V	72.0	128.7	80.67	5.60	1.50	3.73
AGS429	70.0	141.0	84.33	5.00	1.33	9.30
AGS430	70.0	143.7	77.00	5.07	1.40	8.13
KS#1 (ck)	65.0	156.7	64.33	4.87	1.33	6.53
KS#5 (ck)	70.0	151.7	74.67	5.17	1.40	6.70
KS#6 (ck)	67.0	154.0	68.33	5.47	1.53	5.23
Mean	70.8	145.4	75.58	5.13	1.39	7.32
LSD (5%)	0.0	12.1	1.26	0.18	0.09	1.56

[1] Lines sown on 7 September and harvested 10–18 November 2004.
[2] Measured from double-seeded pods.

(4 February–4 May), with mean day/night air temperatures at 26.7/17.7°C, a total of 73 mm rainfall).

KVS7 produced the highest yield in spring 2003 and spring 2004; it also gave the highest overall mean yield across all seasons at 9.83 t/ha, and outyielded check varieties by 79.4 % and 61.7 %, respectively (Table 9). KVS8 produced the highest yield in autumn 2003, and gave the second highest overall mean yield across all seasons at 9.40 t/ha, and outyielded check varieties by 71.5% and 54.6%, respectively. KVS6 produced the lowest overall mean yield across all seasons at 3.50 t/ha, but its performance in shelled bean ratio was best than all other varieties, and its 100-fresh-seed weight was also best than all the other tested lines (Table 10), except in spring 2003.

Table 9. Graded pod yield (t/ha) of taro-flavor vegetable soybean lines tested in regional yield trials at AVRDC, spring 2003 to spring 2004.

Lines	Spring 2003[1]	Autumn 2003[2]	Spring 2004[3]	Mean
KVS2	4.10	4.53	4.25	4.29
KVS3	3.50	7.50	4.10	5.03
KVS7	9.90	7.20	12.38	9.83
KVS8	8.10	8.65	11.45	9.40
KVS6	2.00	4.13	3.50	3.21
TS85-21V	8.40	5.00	8.05	7.15
Shon-gi (ck)	5.60	4.75	6.08	5.48
Black-5-leave (ck)	6.10	5.18	6.95	6.08
Mean	5.95	5.86	7.09	6.30
LSD (5%)	0.82	1.34	0.78	

[1] Lines sown on 29 January and harvested 17 April – 1 May 2003.
[2] Lines sown on 1 September and harvested 31 October – 14 November 2003.
[3] Lines sown on 4 February and harvested 20 April – 4 May 2004.

The check varieties, Shon-gi and Black-5-leave, had higher mean percentages of sugars than the experimental lines, except TS85-21V (11.62%) which had higher mean percentage of soluble solids than others. Its mean yield across all seasons (7.15 t/ha) was also higher than the check varieties. Besides TS85-21V, the other new lines produced darker green pods than check varieties (Table 11).

Another separate trial to evaluate six promising lines of taro-flavor vegetable soybean was conducted in Autumn 2004 (7 September – 23 November, with mean day/night air temperatures at 30.0/20.9°C, a total of 257 mm rainfall) at AVRDC. KVA22 gave the highest yield at 6.90 t/ha, which outyielded the check varieties Shon-gi and Black-5-leave by 53.3% and 80.2%, respectively (Table 12). Further regional yield trials will be conducted to evaluate the stability of yield and pod quality characteristics.

Table 10. Shelled bean ratio (%) and 100-fresh-seed weight (g) of taro-flavor vegetable soybean lines tested in regional yield trials at AVRDC, spring 2003 to spring 2004.

Lines	Spring 2003 Shelled bean ratio (%)	Spring 2003 100-fresh-seed wt (g)	Autumn 2003 Shelled bean ratio (%)	Autumn 2003 100-fresh-seed wt (g)	Spring 2004 Shelled bean ratio (%)	Spring 2004 100-fresh-seed wt (g)	Mean Shelled bean ratio (%)	Mean 100-fresh-seed wt (g)
KVS2	82.00	84.50	62.10	64.00	75.60	72.50	73.23	73.67
KVS3	80.00	81.30	65.54	66.25	63.93	64.00	69.82	70.52
KVS7	61.00	60.30	48.78	49.00	64.05	64.50	57.94	57.93
KVS8	63.00	62.00	60.79	60.00	68.03	68.00	63.94	63.33
KVS6	78.00	78.80	78.47	81.00	89.60	86.25	82.02	82.02
TS85-21V	66.00	61.80	62.72	62.25	64.78	64.75	64.50	62.93
Shon gi (ck)	65.00	64.00	67.29	65.75	62.13	64.25	64.81	64.67
Black 5 leave (ck)	73.00	75.30	74.74	69.25	67.43	69.00	71.72	71.18
Mean	71.00	71.00	65.05	64.69	69.44	69.16	68.50	68.28
LSD (5%)	8.00	6.59	9.56	6.84	7.17	8.04		

Table 11. Quality analysis of taro-flavor vegetable soybean lines tested in regional yield trials at AVRDC, spring 2003 to spring 2004.

Lines	Spring 2003 Protein (%)	Spring 2003 Sugar (%)	Spring 2003 Color[1]	Autumn 2003 Protein (%)	Autumn 2003 Sugar (%)	Autumn 2003 Color[1]	Spring 2004 Protein (%)	Spring 2004 Sugar (%)	Spring 2004 Color[1]	Mean Protein (%)	Mean Sugar (%)	Mean Color[1]
KVS2	39.91	7.47	2.20	36.77	7.94	3.86	40.72	10.57	3.86	39.13	8.66	3.31
KVS3	43.64	5.69	3.53	40.46	6.54	2.91	42.70	7.89	2.91	42.27	6.71	3.12
KVS7	41.70	7.42	3.87	38.12	7.37	3.75	37.49	8.62	3.75	39.10	7.80	3.79
KVS8	41.73	7.75	4.03	38.58	9.24	3.64	37.99	9.74	3.64	39.43	8.91	3.77
KVS6	42.82	6.69	3.05	40.25	9.30	2.68	42.09	7.89	2.68	41.72	7.96	2.80
TS85-21V	40.14	10.21	4.37	36.25	10.95	4.42	39.86	13.70	4.42	38.75	11.62	4.40
Shon-gi (ck)	40.49	10.27	4.58	36.65	10.94	4.95	40.48	13.43	4.95	39.21	11.55	4.83
Black-5-leave (ck)	43.98	9.08	4.42	37.94	11.78	3.61	41.03	14.56	3.61	40.98	11.81	3.88
Mean	41.80	8.07	3.76	38.13	9.26	3.73	40.30	10.80	3.73	40.07	9.38	3.74
LSD (5%)	0.86	0.69	0.43	0.99	0.67	0.25	0.44	0.75	0.25			

[1] Pod color rated on 1–6 scale with 1 = very dark green-yellow and 6 = pale green-yellow.

Table 12. Yield and horticultural characteristics of taro-flavor vegetable soybeans tested at AVRDC, autumn 2004.[1]

Lines	Days to maturity	Pod no./ 500 g	100-fresh-seed wt (g)	Pod length[2] (cm)	Pod width[2] (cm)	Graded pod yield (t/ha)
KVA11	71.0	141.0	66.33	4.87	1.47	5.77
KVA14	78.0	154.3	68.00	4.70	1.53	5.93
KVA17	74.0	182.7	57.00	5.03	1.30	3.77
KVA20	74.0	161.0	69.67	4.93	1.37	2.83
KVA22	71.0	161.7	62.33	4.87	1.30	6.90
TS85-21V	66.3	176.3	59.33	4.97	1.50	6.53
Shon-gi (ck)	63.0	192.7	58.00	4.23	1.40	4.50
Black-5-leave (ck)	71.0	145.3	73.33	4.83	1.43	3.83
Mean	71.04	164.4	64.25	4.80	1.41	5.00
LSD (5%)	3.57	12.00	8.65	0.32	0.10	2.00

[1] Lines sown on 7 September and harvested 8–23 November 2004.

[2] Measured from double-seeded pods.

Observational trial of tropical violet

Tropical violet (*Asystasia gangetica*) is an attractive, fast-growing, creeping perennial with violet flowers. The young shoots are mild in flavor, rich in ß-carotene, vitamin C and minerals, and generally prepared by stir frying or boiling. An observational trial was conducted to collect information on botanical characteristics, nutrients value, and potential yield at AVRDC headquarters.

Cuttings (10 cm in length) were planted in seedling flats on 16 February and then transplanted to the field on 17 March 2004 (cuttings were 25 cm high at that time). They were set into two-row beds, which were 30 cm in height, 2 m in width, and 6 m in length. The spacing was 70 cm between rows and 50 cm between plants. Harvesting was conducted when the plant reached a height of 30 cm and was performed by manually snapping the shoot tips up to the 2nd or 3rd internodes from the top (approximately 5 to 10 cm). Harvesting was initially performed at a two-week intervals starting from the 60 days after transplanting (DAT) up to the 114 DAT. Thereafter, harvesting was conducted weekly. A total of 46 harvestings were performed.

Seeds of tropical violet were collected from one-year-old plants and sown on 12 April and then transplanted to the field on 7 June 2004. Botanical characteristics were investigated. Young shoots were conducted in five harvesting periods, namely 10, 14, 18, 22 and 26 weeks after transplanting (WAT), respectively for nutrition analysis by the Nutrition Unit of AVRDC.

The side-shoot development led to a creeping and radiating growth pattern. Plots established using cuttings were fully covered within 8 WAT and plots established by seeding took 10 WAT to fill in. All transplanted cuttings survived. No major pests or diseases were observed. The length and width of leaf was 4.6–9.2 and 3.3–6.1 cm, respectively.

For cutting-established plots, young shoots could be harvested at 9 WAT, but the peak yields were between 15 to 22 WAT (mean day/night air temperatures at 32.7/25.2 °C) (Fig. 3). The yield was reduced during 26 to 57 WAT due to decreasing temperature (mean day/night air temperatures at 26.0/16.9 °C). The total yield harvested for 50 weeks was about 97.2 t/ha while mean yield per harvest was 2.16 t/ha and average yield per plant was 0.09 t/ha.

For seeding-established plots, young shoots could be harvested at 10 WAT. The total yield harvested for 31 weeks was about 28.8 t/ha while mean yield per harvest was 0.96 t/ha and average yield per plant was 0.04 t/ha.

The yields increased in all plots as temperature increased. Plots could be harvested continuously for years. High temperatures were related to high shoot yields (Fig. 3).

A germination test for tropical violet was also conducted. The optimal condition for germination was 30/25 °C (day/night temp.), and the germination rate

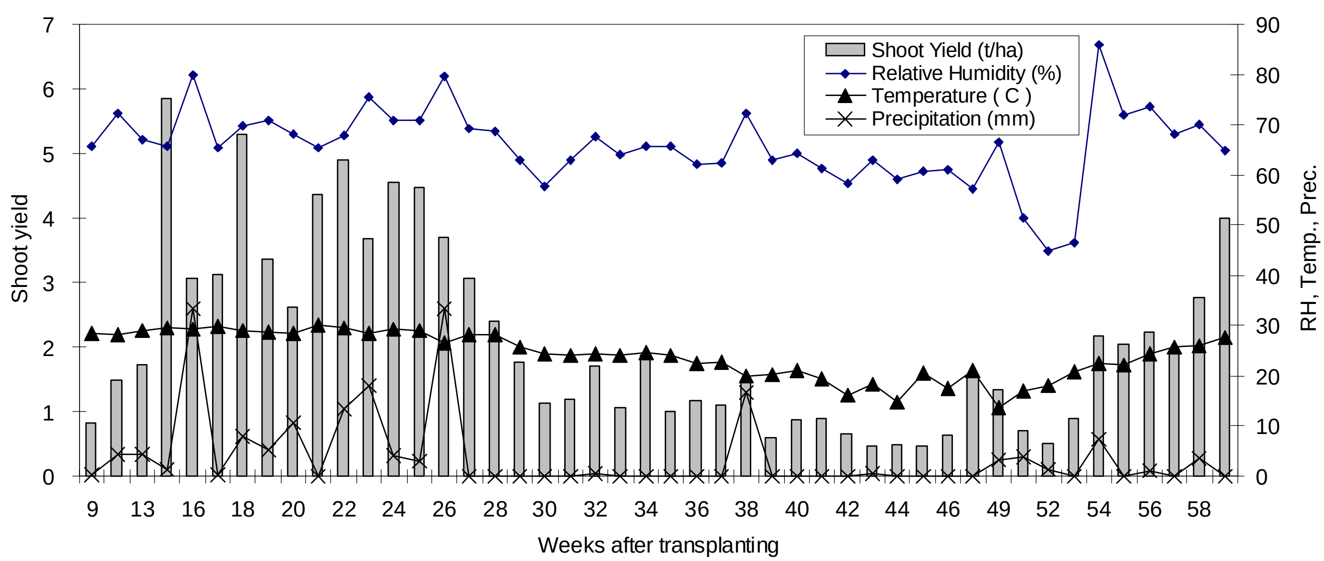


Fig. 3. Shoot yield of *Asystasia gangetica* (grown from cuttings) under different climatic factor plotted against harvesting time

Table 13. Yield performance and nutrition analysis[1] of *Asystasia gangetica* young shoots collected at five harvesting periods[2] from seeding practice.

Harvesting period[2]	Yield[3] (t/ha)	Dry matter (g)	Protein (g)	Fiber (g)	Sugar (g)	Folic acid (µg)	β-carotene (mg)	Vitamin C (mg)	Vitamin E (mg)	Calcium (mg)	Iron (mg)	Antioxidant activity (TE[4])
1	1.64	13.83	3.95	1.10	1.28	33.93	3.54	61.95	4.65	189.4	4.43	622.7
2	7.81	10.86	3.35	0.97	0.93	29.28	2.96	53.07	2.87	137.0	4.69	532.8
3	12.95	16.84	4.44	1.30	1.77	31.12	3.23	76.86	3.83	215.2	6.91	558.5
4	17.08	14.47	3.94	1.10	1.36	52.11	3.46	76.45	5.53	181.0	6.74	595.0
5	21.83	14.48	4.12	1.20	1.54	34.31	3.62	72.95	5.14	220.8	5.64	503.9
Mean	12.26	14.09	3.96	1.14	1.37	36.15	3.36	68.26	4.40	188.7	5.68	562.6
LSD (5%)	0.78	0.67	0.35	0.07	0.15	9.73	0.58	10.07	0.93	33.1	2.04	75.5

[1] 100 g edible portion based on fresh weight.

[2] Five harvesting periods were on 10, 14, 18, 22 and 26 weeks after transplanting, respectively by seeding practice. Mean day/night air temperature and precipitation for the five harvesting periods were 33.1/25.0°C, 212 mm; 32.1/25.0°C, 398 mm; 31.1/22.7°C, 13 mm; 29.1/19.0°C, 3 mm; and 27.8/18.0°C, 116 mm, respectively.

[3] Accumulative yield.

[4] TE: Methanol extract Trolox equivalent (µmole Trolox / 100 g fresh weight).

was 98%. However, cuttings were advantageous over seeds as propagules for early harvesting and uniformity of growth. The farmers can use seeds as a starting material, and cuttings for subsequent plantings.

The results of nutrition analysis revealed that the value for all nutrients were fairly stable throughout the five harvesting periods. The young shoots were rich in protein (3.96 g/100 g), ß-carotene (3.36 mg/100 g), vitamin E (4.4 mg/100 g), and iron (5.7 mg/100 g) (Table 13). The dry matter of the second harvesting period was low due to high rainfall, resulting in lower nutrient contents.

In conclusion, the young shoots of tropical violet were nutritious and easy-to-grow. This vegetable has high potential for diversifying cropping systems and consumption patterns in the tropics.

Development and extension of indigenous vegetables from the tropics

The objective of this project is to introduce indigenous vegetables from the tropics and to domesticate them as new health-promoting vegetables. The botanical and horticultural characteristics of 78 collected species were investigated and 17 species were multiplied in 2004. A total of 72 species, including six crops with good adaptability in 2003, were evaluated for nutrient contents and antioxidant activity. Yield trials of accessions of *Asystasia gangetica*, *Coccinia grandis, Moringa oleifera, Abelmoschus esculentus, Corchorus olitorius,* and *Solanum aethiopicum* were conducted in AVRDC's experimental fields.

There were a total 40 accessions of materials collected in Taiwan, including aquatic plants and others. After being multiplied, some of them have been grown in the observational plot for observation and evaluation. Promotion of *C. grandis*, in cooperation with farmers, has been conducted in southern Taiwan with favorable response from the media and various farmers' associations. Over 400 visitors to AVRDC, including many national heads of state, visited our Indigenous Vegetable Observation Plot.

A total of 101 recipes were developed using seven promising indigenous vegetables targeted for future promotion. These include *A. esculentus, A. gangetica, C. grandis, C. olitorius, M. oleifera, Sesbania grandiflora* and *Telosma cordata* (Table 14).

Table 14. No. of recipes and edible parts of seven promising indigenous vegetables

Crop name	Edible part	No. of recipes
Abelmoschus esculentus	Young fruit	20
Asystasia gangetica	Young shoot	15
Coccinia grandis	Young shoot	12
Corchorus olitorius	Young shoot	11
Moringa oleifera	Young shoot	19
Sesbania grandiflora	Flower bud	20
Telosma cordata	Flower bud	12

Advanced yield trial of jute mallow (*Corchorus olitorius*)

Three accessions of *C. olitorius* were evaluated, namely, TOT4312, TOT4541 and TOT6749. These accessions were the highest yielding accessions from the yield trials conducted in Spring 2001 by AVRDC's Technology Promotion and Service Unit and in Summer 2002 by the Genetic Resources and Seed Unit.

The experimental design was RCBD with four replications. Plot consisted of twin rows spaced 1.2 m apart; plants were spaced 50 cm. Plot size was 6 m x 2 m. A total of 24 seedlings were planted in each plot. Fertilization, irrigation, and pest control were uniformly administered on all plots. Seeds were sown on 27 February 2004 and transplanted to the field on 22 March. Harvesting was done on a weekly basis from 23 April to 15 October. Results are presented in Table 15.

Table 15. Yield and horticultural characteristics of *C. olitorius* tested at AVRDC, 2004.

Accession	Shoot yield (t/ha)	Plant height (cm)	Internode length (cm)	Leaf length (cm)	Leaf width (cm)	Shoot (no.)
TOT4312	27.02	53.77	1.17	10.86	5.81	13.13
TOT4541	20.53	65.59	1.88	10.50	5.61	15.25
TOT6749	31.91	67.36	1.73	12.89	5.63	14.70
Mean	26.49	62.24	1.60	11.41	5.69	14.36

The harvested yields for a 26-week period shows great fluctuations (Fig. 4). TOT6749 generally produced the highest shoot yield over time, followed by TOT4312, while TOT4541 often obtained the lowest shoot yield. Across accessions, harvest weeks 15 to 18 seemed to be the most productive period. Highest yield was recorded during the 15th week, about 2 t/ha, from TOT4312. On the other hand, no yield was obtained by TOT4541 during the 26th week of harvesting. In general, it can also be observed that shoot yield continuously decreases starting from the 21st harvest week.

The differences in yield among 3 accessions were showed in cumulative shoot yield (Fig. 5). Final yields obtained from TOT4312, TOT4541, and TOT6749 after 26 harvests were 27.02, 20.53, and 31.91 t/ha, respectively. From these results, it seems that TOT6749 is very much adapted to the conditions of Taiwan. The reason for this is that TOT6749 is indigenous to Taiwan. Previous results of the yield trial conducted at AVRDC likewise reveal the superior shoot productivity of this accession.

To further understand the fluctuations observed in the shoot yield per week, effects of climatic factors were investigated. Figure 6 illustrates the average shoot yield across accession with the respective air temperature, relative humidity and precipitation a week before harvesting. From the data presented, it can be concluded that the shoot yield does not solely depend

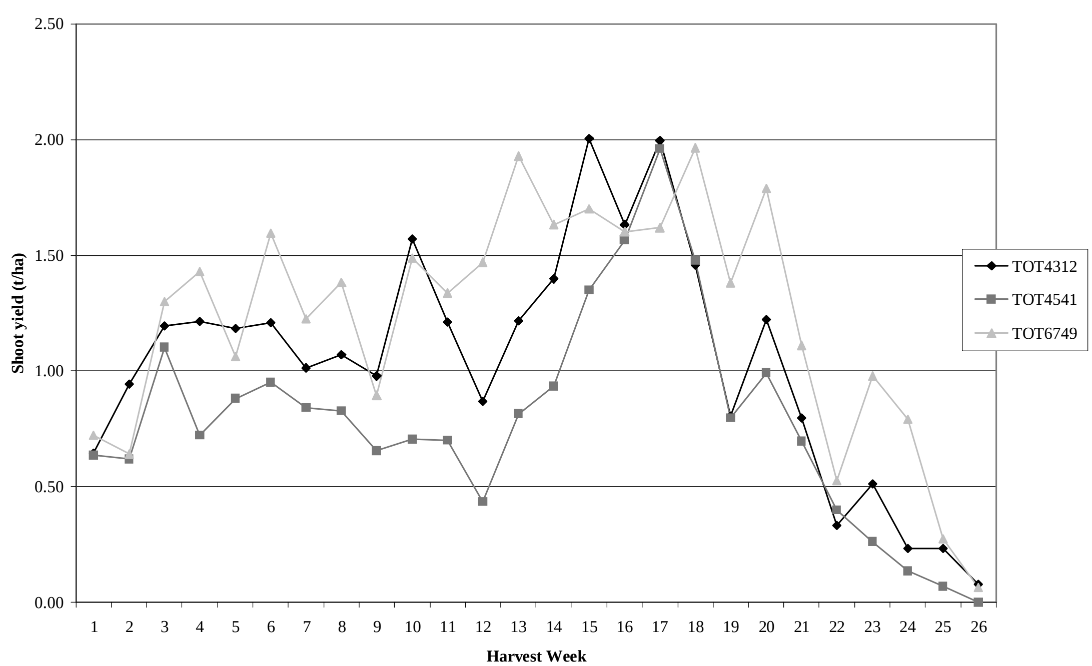


Fig. 4. Weekly yield of *C. olitorius* accessions over a 26-week harvest period.

on one climatic factor alone, but rather interactions among different climatic factors. It can be expected that at higher temperatures, lower relative humidity and normal rainfall, an increase in shoot yield of *C. olitorius* would be observed.

Contact: George Kuo

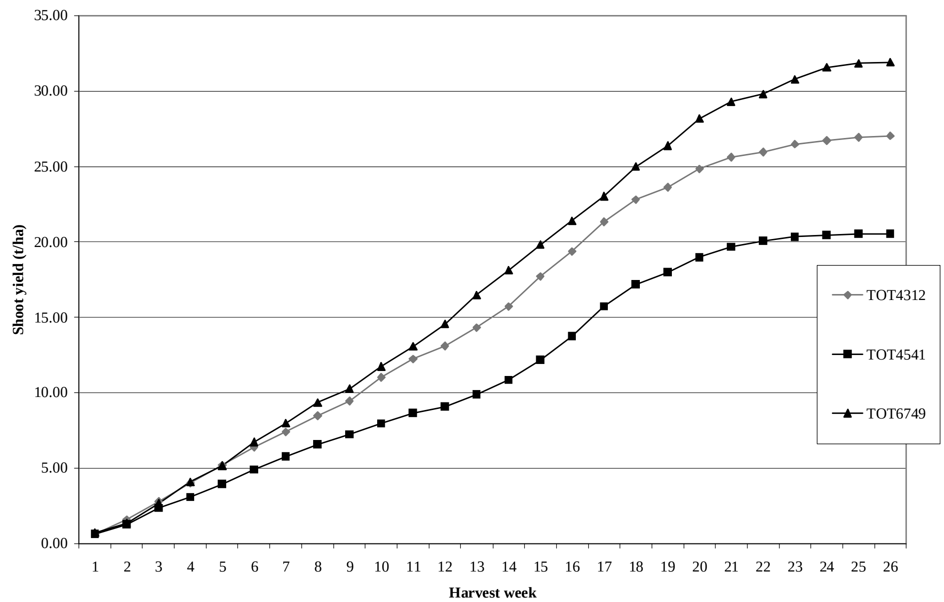


Fig. 5. Cumulative yield of three *C. olitorius* accessions over a 26-week harvest period.

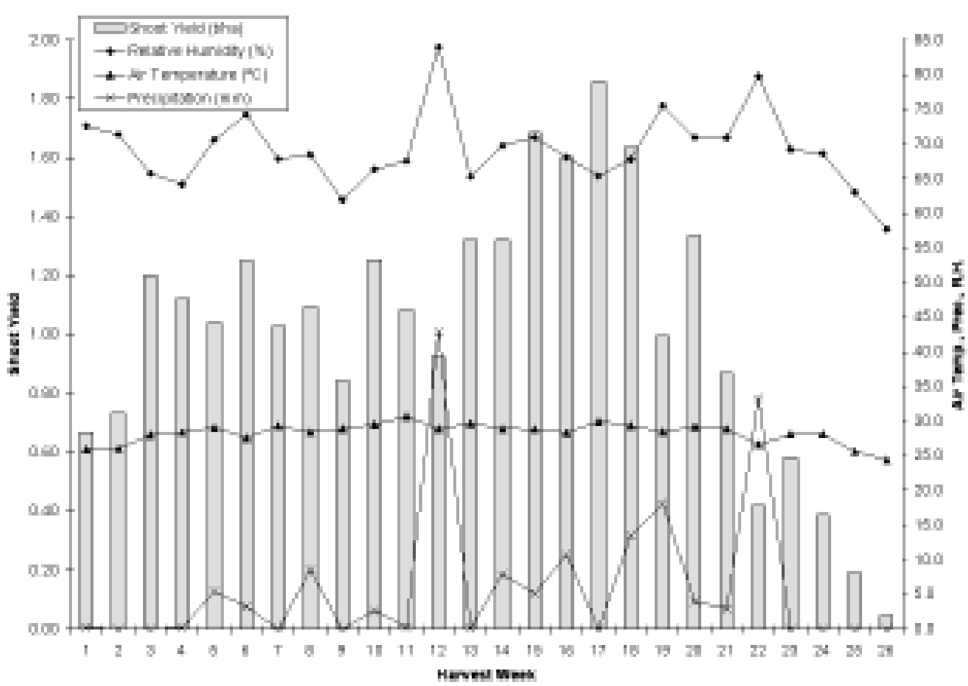


Fig. 6. Shoot yield of *C. olitorius* and different climatic factors plotted against harvesting time.

Asian Regional Center

The AVRDC-Asian Regional Center (AVRDC-ARC) conducts applied research on a wide range of vegetables grown in the region, conducts regional and short-term training courses, and coordinates sub-regional networks and collaborative research and development programs.

ARC is implementing a project entitled "Collaborative Vegetable Research Network for Cambodia, Lao PDR and Vietnam, Phase II (CLVNET-II)" funded by the Asian Development Bank (ADB), which started in 2002 and will end in 2005. The objectives of the project are to increase vegetable production and to strengthen the capacity of national agricultural research and extension systems (NARES) in these countries, with emphasis on dissemination of mature technologies to farmers.

In 2003, ARC started to implement Phase IV of the "Human Resource Development Project (HRDP-IV)" funded by the Swiss Agency for Development and Cooperation (SDC). The 4-year project promotes collaborative research and human resource development in the CLV countries as well as supports the regional training course on vegetable production, research and extension conducted every year at ARC.

ARC started to implement a new project entitled "Research on Physiological Functionalities of Indigenous Vegetable in Southeast Asia" funded by Japan International Research Center for Agricultural Sciences (JIRCAS), which started in 2004 and will end in 2007. The overall goal of this project is to improve the economic status of farmers by adding new values to local agricultural products, particularly indigenous vegetables, and to provide safer and healthier food for consumers through evaluation of indigenous vegetables in terms of food functionalities.

Simple technology for vegetable soybean seed storage

One of the problems in vegetable soybean production in the tropics is the rapid decline of seed viability. An appropriate seed storage technique needs to be developed to help poor farmers solve this problem. The objective of this trial is to identify promising lines and low-cost storage techniques for vegetable soybean production.

A 3-factor factorial, using a completely randomized design (CRD) with 2 replications, was conducted at the laboratory of AVRDC-ARC from April 2003 to March 2004. For Factor A, eight lines were used. For Factor B, five dessicating materials were used: seed:lime ratios of 1:1, 1:2, and 2:1, and seed: burnt rice straw ratios of 1:1 and 1:2. The lime was fully dried in an oven and broken into small pieces. The burnt rice straw was slowly burned until the material turned black but not gray. For Factor C, three methods of replenishing dessicating materials were used: monthly, bimonthly, and none.

For each treatment, about 120 seeds were placed in a sealed clear plastic container. The size of container depended on the seed:dessicating material weight ratio and was sufficient for the seeds and the dessicating materials to fit. For each germination test, 20 seeds were taken and germinated using the sand method.

Comparison of the lines showed that AGS 375, AGS 372, and AGS 190 had the highest germination rate after the critical period of 8 months, which is often the time from cropping season to cropping season. This confirmed the previous findings of 2003, which measured germination rates up to 6 months of storage. The check variety, AGS 292, gave the lowest germination rates from 8 months and afterwards.

In terms of dessicating material, lime proved to be better than burnt rice straw for long-term storage. Among the lime treatments, the 2 seed:1 lime treatment was best (some germination rates were as high as 100% after 12 months of storage) (Table 1). Use of 1:1 seed:burnt rice straw also showed high rates of germination. Therefore, in areas where rock lime is readily available at a reasonable price, a 2:1 seed:lime ratio is recommended because it is easier to prepare; otherwise, farmers can still store seeds using burnt rice straw at an equal proportion to seed.

Changing the dessicating material did not have any significant effect on germination percentage for up to 8 months.

The results showed that AGS 375, AGS 372, and AGS 190 have good seed storage ability. A study is being conducted to evaluate their yield potential as well

Table 1. Bi-monthly percent germination of vegetable soybean seeds by different dessicating materials and material: seed ratio.

Treatment	Storage time (months) 2	4	6	8	10	12
Line						
AGS 190	99.4	95.2	95.9	96.9	89.5	76.4
AGS 328	87.3	74.8	82.1	83.1	61.5	37.0
AGS 370	95.0	91.4	94.4	92.3	86.9	82.4
AGS 372	97.3	94.4	96.4	97.7	93.2	90.8
AGS 373	91.7	87.8	93.1	92.5	88.7	83.0
AGS 375	96.3	93.8	96.6	97.2	96.1	93.8
TN 3	92.7	85.5	89.5	91.0	88.1	78.7
AGS 292 (check)	83.0	65.9	70.5	79.5	54.7	33.0
Material						
Lime	92.8	84.8	87.4	91.3	85.9	77.8
Burnt rice straw	93.8	88.5	93.6	91.9	77.5	64.4
Control	87.5	83.1	90.3	87.3	76.3	60.9
Material:seed ratio						
1 seed:1 lime	92.2	84.7	88.2	93.6	86.5	77.2
1 seed:2 lime	93.0	82.8	84.7	85.2	87.2	79.1
2 seed:1 lime	93.1	87.0	89.2	93.0	84.2	77.2
1 seed:1 burnt rice straw	93.4	87.0	94.2	92.1	75.0	64.4
1 seed:2 burnt rice straw	94.2	88.2	92.8	91.8	78.4	61.4
Control	87.5	83.1	90.3	87.3	76.3	60.9
Material, time of replenishing materials						
Lime, monthly	93.5	80.1	84.5	89.6	88.0	78.6
Lime, every 2 months	92.4	85.1	85.1	88.9	88.3	80.3
Lime, no change	92.4	89.3	92.5	93.4	81.5	74.5
Burnt rice straw, monthly	95.2	89.4	90.9	87.7	65.0	43.3
Burnt rice straw, every 2 months	93.3	87.1	94.1	94.1	80.8	63.8
Burnt rice straw, no change	93.0	89.1	95.5	94.2	84.7	72.0
Control	87.5	83.1	90.3	87.3	76.3	60.9

as acceptability to market. Lime is a better dessicating material over burnt rice straw for long-term storage. There is no need to replace the dessicating material provided that the container will not be opened regularly.

Development of improved mungbean lines

Mungbean lines were selected based on yield and seed qualities such as weight and color. A total of 171 F_2 lines with 100-seed weights ranging from 6.5 to 8.8 g were selected during the dry season for further testing in the rainy season. Seed weights were lower in the rainy season trial, but 46 of the F_3 lines with 100-seed weights ranging from 6.3 to 7.3 g were selected. These lines will be evaluated in a preliminary yield trial next season.

The line with greatest resistance to powdery mildew, VC 6465-8-5-2A, and the line with largest seed weight, VC 6506-127, will be used for developing hybrids.

Training

Regional training course

Sixteen participants attended the 22nd Regional Training Course on vegetable production, research and extension, which was held from 3 November 2003 to 4 April 2004. Two trainees were from Cambodia, three from Lao PDR, three from Myanmar, two from North Korea, one from Thailand, and six from Viet Nam. All participants, except the one from Thailand, were supported by the Swiss Agency for Development and Cooperation (SDC). This is the first time that

Table 2. Bi-monthly percent germination of selected vegetable soybean seeds by different dessicating materials and material:seed ratios.

Line	Storage material	Storage time (months) 2	4	6	8	10	12
AGS 190	1 seed : 1 lime	100.0	93.3	91.7	97.5	97.5	95.0
AGS 190	1 seed : 2 lime	99.2	93.3	90.8	93.3	96.7	94.2
AGS 190	2 seed : 1 lime	99.2	98.3	97.5	100.0	90.8	91.7
AGS 190	1 seed : 1 burnt rice straw	100.0	95.8	100.0	97.5	78.3	63.3
AGS 190	1 seed : 2 burnt rice straw	100.0	95.0	100.0	98.3	86.7	49.2
AGS 190	Control	95.0	95.0	95.0	95.0	95.0	95.0
AGS 373	1 seed : 1 lime	92.5	84.2	96.7	96.7	90.0	87.5
AGS 373	1 seed : 2 lime	95.8	91.7	89.2	91.7	91.7	84.2
AGS 373	2 seed : 1 lime	91.7	88.3	92.5	95.0	90.0	89.2
AGS 373	1 seed : 1 burnt rice straw	87.5	91.7	95.8	90.0	85.0	71.0
AGS 373	1 seed : 2 burnt rice straw	93.3	85.8	92.5	90.0	86.0	82.0
AGS 373	Control	85.0	80.0	90.0	90.0	87.5	80.0
AGS 375	1 seed : 1 lime	97.5	91.7	92.5	97.5	98.3	92.5
AGS 375	1 seed : 2 lime	92.5	91.7	95.8	92.5	95.0	93.3
AGS 375	2 seed : 1 lime	95.0	94.2	95.0	100.0	97.5	100.0
AGS 375	1 seed : 1 burnt rice straw	99.2	95.0	99.2	96.7	98.3	95.8
AGS 375	1 seed : 2 burnt rice straw	98.3	95.8	99.2	99.2	93.3	87.5
AGS 375	Control	92.5	95.0	100.0	97.5	90.0	92.5
AGS 292 (check)	1 seed : 1 lime	81.7	72.5	79.2	85.0	64.2	45.8
AGS 292 (check)	1 seed : 2 lime	83.3	59.2	56.7	75.0	67.5	47.5
AGS 292 (check)	2 seed : 1 lime	85.8	73.3	64.2	91.7	64.2	46.7
AGS 292 (check)	1 seed : 1 burnt rice straw	84.2	65.8	78.3	71.7	40.8	22.5
AGS 292 (check)	1 seed : 2 burnt rice straw	82.5	65.8	75.0	78.3	41.7	11.7
AGS 292 (check)	Control	75.0	45.0	67.5	67.5	40.0	5.0

participants from North Korea attended the course, which was done upon the request of SDC. The trainees from Cambodia, Lao PDR, Thailand, and Viet Nam were selected based on personal interviews of the candidates with ARC staff, while participants from Myanmar and North Korea were selected by their respective ministries of agriculture.

At the request of SDC, the training placed more emphasis on improving the extension and training capabilities of the participants. After the course revision, the extension and training module accounted for 124 training hours compared to 72 hours in the previous course. Certificates of recognition for exemplary academic performance were awarded to three training scholars: Mr. Nguyen Sy Linh from Viet Nam, Ms. Phyu Htwe Htwe Aung from Myanmar, and Mr. Nguyen Dinh Thi from Viet Nam.

The 23rd Regional Training Course started on 1 November 2004 with 15 participants from four countries: three from Cambodia, four from Lao PDR, two from Myanmar, and six from Viet Nam (two from northern, two from central and two from southern regions). No trainee was accepted from Thailand because its Department of Agricultural Extension failed to find a suitable candidate willing to be released by their office for five months. All trainees were supported by SDC.

Short training courses

The Asia and Pacific Seed Association sponsored the International Seed Testing Association (ISTA) Seed Testing Training Course conducted by the Asian Regional Center of AVRDC – the World Vegetable Center on 23–27 August 2004. The course was held at the facilities of the Tropical Vegetable Research and Development Center of Kasetsart University.

A total of 19 participants from private seed companies, research institutions, and government offices from seven countries in Asia (Bangladesh, China, India, Indonesia, Japan, Thailand, and Viet Nam) attended the course.

Ms. Anny van Pijlen, Auditor of ISTA and Supervisor, International Cooperation and Training of NAK AGRO in the Netherlands, acted as the main resource person, ably supported by Dr. Sutevee Sukprakarn and Dr. Sunanta Juntakool of Kasetsart University.

After the completion of the course, the majority of trainees expressed satisfaction on the content and quality of information and hands-on experience they obtained. Everybody was pleased with the willingness of the resource persons to share their knowledge to them. Several trainees commented that the course should be extended from five to ten days. Most trainees said they are now more confident in performing their jobs on seed testing.

In-country training courses

A total of 34 in-country training courses were conducted in Cambodia, Lao PDR, Myanmar and Viet Nam. These courses trained 1,100 persons (459 female); these were researchers, extension workers, and lead farmers in the target areas of the CLVNET and HRD projects. The details of in-country training courses in the CLVM countries for 2004 are listed in Table 3.

A special training course was provided for a Myanmar entomologist Ms. Su Su Htwe on “Rearing parasites of DBM” for six weeks at the Research Institute of Fruits and Vegetables, Viet Nam. Dr. Murray Hill, Professor of Lincoln University in New Zealand, was dispatched as a consultant to Cambodia, Lao PDR and Viet Nam during 8–17 August to advise government officials responsible for establishing seed regulation systems in these countries.

Germplasm collection, multiplication and exchange

Table 4 summarizes the distribution of vegetable seed packets through AVRDC-ARC.

Web site development

Numerous additions were made to the AVRDC-ARC web site (www.arc-avrdc.org) in 2004. These included training reports of alumni of the five-month regional training course, highlights of in-country training activities in the CLV region, and new databases of mungbean and eggplant.

Table 3. Details of in-country training courses for 2004.

No.	Course title	Location	Date	Participants[1]
1.	Mulching and composting technologies	Kandal, Cambodia	10–12 May	30 (F12)
2.	General vegetable production	Kandal, Cambodia	17–19 May	30 (F16)
3.	Off-season vegetable production	Kandal, Cambodia	24–26 May	30
4.	Vegetable home gardening	Kandal, Cambodia	22–24 June	30 (F12)
5.	Vegetable seed production and preservation techniques	Kandal, Cambodia	25–27 August	30 (F13)
6.	Vegetable seed production	Kandal, Cambodia	4–6 November	28
7.	Off-season vegetable production	Kandal, Cambodia	22–24 November	30
8.	Off-season vegetable production	Kandal, Cambodia	9–11 December	30
9.	Vegetable production	Vientiane, Lao PDR	4–5, May	23 (F7)
10.	Off-season vegetable production	Vientiane, Lao PDR	11–12 June	38(F22)
11.	IPM	Vientiane, Lao PDR	17–18 August	29 (F8)
12.	Vegetable production	Vientiane, Lao PDR	26–28 August	26 (F7)
13.	Experimental design	Vientiane, Lao PDR	20–23 October	16
14.	Saving fund group	Vientiane, Lao PDR	17–20 November	60 (F26)
15.	Project management	Vientiane, Lao PDR	27–28 December	32 (F5)
16.	Improvement of extension skills	Phutho, Viet Nam	10–12 August	35 (F33)
17.	Improvement of extension skills	Hoa Binh, Viet Nam	3–5 September	35 (F33)
18.	Seed production technologies	Nghean, Viet Nam	15–17 September	35 (F25)
19.	Vegetable production technology	Nghean, Viet Nam	17–19 September	35 (F26)
20.	Vegetable production technology	Quang Ninh, Viet Nam	20–22 September	35 (F25)
21.	Off-season vegetable production	Quang Nninh, Viet Nam	23–25 September	35 (F35)
22.	mprovement of extension skills	Hoa Binh, Viet Nam	1–3 October	35 (F35)
23.	Identification and rearing of local parasitoids	Hanoi, Viet Nam	28–30 November	20
24.	Off season vegetable gardening	Hue, Viet Nam	14–15 February	40 (F11)
25.	Vegetable cultivation on sandy soil	Hue, Viet Nam	27–28 March	45 (F24)
26.	Off season vegetable production	Da Nang City, Viet Nam	22–23 July	35 (F15)
27.	Off season vegetable production	Quang Tri, Viet Nam	30–31 August	34 (F19)
28.	Net house and growing vegetables in net house	Ho Chi Minh City, Viet Nam	8–9 April	35 (F10)
29.	Practical vegetable production in net house	Hoa Binh, Viet Nam	26–30 August	14 (F4)
30.	Home vegetable garden in sandy soil	Thuan Hai, Viet Nam	10–11 August	45 (F13)
31.	Home vegetable garden in sandy soil	Thuan Hai, Viet Nam	14–15 September	45 (F13)
32.	Controlling DBM by IPM	Hlegu, Myanmar	8–12 March	35 (F32)
33.	Planning the field experiment	Yangon, Myanmar	14–16 July	30 (F19)
34.	Introduction and evaluation of DBM parasitoids	Shan State, Myanmar	18–19 September	15 (F12)
Total				1,100 (F459+)

[1] Female participants (F) are listed, when data are available.

Table 4. Distribution of vegetable seed germplasm sent to Asian countries in 2004.

Crop	Cambodia	China	Lao PDR	Myanmar	Thailand	Viet Nam	Total
Alliums	0	0	0	0	0	0	0
Brassicas	0	16	0	0	0	0	16
Eggplant	0	7	0	0	0	11	18
Vigna	12	30	0	9	0	7	58
Peppers	40	478	60	90	210	280	1,158
Soybean	68	5	60	33	83	40	289
Tomato	60	274	52	78	270	233	967
Others	127	1	120	5	141	0	394
Total	307	811	292	215	704	571	2,900

Regional Center for Africa

During the year 2004, AVRDC-Regional Center for Africa (AVRDC-RCA) implemented four projects, namely:

- Promotion of neglected indigenous leafy and legume vegetable crops for nutritional health in Eastern and Southern Africa
- Germplasm collection, evaluation and improvement of African leafy vegetables
- Conservation, capacity building, and characterization of African leafy vegetables. (AVRDC-RCA technical support to International Plant Genetic Resources Institute-Sub-Saharan Africa)
- Empowering small scale and women farmers through sustainable production, seed supply and marketing of African indigenous vegetables in Eastern Africa

Besides the above projects, AVRDC-RCA has also implemented the XI Africa Regional Vegetable Crops Production and Research Training Course from July to November 2004. Twenty-two participants from 14 African countries attended the course.

Two special skills training courses on indigenous vegetable crops production, marketing, and utilization involving participants from the target countries of the German Federal Ministry for Economic Cooperation and Development (BMZ)/German Technical Cooperation (GTZ) and Maendeleo Agriculture Technology-funded projects were carried out from April 4 to 24 and May 23 to 30, respectively. Additionally, 12 two- to three-day training courses in vegetable crops processing, preservation, and utilization were conducted from January to December. A total of 250 participants attended the courses.

A planning meeting was conducted from 22–23 March 2004 to prepare a workplan for the Maendeleo Agriculture Technology-funded project "Empowering small scale and women farmers through sustainable production, seed supply and marketing of African indigenous vegetables in Eastern Africa". Fifteen participants from Tanzania and Kenya attended the workshop.

In the frame of the above BMZ/GTZ project, 155 lines of indigenous vegetables have been collected this year and baseline surveys were completed in Tanzania, Malawi, Uganda and Rwanda. Two other baseline surveys were conducted in Kenya and Tanzania under the Maendeleo Agriculture Technology-funded project. Twenty-five trials were conducted on various agronomic and horticultural crops.

A number of new initiatives are being undertaken with the Southern African Development Community (SADC)/Food, Agriculture and Natural Resources (FANR), Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), West and Central African Council for Agricultural Research and Development (CORAF), United States Agency for International Development (USAID), Rockefeller Foundation, and the European Union (EU) in the coming year and concept notes and proposals have been submitted.

Evaluation of late blight-resistant tomato lines

Tomato (*Lycopersicon esculentum*) cultivation is widespread throughout Africa but yields are low and severely constrained by diseases and pests. Late blight disease caused by *Phytophthora infestans* is one of the most serious tomato diseases in Africa, especially in the highlands. It mainly occurs during the wet season. In order to reduce losses caused by late blight, resistant tomato lines have been developed by AVRDC.

This study was undertaken at AVRDC-RCA, Arusha, Tanzania from June to December 2003, to evaluate the horticultural traits of ten late blight-resistant lines along with three check commercial varieties. All lines are indeterminate, with the exception of Marglobe, which is semi-determinate. The experiment was laid out in RCBD with three replications. The plot size was 6 × 1 m with 2 rows per plot and 12 plants per row. Seedlings were transplanted on 5 July 2003 on raised beds (30 cm high) at a spacing of 75 cm between rows and 40 cm between plants within rows. Fertilizer at the rate 50N–10.8P–20.8K kg/ha was applied as a sidedressing two weeks after transplanting. Sidedressings in the form of urea at 50N kg/ha each were applied two and five weeks after transplanting. Staking was carried out two weeks after transplanting.

The experimental plots were furrow irrigated once or twice a week and weeding and pesticide application were carried out whenever necessary. Pruning was carried out once on lateral buds. The incidence of late blight was relatively lower than in previous years of testing.

Marglobe gave significantly higher marketable fruit yield (104.0 t/ha) compared to other entries tested (Table 1). Among the late blight-resistant (LBR) lines, LBR44-5 gave the highest marketable fruit yield of 84.0 t/ha which was statistically comparable to LBR19-2, LBR19-3, LBR44-2, LBR44-3, and the other two commercial checks.

The average fruit weight of Marglobe and LBR44-5 were similar, 164.8 and 162.7 g/fruit, and among the highest of the entries evaluated (Table 2). Data regarding days to flowering, seed yield, and fruit characteristics are presented (Table 2).

The results from this study show that line LBR44-5 can yield comparably to some commercial varieties, even when the incidence of late blight disease is low. In previous years under more severe levels of late blight, LBR44-5 outyielded the commercial varieties.

Table 1. Evaluation of late blight-resistant tomato lines for yield traits.

Entry	Total yield (t/ha)	Marketable yield (t/ha)
LBR19-2	66.0 b-e	65.4 b-f
LBR19-3	73.1 bc	71.5 bcd
LBR 44-1	59.7 c-f	59.7 d-g
LBR 44-2	69.2 bcd	68.4 b-e
LBR 44-3	71.1 bc	71.1 bcd
LBR 44-4	51.4 def	50.9 efg
LBR 44-5	84.2 b	84.0 b
LBR 50-2	45.0 f	43.7 g
LBR 80-2	47.4 ef	46.8 fg
LBR 81-1	63.6 c-f	63.5 c-f
Tengeru 97 (ck)	65.4 b-e	64.4 b-f
Marglobe (ck)	104.0 a	104.0 a
Moneymaker (ck)	83.2 b	83.1 bc
LSD (5%)	17.3	17.4
F-Test	***	***
CV (%)	15.1	15.3

*** Significant at $P < 0.001$.

Table 2. Horticultural characteristics of late blight-resistant tomato lines.

Entry	Days to 50% flowering	Fruit set (%)	Fruit diam. (cm)	Fruit wall thickness (%)	Avg fruit wt (g)	Fruit shape	Seed yield/ fruit
LBR 19-2	37.7 bc	65.0 ab	6.5 abc	0.74 b	111.0 e	Flattened	141 efg
LBR 19-3	38.3 abc	67.2 ab	6.8 ab	0.75 ab	134.4 d	Flattened	194 c
LBR 44-1	41.0 a	71.9 a	6.2 bcd	0.79 ab	145.7 c	Heart shape	137 fg
LBR 44-2	37.7 bc	68.8 ab	6.8 ab	0.74 b	174.8 a	Flattened	161 d
LBR 44-3	39.0 abc	72.7 a	6.9 a	0.85 a	171.1 ab	Flattened	156 de
LBR 44-4	41.0 a	67.4 ab	6.6 ab	0.71 bc	119.2 e	Flattened	109 h
LBR 44-5	40.3 ab	73.8 a	6.8 ab	0.79 ab	162.7 b	Flattened	272 a
LBR 50-2	39.0 abc	73.8 a	6.5 abc	0.76 ab	82.7 g	Round	215 b
LBR 80-5	37.7 bc	68.8 ab	5.9 cd	0.75 ab	80.7 g	Round	90 i
LBR 81-1	38.3 abc	71.1 ab	6.7 ab	0.73 b	97.0 f	Round	145 def
Tengeru 97 (ck)	37.7 bc	67.7 ab	6.7 ab	0.78 ab	93.5 f	Flattened	126 g
Marglobe (ck)	39.0 abc	68.0 ab	7.0 a	0.62 c	164.8 b	Flattened	156 de
Moneymaker (ck)	37.0 c	73.5 a	5.6 d	0.70 bc	80.1 g	Flattened	90 i
LSD (5%)	1.5	4.7	0.3	0.05	4.4	-	8
F-Test	*	*	*	*	***	-	***
CV (%)	4.6	8.3	6.5	8.2	4.4	-	6.1

Transplanted on 5 July 2003 at AVRDC-RCA.
*, **, *** Significant at $P < 0.05$, 0.01, or 0.001, respectively.
Mean separation by Duncan's multiple range test, $P < 0.05$.

Evaluation of cherry and fresh market tomato for fruit quality and yield

Cherry tomato (*Lycopersicon esculentum* var. *cerasifome*) is becoming popular in the tropics and has the potential of becoming a valuable cash crop in Africa. The objective of this study was to identify superior cherry tomato lines and compare their yield and fruit qualities with selected fresh-market tomato lines.

A total of 14 open-pollinated lines and two F_1 hybrid tomato lines were evaluated for their yield and quality characteristics under Arusha conditions. The experiment was conducted from June to December 2003. Seedlings were raised in nursery beds and transplanted 35 days after sowing on beds raised 30 cm high in plot sizes measuring 6 × 1 m with 2 rows per plot and 12 plants per row. The experiment was laid out using RCBD design with three replications. The seedlings were transplanted at a spacing of 60 cm between rows and 50 cm between plants within rows. Fertilizer at the rate 50N–10.8P–20.8K kg/ha was applied as a sidedressing two weeks after transplanting. Sidedressings in the form of urea at 50N kg/ha each were applied two and five weeks after transplanting. The plants were furrow irrigated immediately after transplanting and at weekly intervals thereafter or whenever necessary. Weeding as well as insecticide and fungicide applications were carried out as necessary.

Fruit firmness was recorded by pressing together in the palm on the side of a fruit at its widest girth 10 days after harvesting. The ripening period for each line was determined from mature green fruit placed in a polyethylene bag at 22 ± 1 ºC. Total soluble solids (TSS) were measured directly from the fruit juice using a hand refractometer. A 10 ml sample was used for determination of pH. Citric, malic, tartaric, and acetic acid content were analysed by titration method. Ascorbic acid was measured by the 2,6 dichlorophenol-indophenol titration method.

Significant differences in yield and sensory qualities were observed among the lines. Among the cherry lines, the fruit of CLN1558A had the lowest pH and highest percentages of citric, malic, tartaric, and acetic acid contents (Table 3). Hybrids CHT154 and CHT155 produced the smallest fruits. Although yields were statistically comparable, yields of the two hybrids were among the lowest (Table 4). The highest yield was

Table 3. Quality characteristics of cherry and fresh market tomato lines.

Entry	Solids (°Brix)	Days to green maturity	Fruit pH	Citric acid (%)	Malic acid (%)	Tartaric acid (%)	Acetic acid (%)
Cherry							
CLN1558A	6.2 ab	18.0 a	6.04 e	1.634 a	1.710 a	1.915 a	1.532 a
CLN2070B	6.0 abc	15.0 b	6.32 a	0.935 d	0.977 d	1.093 d	0.875 d
CHT154	7.2 a	15.3 b	6.15 cd	1.200 b	1.256 b	1.406 b	1.125 b
CHT155	7.1 a	12.0 c	6.20 bcd	1.206 b	1.263 b	1.413 b	1.131 b
PT4664b	4.8 cde	15.3 b	6.17 cd	1.055 c	1.105 c	1.237 c	0.989 c
Fresh market							
CLN5915-206	5.2 b-e	18.0 a	6.25 a-d	-	-	-	-
CLN1314G	5.6 b-e	18.0 a	6.29 ab	1.176 b	1.231 b	1.378 b	1.102 b
CLN1462A	4.4 de	15.0 b	6.25 a-d	0.843 e	0.848 e	0.949 e	0.759 e
CLN1466P	5.1 b-e	18.0 a	6.31 ab	0.907 de	0.949 d	1.063 d	0.850 d
CLN2026D	5.7 bcd	12.0 c	6.19 bcd	1.169 b	1.224 b	1.369 b	1.096 b
CLN2037B	4.3 e	12.0 c	6.35 a	0.826 e	0.865 e	0.968 e	0.775 e
CLN2116B	4.7 cde	12.0 c	6.26 abc	0.963 d	1.008 d	1.128 d	0.903 d
CLN2123A	4.7 cde	12.0 c	6.24 a-d	0.953 d	0.997 d	1.154 d	0.892 d
PT4719A	4.5 de	18.0 a	6.14 de	1.085 c	1.136 c	1.272 c	1.017 c
LSD (5%)	2.0	0.9	0.10	0.081	0.072	0.081	0.065
F-test	***	***	***	***	***	***	***
CV (%)	13.3	3.4	0.99	4.49	3.82	3.82	3.82

Sown in June 2003 at AVRDC-RCA.
*** Significant at $P < 0.001$.
Means within the same column followed by the same letter(s) are not significantly different at 5% probability level by DMRT.

produced by CLN2070B, a high-beta carotene type developed to reduce vitamin A deficiencies in diets (such deficiency contributes to most deaths in Africa).

Generally speaking, the soluble solids among the cherry lines, especially the hybrid cherry lines, exceeded those of the fresh market types (Table 3). The average fruit weights of the cherry types were less than the fresh market types, as expected.

The highest yielding lines, including bacterial wilt-resistant CLN1462A, were fresh market types, although again, differences may not be significant (Table 4). Lines CLN1462A and CLN2037B produced the highest yields and showed the largest fruit weights, 133.3 and 112.5 g, respectively).

Results from this study shows that cherry tomato lines have similar or better quality characteristics than many fresh market tomato lines. Although fruit yields may be lower, consumer preferences may make cherry tomato a valuable crop in East Africa.

Table 4. Vine type, special qualities,and yield characteristics of cherry and fresh market tomato lines.

Accessions	Vine type, remarks	Total yield (t/ha)	Marketable yield (t/ha)	Fruit set (%)	Avg fruit weight (g/fruit)
Cherry					
CLN1558A	Indeterminate	54.5 bcd	48.8 bc	90.1 a	37.3 h
CLN2070B	Indeterminate, high beta	53.4 bcd	52.9 abc	89.0 ab	47.5 g
CHT54	Indeterminate, hybrid	42.8 d	42.3 c	78.03 b-e	13.3 i
CHT155	Indeterminate, hybrid	35.1 d	34.7 c	77.9 b-e	14.2 i
PT4664B	Indeterminate, processing	52.2 bcd	41.4 c	80.2 a-d	37.5 bd
Fresh market					
CLN5915-206	Indeterminate	61.3 a-d	52.1 abc	78.96 a-d	140.0 a
CLN1314G	Indeterminate, high beta	76.3 abc	66.5 abc	66.83 e	108.0 c
CLN1462A	Indeterminate	88.3 a	82.0 a	79.83 a-d	133.8 a
CLN1466P	Determinate	52.5 bcd	45.4 bc	78.6 a-d	117.8 b
CLN2026D	Determinate	64.9 a-d	58.9 abc	79.6 a-d	93.3 d
CLN2037B	Determinate	81.7 ab	76.9 ab	76.9 cde	112.5 bc
CLN2116B	Determinate	47.6 cd	42.0 c	82.3 abc	72.5 e
CLN2123A	Determinate	52.8 bcd	49.1 bc	76.2 cde	50.0 g
PT4719A	Determinate, processing	62.3 abcd	55.5 abc	69.57 de	64.2 f
LSD (5%)		28.3	28.3	10.21	7.444
F-test		*	*	**	***
CV (%)		28.6	31.5	7.71	5.56

Sown in June 2003 at AVRDC-RCA.

*, **, *** Significant at $P < 0.05$, 0.01, or 0.001, respectively.

Means within the same column followed by the same letter(s) are not significantly different at 5% probability level by DMRT.

Effect of spacing on leaf and seed yield of sunhemp

Sunhemp, a popular African indigenous vegetable legume in some regions, has several species but the most cultivated ones are *Crotaloria ochroleuca* and *C. brevidens*. They are also found in the wild from West to East Africa. In East Africa, it is mainly cultivated on small plots at altitudes of 1000–1200 meters. *C. ochroleuca* leaves are also used as fodder, while seeds can be used to feed poultry. In intercropping systems, the other crops can benefit from the nitrogen it fixes and from its nematode reduction capacity. The oil in the seeds can also be used to control insect pests. As little is known about the production practices of *Crotolaria* spp., this study aimed to evaluate the best spacing for optimum leaf and seed yields.

The experiment was carried out at AVRDC-RCA in Arusha, Tanzania from January to September 2004. The experiment was laid out in RCBD design with three replications. The following spacings of 20 × 20, 40 × 40, 60 × 60, and 80 × 80 cm were tested. Seeds were directly sown along ridges raised 30 cm high. The ridges were furrow irrigated before sowing then followed by drilling of the seeds in rows according to the respective spacings. The spacing treatments, 40, 60, and 80 cm were sown on ridges while the 20 cm spacing treatments were sown on flat beds. One month after sowing, the seedlings were thinned to one seedling per hill. Furrow irrigation was carried out regularly. Weeding and pest control were done whenever necessary.

Results showed that leaf yield/ha peaked at the 20 × 20 cm spacing using flat beds and declined as spacings using ridges increased (Table 5). On the other hand, leaf yield per plant increased with an increase in spacing.

Seed yield/ha followed the same trend as leaf yield/ha, with the closest spacing producing the most seed/ha. Seed yields and weights were not affected by spacing.

Table 5. Effects of spacing on yield characteristics of sunhemp.

Spacing[1]	Leaf yield (g/plant)	Leaf yield (t/ha)	Seed yield (g/plant)	Seed yield (kg/ha)	No. of seeds/plant	No. of pods/plant	No. of seeds/pod	200-seed wt (g)
20 × 20	17.1 c	4.27 a	4.47	1117 a	908	61.9 b	14.63	0.98
40 × 40	23.4 bc	1.46 b	7.01	4382 b	1418	97.2 ab	14.31	1.02
60 × 60	30.7 ab	0.85 c	6.57	183 bc	1493	126.2 a	12.25	0.88
80 × 80	36.1 a	0.57 c	5.09	80 c	1126	120.1 a	9.01	0.94
LSD (0.05)	7.5	0.41	-	332	-	45.7	-	-
F-Test	**	***	NS	**	NS	*	NS	NS
CV (%)	14.0	11.38	30.28	37	34	22.6	26.44	11.05

Sown in January 2004 at AVRDC-RCA.

^{NS}, *, **, *** Nonsignificant and significant at $P < 0.05$, 0.01, or 0.001, respectively.

Means within the same column followed by the same letter(s) are not significantly different at 5% probability level by DMRT.

[1] 20 × 20 plots were on flat beds; all other spacing treatments were on 30-cm-high raised beds.

Evaluation of Ethiopian mustard lines for resistance to TuMV and downy mildew

Ethiopian mustard (*Brassica carinata)* is one of the most important *Brassica* species; however, it is susceptible to many diseases and pests. Turnip mosaic virus (TuMV), transmitted by aphids, is the most serious disease and downy mildew (*Peronospora parasitica)* can be found on the crop depending on the weather conditions. Both pathogens are difficult to control and the crop has to be sprayed at a specific stage of development to successfully control the diseases.

The identification or development of lines resistant to these diseases will enhance the quality and productivity of the crop. Since the extent of diversity of this species is still not known, although it occurs widely in Africa, germplasm accessions were collected from all over Tanzania to determine the intra-species diversity within the country.

Twenty-eight accessions were evaluated at AVRDC-RCA from July to November 2004. The experiment was laid out in a RCBD with three replications. The seedlings were transplanted on 30 July on 30-cm-high beds in twin rows. The plots measured 6 m long and the plants were spaced 60 cm between rows and 40 cm between plants within the row. Fertilizer at the rate 30N–6.5P–12.5K kg/ha was applied as a sidedressing two weeks after transplanting. Sidedressings in the form of urea at 50N kg/ha each were applied two and five weeks after transplanting. Selecron was sprayed 1 and 21 days after transplanting to control insect pests. The plants were furrow irrigated once a week or as necessary. Weeding was also carried out whenever necessary. To favor vegetative growth, flowers were frequently removed. Plants were regularly observed for disease symptoms. Data were subjected to ANOVA analysis using COSTAT software.

Differences in the incidence of both diseases were detected among the accessions. Accessions Sit 5A, Sit 8, 14, 15, 44, and 47 had relatively low incidence of TuMV incidence; on the other hand, accessions Sit 3, 45, 10B, and 51 showed the highest incidences of this disease. Accessions Sit 5A, 13, 30B, 37, 40, 45, and 47 showed no incidence of downy mildew symptoms; in contrast, accessions Sit 10B, 18, and 53B each showed incidences exceeding 20% (Table 6).

Table 6. Incidence of turnip mosaic virus (TuMV) and downy mildew on accessions of Ethiopian mustard.

	% plants showing symptoms	
Accession	TuMV	Downy mildew
Sit 3	90.0 a	8.3 bc
Sit 4	82.1 abc	5.5 bc
Sit 5A	17.0 ijk	0.0 c
Sit 6	84.2 ab	19.1 abc
Sit 8	21.8 h-k	17.6 abc
Sit 10B	90.0 a	20.1 abc
Sit 13	34.6 f-k	0.0 c
Sit 14	5.6 k	12.1 bc
Sit 15	14.3 jk	6.8 bc
Sit 18	56.6 a-g	36.9a
Sit 22A	40.9 e-j	10.9 bc
Sit 27B	79.5 a-d	7.2 bc
Sit 29	48.3 c-j	15.3 bc
Sit 30B	64.0 a-f	0.0 c
Sit 37	47.9 d-j	0.0 c
Sit 40	68.4 a-f	0.0 c
Sit 41	84.4 ab	5.0 bc
Sit 42	73.4 a-e	4.0 bc
Sit 43	77.9 a-d	4.7 bc
Sit 44	27.8 g-k	9.8 bc
Sit 45	90.0 a	0.0 c
Sit 47	24.9 g-k	0.0 c
Sit 49	50.1 b-h	8.6 bc
Sit 50	54.1 b-h	7.2 bc
Sit 51	90.0 a	9.7 bc
Sit 52B	43.5 e-j	3.8 bc
Sit 53B	45.6 d-j	24.5 ab
Sit 68A	84.6 ab	9.8 bc
F-Test	***	*

Transplanted 30 July 2004 at AVRDC-RCA.
*, **, ***Significant at $P < 0.05$, 0.01, or 0.001, respectively.
Mean separation in columns by Duncan's multiple range test, $P < 0.05$.

This study has identified several promising lines, including Sit 5A, 15, 44 and 47, which show at least partial resistance to both pathogens. Further testing is needed to verify the results and determine whether or not genes for resistance exist in these and other accessions.

Alternative pest and disease control methods in Ethiopian mustard

Diseases and insect pests are major constraints in vegetable crop production. Chemical pesticides are commonly used to control diseases and pests, but such chemicals are toxic and pests may develop tolerance to the chemicals. Sources of genetic resistance are useful, but not always available. Thus, alternative pest management technologies need to be discovered. Among these, disease resistance inducers (DRI) have been proven to be effective in both the laboratory and in a few field cases. Some plant extracts, such as neem kernel extract, are non-toxic to humans and may control insect pests.

Ethiopian mustard (*Brassica carinata*) is grown throughout East and Central Africa. Its leaves are a nutritious vegetable and its seeds are used to extract an edible oil. Major constraints of this crop include turnip mosaic virus (TuMV), black rot (*Xanthomonas campestris* pv. *campestris)*, white rust (*Albugo candida)*, black spot (*Alternaria brassicola)*, and downy mildew (*Peronospora parasitica)*. Aphids and diamondback moth (DBM, *Plutella xylostella)* are among the most serious pest found on the crop. The aim of this study was to evaluate the effect of non-toxic compounds in controlling diseases and pests in Ethiopian mustard.

The experiment was conducted at AVRDC-RCA in Arusha, Tanzania from July to November 2004. This period was characterized by low temperatures (16.9–24.5°C). One month-old seedlings of the line Mbeya Green were transplanted in raised beds with four rows per treatment . The plants were transplanted on both sides of the ridge spaced at 60 cm with 24 plants/row. Plants were spaced at 40 cm within the rows.

The following compounds were mixed in water and sprayed on the seedlings: Doble P-K (a foliar fertilizer with phosphorus and potassium) at 3, 7 and 10 ml; Recti-Ca (a 14% calcium-based fertilizer mainly derived from calcium nitrate) at 3, 6, and 10 ml; DC-Tron Plus (a highly refined, emulsifiable, agricultural spray oil more often used in orchards to control pests) at 1, 2, 3 and 5 ml; neem seed kernel extract (soaked in water over night before use) at 12.5, 25.0 and 50.0 g/L; and Juglam-25 (an organic fertilizer composed of 25% free amino acids) at 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, and 4 ml/L. The control treatment consisted of spraying the seedlings with water. The experiment was laid out in RCBD design with three replications.

The first compound application consisted of dipping roots of seedlings overnight in the different solutions before transplanting (15 July 2004). Three weeks after transplanting, seedlings were again sprayed with the appropriate chemicals at the same concentrations. The treatments were thereafter applied every three weeks. Incidence of TuMV, powdery mildew and aphids were recorded and data angularly transformed to Arc sin values before ANOVA.

Based on statistical results presented in Table 7, both Juglam-25 (2 ml) and Recti-Ca (10 ml) gave the best and equally good levels of control against TuMV and aphids (disease incidences of 18.6 and 22.1%, respectively, compared to 62.7% for the control treatment). The numerical difference in the disease incidence between these two is only due to random variation.

As TuMV is mainly transmitted by aphids, examination of the effects of the tested compounds showed that the same chemicals also control aphids (pest incidence values of 22.2 and 24.1%, respectively, compared to 74.5% for the control). Both treatments also provided impressive levels of control of powdery mildew (Table 7). Incidence of disease for these two treatments were 16.4 and 20.1%, respectively, compared to 46.7% for the control. Doble PK (7 ml) gave the highest level of control of powdery mildew with an incidence of 10.5%.

Neem extract and DC-Tron, known to control insect pests, failed to control aphids and consequently TuMV. Further testing of these compounds is ongoing to determine their usefulness as pesticides in the production of Ethiopian mustard.

Table 7. Effects of various compounds on the incidence of turnip mosaic virus (TuMV), powdery mildew, and aphids on Ethiopian mustard.

		Plants showing symptoms (%)		
Treatment	Conc.	TuMV	Powdery mildew	Aphids
Water	Until runoff	62.7 ab	46.7 a-f	74.5 abc
Juglam-25	0.5 ml	68.2 ab	36.4 d-g	59.8 def
	1 ml	69.3 a	57.8 ab	66.1 b-e
	1.5 ml	68.5 ab	40.9 a-f	72.6 abc
	2 ml	18.7 c	16.4 h	22.2 g
	2.5 ml	63.9 ab	51.6 a-e	65.3 b-f
	3 ml	75.2 a	41.1 a-f	59.8 def
	3.5 ml	69.5 a	37.0 d-g	68.6 a-e
	4 ml	64.7 ab	55.3 a-d	72.8 abc
DC-Tron Plus	1 ml	69.7 a	47.3 a-f	77.2 ab
	2 ml	67.7 ab	53.9 a-d	70.3 a-d
	3 ml	64.7 ab	44.6 a-f	73.4 abc
	5 ml	67.8 ab	42.7 a-f	80.7 a
Doble P-K	3 ml	66.8 ab	34.2 e-h	63.0 c-f
	7 ml	69.6 a	10.5 h	68.8 a-e
	10 ml	66.8 ab	59.0 a	77.5 ab
Neem	12.5 g/L	65.5 ab	29.6 fgh	67.8 a-e
	25 g/L	60.3 ab	38.9 b-g	69.5 a-d
	50 g/L	60.6 ab	52.9 a-e	67.2 b-e
Recti-Ca	3 ml	65.2 ab	57.2 abc	53.3 f
	6 ml	62.0 ab	38.3 c-g	57.1 ef
	10 ml	22.1 c	20.1 gh	24.1 g
LSD (5%)		15.4	19.4	12.4
F –test		***	**	***
CV (%)		15.2	27.5	11.7

Transplanted 30 July 2004 at AVRDC-RCA.
**, ***Significant at $P < 0.01$ or 0.001, respectively.
Mean separation in columns by Duncan's multiple range test, $P < 0.05$.

Evaluation of eggplant lines for yield characteristics and adaptability

Eggplant (*Solanum melongena*) is increasingly becoming an important economic crop in sub-Saharan Africa with production trends rising as local consumption is increasing. Additionally, it has increasingly become an important export crop with good economic returns. However, the crop is still underutilized and new varieties need to be introduced to help improve the diversity and productivity.

A trial was conducted at AVRDC-RCA, Arusha, Tanzania from May 2003 to April 2004 to evaluate yield and adaptability potential of eight lines. The trial also aimed to validate previous results as described in *AVRDC Report 2002*. The trial was laid out in RCBD design with three replications. Sowing was carried out on 20 May 2003 and the seedlings were transplanted on 21 August 2003. The seedlings were transplanted at a spacing of 60 cm between rows and 50 cm between plants. Urea was applied as a sidedressing at the rate of 210 kg N/ha, which was divided equally among three splits. The first application was three weeks after transplanting, followed by applications two and four months later. In addition, 20N–4.3P–8.3K kg/ha of fertilizer was applied three weeks after transplanting. Irrigation water was applied immediately after transplanting followed thereafter once a week or as needed. Weeds and pests were controlled regularly. Harvesting started on 24 November 2003 and terrminated on 14 April 2004.

Results showed that lines EG192 and EG219 had the highest total and marketable fruit yield, which were statistically comparable with other entries, except the low yielding lines S69 and 556B (Table 8). Line EG048 produced the heaviest fruits (124.2 g) while line S69 produced the lightest (30.1 g). In general, the results were in conformity to results from trials in years 2001 and 2002. Although the diversity in fruit characteristics among the eggplant lines is varied and consumers prefer varied characteristics depending on the region, the purple-fruited EG192 and green-fruited EG219 may be recommended for promotion in the Arusha area.

Table 8. Yield and fruit characteristics of elite eggplant lines.

Entry	Fruit color	Fruit shape	Total yield (t/ha)	Marketable yield (t/ha)	Avg fruit wt (g)	Fruit length (cm)	Fruit diameter (cm)
EG192	Purple	Elongated	104.4 a	98.0 a	69.6 c	14.1 b	4.0 c
2038	Purple	Oblong	76.8 a	71.4 ab	81.4 bc	8.4 d	5.5 b
EG193	Purple	Elongated	75.0 a	66.5 b	45.8 d	16.4 a	3.3 d
S90	Light green	Round	74.3 a	72.5 ab	47.2 d	4.0 e	5.1 b
EG048	Light green	Oblong	74.3 a	71.9 ab	124.2 a	7.4 d	6.3 a
EG219	Greenish w/ white spots	Elongated	79.2 a	72.9 ab	85.5 c	11.2 c	4.5 c
S69	Greenish w/ white spots	Round	31.9 b	30.0 c	30.1 e	3.0 e	4.4 c
556B	Greenish w/ white spots	Round	31.8 b	29.9 c	36.4 de	3.3 e	4.4 c
LSD (5%)			29.4	28.2	13.7	1.3	0.5
F-test			**	**	***	***	***
CV (%)			24.5	25.1	12.0	8.8	6.0

Transplanted 21 August 2003 at AVRDC-RCA.
**, ***Significant at $P < 0.01$ or 0.001, respectively.
Mean separation in columns by Duncan's multiple range test, $P < 0.05$.

Evaluation of onion lines for yield adaptation and storage

In sub-Saharan Africa, traditional onion varieties are still widely used. The current strategy of AVRDC onion improvement program is to develop high-yielding well-adapted lines with long storage life under ambient storage conditions. The aim of this study was to evaluate 17 onion lines/varieties for yield and storage characteristics.

The experiment was conducted at AVRDC-RCA, in Arusha, Tanzania from June to November 2003. The experiment was laid out in RCBD with three replications in plot sizes measuring 1 × 6 m. The spacing was 10 cm between plants and 15 cm between rows. The seeds were sown on 4 June 2003 and seedlings transplanted by 21 July. Fertilizer at the rate of 50N–10.8P–20.8K kg/ha was applied two weeks after transplanting. Sidedressings of urea at the rate of 23N–0P–0K kg/ha were applied two weeks after transplanting and again later when bulb formation was initiated. The crop was furrow irrigated whenever necessary. Manual weeding was done regularly.

The bulb yield of the lines tested ranged from 46.9 to 100.0 t/ha. Yellow lines 15293, CAL 606 and Texas Grano and red line 15205 showed significantly larger yields compared to other lines (Table 9). The soluble solids content was highest in Red Creole (13.7°Brix) and lowest in yellow lines CAL 606 and 15293 (6.3°Brix). Red line AC313C had the thickest neck (1.73 cm) followed by yellow lines 15012 and 15217 (1.71 cm). Red Creole and Bombay Red showed the highest bolting rates (22.5 and 18.8% respectively), while most yellow lines showed no bolting. After four months of storage, red lines Bombay Red and 15205 suffered losses exceeding 70% while lines 15012 and 15099 experienced the lowest storage losses (12.6 and 14.5% respectively).

In conclusion, yellow lines 15293, CAL 606 and Texas Grano were highest yielding; for storage onion crops, lines 15012 and 15099 are also promising. Among red lines, 15205 was highest yielding and the industry standard for red storage onions, Red Creole, performed well.

Table 9. Yield characteristics and storability of onion lines.

Bulb color Entry	Bulb color	Bulb shape	Yield (t/ha)	Bulb weight (g)	Bulb length (cm)	Bulb diameter (cm)	Neck thickness (cm)	Soluble solids (°Brix)	Bolting (%)	Storage loss (%)
15205	Red	Globe	82.2 abc	100.0 cd	6.03 a-d	5.44 de	1.42 bcd	9.3 abc	11.2 b	71.1 a
AC313C	Red	Globe	61.3 def	92.0 cd	5.03 cde	5.95 a-d	1.73 a	12.3 ab	15.5 ab	30.8 bc
Red Creole	Red	Globe	61.3 def	92.0 cd	4.83 de	5.70 bcd	1.56 abc	13.7 a	22.5 a	30.4 bc
Red Bone	Red	Globe	60.0 def	90.0 cd	4.31 e	5.60 cd	1.24 de	10.3 abc	14.7 ab	50.6 ab
15225	Red	Globe	56.2 def	84.3 cd	4.65 de	5.68 bcd	1.36 cde	10.3 abc	13.3 ab	29.6 bc
14977	Red	Globe	51.6 ef	77.3 cd	4.78 de	5.50 cd	1.28 cde	10.3 abc	14.6 ab	20.1 bc
Bombay Red (ck)	Red	Globe	58.2 def	87.3 cd	4.69 de	5.87 a-d	1.45 a-d	8.3 bc	18.8 ab	74.0 a
15293	Yellow	Highly globe	100.0 a	150.0 a	7.04 ab	6.27 ab	1.18 de	6.3 c	0.0 c	42.2 abc
CAL606	Yellow	Highly globe	96.7 a	145.0 a	6.30 a-d	6.34 a	1.26 cde	6.3 c	0.0 c	49.0 ab
Texas Grano	Yellow	Highly globe	92.9 ab	139.3 ab	7.10 ab	6.14 abc	1.22 de	9.0 abc	0.0 c	30.9 bc
15217	Yellow	Highly globe	76.0 bcd	114.0 abc	6.89 ab	5.46 de	1.71 ab	9.7 abc	0.0 c	46.0 abc
377C	Yellow	Highly globe	69.3 cde	104.0 bcd	6.27 a-d	5.41 de	1.07 e	8.0 bc	0.0 c	50.3 ab
1521	Yellow	Highly globe	62.0 def	93.0 cd	7.20 a	5.35 def	1.26 cde	8.0 bc	0.0c	23.4 bc
15099	Yellow	Highly globe	57.8 def	86.7 cd	6.68 abc	4.91 ef	1.32 cde	8.7 abc	0.0 c	14.5 bc
15091	Yellow	Globe	56.7 def	85.0 cd	5.50 a-e	5.42 de	1.47 a-d	11.7 ab	4.0 c	19.6 bc
15254	Yellow	Globe	54.4 ef	81.7 cd	5.02 cde	5.47 de	1.56 abc	10.7 abc	13.9 ab	25.6 bc
15012	Yellow	Highly globe	46.9 f	70.3 d	5.48 b-e	4.76 f	1.71 ab	8.3 bc	0.0 c	12.6 c
LSD (5%)			17.8	25.7	1.15	0.67	0.31	3.5	4.0	30.6
F-test			***	***	***	***	**	**	***	**
CV (%)			15.9	15.6	11.97	6.83	13.13	21.9	77.6	50.4

Transplanted 21 July 2003 at AVRDC-RCA.
**, ***Significant at $P < 0.01$ or 0.001, respectively.
Mean separation in columns by Duncan's multiple range test, $P < 0.05$.

Effect of irrigation scheduling and insecticide application on thrips infestation on onion

Thrips (*Thrips tabaci*) is a major pest of onion. Severe infestations cause leaf tips to turn brown and eventually wither. In injured plants, the bulbs mature prematurely as well as become deformed and reduced in size. In some tropical countries up to 66% of the onion crop may be lost due to thrips damage. They also serve as vectors of some viruses and fungi (e.g. *Alternaria porri*).

To help farmers reduce thrips infestation, research has been carried out on insecticide, biological control, and irrigation scheduling. Previous experiments conducted at AVRDC showed that effective control of onion thrips can be achieved by adjusting the irrigation water quantity and schedule. In other experiments, it has been found that onions are much more vulnerable during the bulb enlargement stage; spraying of insecticides to protect the crop should be done during this critical time rather than starting at seedling stage in order to minimize insecticide use and reduce production costs. Independent trials evaluating the timing of irrigation and interval of insecticide application were evaluated at AVRDC-RCA from July to November 2004. The trials were laid out in RCBD design with three replications. Each replication contained seven beds of 3 m^2 with a total number of 200 plants per bed at a spacing of 10 cm between plants and 15 cm between rows. A distance of 1.5 m between two adjacent plots and 6 m between two adjacent blocks were observed to minimize insect migration from one block to another.

A promising onion line, Red Bone, was used as a model species. The seeds were sown on nursery beds on 13 July 2004 and seedlings transplanted five weeks later. In both trials, 150 kg of 20–10–10 (30N–6.5P–12.5K kg/ha) fertilizer and urea at 45 kg N/ha were applied as a sidedressing two weeks after transplanting. An additional 45 kg N/ha of urea was applied three weeks later at bulbing stage. Plants were furrow irrigated twice weekly initially and afterwards whenever needed based on the treatments. Weeding was done three weeks after transplanting and then continued whenever necessary.

Furrow irrigation for all treatments was carried out up to eight weeks after transplanting. Thereafter, the following amounts of water were applied: 100, 60, and 20 L weekly until harvest, and the same amounts every two weeks until harvest. The control treatment consisted of normal irrigation (furrow irrigation twice weekly). Precautions were taken to make sure that no plants were splashed with water during irrigation to minimize chances of washing out thrips from the leaves. The amount of water scheduled for each bed in each replication was applied as uniformly as possible to ensure good water distribution.

In the insecticide experiment, selecron (20 ml/15 L of water) was applied starting on the fourth week after transplanting up to harvest. Plain water was used to spray the control treatment plots. The spraying schedule started at: 4, 6, 8, 9, 10, and 11 weeks after transplanting. A 1-m section of the two middle rows in each plot was checked for thrips damage. A six point scale (0–5) was used to score severity of thrips attack with 0 = no damage and 5 = 100% leaf area damaged. Data were collected and subjected to ANOVA using CoStat software.

Results (Table 10) showed no significant differences among irrigation treatments for bulb and biological yield and bulb sizes. The only significant difference was in the number of leaves per plant, but even this trait showed no clear pattern. All treatments were heavily infested by thrips.

Results on insecticide spraying showed that start of spraying at the earliest time, four weeks after transplanting, significantly increased bulb yield (29.8 t/ha) and biological yields (72.2 t/ha) compared to other treatments (Table 11). Any delay in spraying reduced bulb yields. These results are contrary to what was found at AVRDC in Taiwan, where it was found that pesticide spraying can be delayed until 8–10 weeks after transplanting (which is during the bulbing stage) without yield loss.

Table 10. Effect of irrigation water scheduling on yield and control of thrips in onion.

Water applied	Bulb yield (g/plant)	Bulb yield (t/ha)	Biological yield (g/plant)	Biological yield (t/ha)	No. leaves plant	Bulb length (cm)	Bulb width (cm)	Thrips damage index[1]
100 L every week	58.2	38.8	72.0	48.0	8.55 ab	4.28	4.67	3.67
100 L every 2 weeks	45.8	30.6	58.8	39.2	9.70 a	4.11	4.69	3.67
60 L every week	65.3	43.5	72.0	48.0	8.27 ab	4.59	5.05	4.00
60 L every 2 weeks	54.7	36.5	70.5	47.0	8.15 ab	4.34	4.50	3.33
20 L every week	55.6	37.0	68.7	45.8	7.48 b	4.48	4.76	4.00
20 L every 2 weeks	53.6	35.8	66.7	44.5	8.78 ab	4.66	5.54	3.67
Control[2]	55.5	37.0	63.6	42.4	8.32 ab	4.20	4.52	3.67
LSD (5%)	-	-	-	-	1.68	-	-	-
F-test	NS	NS	NS	NS	*	NS	NS	NS
CV (%)	15.7	15.7	11.6	11.6	11.13	8.99	15.01	13.57

Transplanted in mid-August 2004 at AVRDC-RCA.
NS,*, **, *** Nonsignificant, or significant at $P < 0.05$, 0.01 or 0.001, respectively.
Mean separation by Duncan's multiple range test, $P < 0.05$.
[1]Thrips infestation rating (0–5) with 0 = no damage and 5 = 100% leaf area damaged.
[2]Furrow irrigation twice weekly.

Table 11. Effects of insecticide scheduling on yield and control of thrips on onion.

Initiation of insecticide (wks after transplanting)	Bulb yield (g/plant)	Bulb yield (t/ha)	Biological yield (g/plant)	Biological yield (t/ha)	No. leaves plant	Bulb length (cm)	Bulb width (cm)	Thrips damage index[1]
4	44.7 a	29.8 a	48.1 a	72.2 a	8.42 c	4.33	4.17 a	1.00 c
6	36.5 b	24.3 b	39.0 b	58.5 b	10.33 a	4.13	3.64 bc	2.67 b
8	34.0 b	22.7 b	36.7 b	55.0 b	9.22 bc	3.96	3.72 abc	4.00 a
9	35.3 b	23.5 b	36.5 b	54.7 b	10.67 a	4.08	3.86 abc	4.00 a
10	35.6 b	23.8 b	36.5 b	54.8 b	10.00 ab	4.13	4.09 ab	4.33 a
11	35.0 b	23.3 b	35.6 b	53.5 b	9.67 ab	3.87	3.58 c	4.67 a
None	35.4 b	23.6 b	35.4 b	53.1 b	9.75 ab	3.94	3.4 7c	4.67 a
LSD (5%)	7.8	5.2	6.7	10.0	1.02	-	0.46	0.78
F-test	*	*	*	*	**	NS	*	***
CV (%)	12.0	12.0	9.8	9.8	5.91	6.97	6.81	12.06

Transplanted in mid-August 2004 at AVRDC-RCA.
NS,*, **, *** Nonsignificant or significant at $P < 0.05$, 0.01 or 0.001, respectively.
Mean separation by Duncan's multiple range test, $P < 0.05$.
[1]Thrips infestation rating (0–5) with 0 = no damage and 5 = 100% leaf area damaged.

Vegetable soybean seed production

Vegetable soybean (*Glycine max*) is a good source of protein for human consumption and it has good potential in developing countries, especially in Africa where it is relatively unknown. The crop can enhance soil fertility and can also fit well in home garden and commercial cropping systems. The adoption of vegetable soybean can contribute to enhance farmer's income and improve their diets. It can be cultivated in the tropics throughout the year with greater yields realized in warmer seasons.

Two experiments were conducted at AVRDC-RCA from September 2003 to January 2004. The objectives were to identify superior lines and to determine economical fertilizer rates.

Each trial used RCBD with three replications. Plots of the variety trial measured 6 × 0.45 m, with plants spaced 10 cm apart in twin rows, and spaced 15 cm apart. No fertilizer was applied.

Plots of the fertilizer trial were 4 × 1.2 m, with plants spaced 10 cm apart in 5 rows, and each spaced 15 cm apart. Treatments included four levels (100, 250, 500 and 750 kg/ha) of 20N–10P_2O_5–10$K_2$0 and a control that received no fertilizer.

No significant differences were detected for seed yield or pod size characteristics (Table 12). The only significant difference was in plant height, with AGS339 being taller than the other lines tested.

In the fertilizer trial, significant differences were detected in seed yield with the 250 and 500 kg/ha fertilizer treatments outperforming the control treatment (Table 13). The highest seed yield was detected at the 100N–21.5P–41.4K rate, but the performance of all fertilizer treatments was comparable.

In conclusion, none of the lines were superior compared to one another for seed yield traits. Fertilization led to higher seed yields, but plants did not particularly respond to high rates; therefore, growers should use fertilizer prudently to maximize returns.

Table 12. Performance of selected lines of vegetable soybean for seed yield characteristics.

Line	Seed yield (g/plant)	Seed yield (t/ha)	Plant height (cm)	Pod length (cm)	Pod width (cm)	No. of seeds/ pod
AGS292	8.60	5.74	29.4 b	5.14	1.04	2.56
AGS329	8.48	5.70	31.0 b	5.21	1.06	2.51
AGS338	8.84	5.89	31.3 b	5.09	1.05	2.51
AGS339	8.50	5.67	35.9 a	5.25	1.08	2.50
LSD (5%)	-	-	2.2	-	-	-
F-test	NS	NS	***	NS	NS	NS

Sown in September 2003 at AVRDC-RCA.
NS,*, **, *** Nonsignificant or significant at $P < 0.05$, 0.01, or 0.001, respectively.
Mean separation by Duncan's multiple range test, $P < 0.05$.

Table 13. Effects of fertilizer rates on seed yield characteristics of vegetable soybean.

Fertilizer rate	Seed yield (g/plant)	Seed yield (t/ha)	Plant height (cm)	Pod length (cm)	Pod width (cm)	No. of seeds/ pod
0	6.87 b	4.58 b	32.2	5.08	1.03	2.50
20N–4.3P–8.3K	8.68 ab	5.79 ab	31.4	5.31	1.08	2.53
50N–10.8P–20.8K	9.82 a	6.61 a	31.1	5.08	1.07	2.64
100N–21.5P–41.4K	9.12 a	6.07 a	32.4	5.20	1.07	2.46
150N–32.3P–62.3K	8.47 ab	5.65 ab	31.0	5.17	1.04	2.48
LSD (5%)	1.67	1.10	-	-	-	-
F test	**	**	NS	NS	NS	NS
CV (%)	29.18	28.91	11.9	10.84	7.78	8.65

Sown in September 2003 at AVRDC-RCA.
NS,*, **, *** Nonsignificant or significant at $P < 0.05$, 0.01, or 0.001, respectively.
Mean separation by Duncan's multiple range test, $P < 0.05$.

Training

Regional Vegetable Crops Production and Research Training Course

AVRDC-RCA conducted the 11th Regional Vegetable Production and Research Training Course for staff of national agricultural research and extension systems in Africa. The course was held from 4 July to 4 November 2004. Twenty-two participants (12 female and 10 male) from NARES in 15 countries, namely Angola (1), Botswana (2), Cameroon (1), Ethiopia (1), Kenya (2), Lesotho (1), Malawi (1), Mauritius (1), Rwanda (1), Seychelles (1), Swaziland (1), Sudan (1), Tanzania (6), Uganda (1) and Zambia (1), attended the training course. A course evaluation by the training participants found the lectures and hands-on useful and helpful in improving their knowledge and enhancing their capacity to conduct quality research, training and extension duties upon returning to work.

Indigenous Vegetable Crops Production, Conservation, and Utilization Training Course

A training of trainers on "Indigenous Vegetable Crops Production, Conservation, and Utilization", funded by BMZ-GTZ, was carried out at AVRDC-RCA from 4 to 24 April 2004. Twenty participants (12 male and 8 female) from 5 countries attended the course. The participants came from Kenya (1), Malawi (3), Rwanda (4), Tanzania (8) and Uganda (4). The course trained participants with skills to enhance their work activities related to maintaining biodiversity and increasing productivity of indigenous vegetable crops. Participants reported that this training was very useful for them.

Indigenous Vegetable Crops Production and Marketing Training Course

A training-of-trainers course on "Indigenous Vegetable Crops Production and Marketing" was carried out at AVRDC-RCA from 23–29 May 2004. Twenty-four participants (10 female and 14 male) from Kenya (13) and Tanzania (11) attended the course. Participants were trained in skills required to improve indigenous vegetable marketing and utilization.

Training courses in nursery management, vegetable production, IPM techniques, vegetable processing and utilization

Twelve two-day courses were conducted at AVRDC-RCA for women groups and small-scale farmers in the Arusha region. A total of 250 farmers, 90% of them women, were trained. The course offered modules on seedling nursery management, vegetable production and IPM techniques as well as vegetable processing, preservation and utilization techniques. Trainees learned production and processing techniques needed to improve productivity, reduce micronutrient malnutrition at the community level, and improve post-harvest handling techniques, and marketing of indigenous vegetables and tomato.

Farmers' field day

A farmer's field day was held at AVRDC-RCA on 22 Oct. 2004. The event featured technology demonstrations for applied vegetable production and new high yielding vegetable varieties. A total of 160 farmers, research scientists and personnel from NARES and the private sector attended the field day. Demonstrations were followed by a question-and-answer session with the aim of addressing farmer's problems.

Workshops

Improving Seed Supply and Marketing of Indigenous Vegetables

A planning workshop on "Empowering Small Scale and Women Farmers through Sustainable Production, Seed Supply and Marketing of African Indigenous Vegetables in Eastern Africa" was held at AVRDC-RCA from 22–23 March 2004. Sponsored by Maendeleo Agriculture Technology Fund, the project seeks to increase the productivity, utilization and marketing of African indigenous vegetable to improve the health and income of vulnerable groups. Fifteen participants from Tanzania and Kenya attended the workshop. Participants were from NARES, NGOs, and the private sector. A two-year workplan to implement project activities was developed at the workshop.

West Africa Vegetable Network

Promotion of superior vegetables cultivars in West Africa

Vegetable production has been steadily increasing in West Africa over the last 25 years due to the effects of urbanization and the desire of rural and peri-urban farmers to diversify their incomes. Despite these gains, the average per capita consumption of vegetables per year is only 48.6 kg in the region, less than 73 kg recommended for healthy diets. Vegetable producers face numerous constraints: extreme agro-ecological and seasonal conditions; lack of improved varieties suited for these conditions; high disease and insect pest pressures; low availabilities of inputs, improper use of pesticides; high levels of postharvest losses; and lack of available information on production.

To overcome these constraints, AVRDC and WARDA developed a joint project on “Promotion of superior vegetable cultivars in West Africa”, which started in September 2003. Funded by the Taiwan Ministry of Foreign Affairs for three years, the objective of this project is to promote year-round vegetable production and consumption in West Africa. Research and development activities were planned and are conducted in close collaboration with national research institutions of Burkina Faso, Benin, Chad, Côte d’Ivoire, The Gambia, Mali, Niger, Senegal, and Togo.

Project priorities and activities were identified during a planning workshop held 9–11 March 2004, in Bamako, Mali. Partners from all nine countries were present, as well as representatives of development organizations involved in vegetable R&D. Partners were invited to identify vegetables of regional priority, as well as the main constraints to be overcome through introduction of improved cultivars, training needs and subjects for information dissemination. In November 2004, partners were again invited in Bamako to present their preliminary results.

Setting regional priorities

Popular vegetables differ from one country to another. For example, indigenous leafy vegetables are popular in coastal countries of Benin, Togo, and Côte d’Ivoire, whereas introduced fruit-type vegetables are relatively more popular in the Sahelian countries.

Tomato, onion, hot pepper, okra and cabbage were identified as the most important vegetables across the region (Table 1). Production constraints and recommended intervention schemes were also identified for these vegetables. With a small amount of financial support from the project, each country agreed to conduct variety trials with at least two of the priority crops.

The improvement of the cultural practices was also included in the project’s activities. Instead of conducting new trials for this purpose, partners argued that several improved cultural practices were already available. It was then decided to centralize all this information to produce leaflets on the good cultural practices for each of the priority vegetables.

Two in-country training courses were planned. The first was a comprehensive course for vegetable specialists on conducting variety trials, including the establishment of seedlings, laying out plots, growing and harvesting the plants, and analyzing data. The second course was designed to teach extension workers on vegetable seed multiplication at the farmer’s level.

Regional variety trials

Preliminary results in November 2004 showed a great deal of interest among the partners for the variety trials. Seven out of nine countries conducted trials with at least three regional priority crops, instead of two as initially planned.

A total of 63 variety trials are being conducted (Table 2). The varieties/lines being tested include materials developed by AVRDC HQ, AVRDC-RCA, local programs, and seed companies, as well as traditional varieties.

The tomato trial was most popular—nearly all countries tested improved varieties for their tolerance to hot and humid conditions. Tolerance to leaf curl geminivirus is also a high priority in the region; indeed, many farmers in the region have stopped producing tomato during the cool-dry season due to this virus.

In contrast to the tomato trial, the collaborators did not express much interest in evaluating onion varieties since many well-adapted local varieties are available, including Violet de Galmi from Niger. The major production constraints in onion were believed to be improper cultural and storage practices.

The partners initially did not express interest in testing okra or hot pepper, but when the seeds arrived, many of them agreed to evaluate the materials. The partners were also curious to test mungbean, vegetable soybean and ivy gourd, which are vegetables rarely grown in the region.

Preliminary results are encouraging and the most promising cultivars will be tested in farmers' fields in 2005/2006.

Survey on integrated rice and vegetable systems

Rice and vegetable production are closely associated in the rice-based systems of West Africa. It is thought that vegetable production enhances the sustainability of those systems by the multiple interactions it has with rice, should it be at a bio-physical, socio-economical

Table 2. Number of variety trials conducted in West Africa during the 2004/2005 cropping season, within the nine collaborating countries (including Samanko research station), by season.[1]

Crop	Purpose of trial	Rainy season	Dry season	Total
Tomato	Tolerance to heat, humidity	9	0	9
	Tolerance to TYLCV	0	6	6
	Tolerance to bacterial wilt	0	2	2
Onion	Improved yields, storability	1	2	3
Hot pepper	Tolerance to anthracnose	5	8	13
Okra	Improved yields	6	5	11
Cabbage	Tolerance to heat, humidity	2	0	2
Sweet pepper	Improved yields	5	2	7
Lettuce	Improved yields	2	1	3
Mungbean	Adaptability, acceptance	3	0	3
Veg. soybean	Adaptability, acceptance	2	1	3
Ivy gourd	Adaptability, acceptance	1	0	1
Total		36	27	63

[1] Rainy season is May to September, while dry season is October to April.

Table 1. Vegetables of regional priority for West Africa, including their main constraints and means to overcome the constraints, as defined by national partners in March 2004.

Crop	Priority score[1]	Constraints	Means to overcome the constraint
Tomato	9.8	Low productivity in hot-wet season	Introduce improved varieties[2]
		Low yield	Introduce improved varieties and production practices[2]
		Low dry matter content	Introduce improved varieties
		Sensitivity to viruses	Introduce improved varieties[2]
		Sensitivity to bacterial wilt	Introduce improved varieties[2]
		Sensitivity to nematodes	Introduce improved varieties
		Poor shelf-life	Introduce improved varieties and post-harvest practices
Onion	9.4	Low yields	Introduce improved varieties and production practices[2]
		High flowering rate in the first year	Introduce improved varieties and production practices
		Sensitivity to nematodes	Introduce improved varieties
		Sensitivity to thrips	Introduce improved varieties and production practices
		Poor storability	Introduce improved varieties, production and post-harvest practices[2]
Hot pepper	8.3	Low yield	Introduce improved varieties[2]
		Insufficient number of varieties available	Introduce improved varieties[2]
		Sensitivity to anthracnose	Introduce improved varieties[2]
		Sensitivity to viruses	Introduce improved varieties
Okra	8.2	Low yield	Introduce improved varieties[2]
		Fast ripening of the fruits	Introduce improved varieties[2]
		Sensitivity to nematodes, viruses, aphids	Introduce improved varieties
Cabbage	7.0	Seed multiplication problems	Introduce improved production practices
		Poor adaptability of available varieties	Introduce improved varieties[2]
		High insect pest pressure	Introduce improved production practices

[1] Rated on a scale of 1–10, with 10 indicating highest priority.

[2] Constraints targeted by this project.

and/or nutritional level. Unfortunately, very little is actually known about these interactions. A survey was implemented to: 1) identify current constraints to vegetable production and marketing in integrated rice-vegetable systems in West Africa; 2) compile information on vegetables used in those systems, including socio-economic importance and indigenous knowledge; 3) assess interactions between rice and vegetable production and the opportunities for improvement; and 4) identify opportunities for expanded vegetable R&D in selected countries of West Africa.

Two sites were selected to conduct the survey. A total of 120 rice-vegetable farmers were surveyed in Boundoum, Podor, Guede of the Inner Senegal Valley of Senegal. This region is a Sahel savanna ecosystem with annual rainfall of 150–300 mm and irrigated perimeter rice production systems. Eighty rice-vegetable farmers were surveyed from Ganpetin, Odo Otchere of Benin. This region is a Guinea savanna ecosystem with annual rainfall of 1,250 mm and inland valley rice production systems. Information has been gathered on crop types, constraints to production, water management, agricultural calendar, land tenure, and gender issues. At each location, a team of researchers and extension agents was formed to assist in survey design and implementation. Results of the survey are forthcoming.

Closing comments

After one year, the project has successfully established collaborative relationships among the national programs. The establishment of a formal network is planned in late 2005, which will enhance opportunities to gain support from additional partners and funding agencies.

Contact Virginie Levasseur

Organizational statement

Our Mission

Reduce malnutrition and poverty among the poor through vegetable research and development.

Our Strategy

Build partnerships and mobilize resources from private and public sectors to effectively tackle problems of vegetable production and consumption in the tropics. This strategy will contribute to:

- Increased productivity of the tropical vegetable sector
- Equity in economic development in favor of rural and urban poor
- Healthy and more diversified diets for low-income families
- Environmentally-friendly and safe production of vegetables
- Improved sustainability of cropping systems

Our Core Expertise

- Management of diverse vegetable germplasm
- Innovations in crop improvement, including the use of molecular tools
- Sustainable production of safe and nutritious vegetables in the tropics
- Networks of strategic alliances for generating and sharing knowledge
- Analysis of direct and indirect impacts of vegetables

Our Unique Role

AVRDC functions as a catalyst to:

- Build international and interdisciplinary coalitions that engage in timely issues
- Generate and disseminate international public goods that address economic and nutritional needs of the poor
- Collect, characterize, and safeguard genetic resources for worldwide use
- Provide globally accessible, user-friendly, science-based information

Board members

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[1] Left during 2004
[2] Assumed office during 2004

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[1] Left during 2004
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[3] Promoted in 2004
[4] On study leave

Trainees

Genetic Resources and Seeds

Victor P. Alcantara, Philippines, 01 May 2004-28 October 2004, Design improvement of AVGRIS and online dissemination of GRSU activities and publications.

Victor P. Alcantara, Philippines, 14 November 2004-14 November 2005, Design improvement of AVGRIS and online dissemination of GRSU activities and publications.

Maryam Ali, USA, 01 July 2004–31 August 2004, Sex-associated RADP marker in spiny bitter gourd (*Momordica cochinchinensis*).

Josefina A. Atienza, Philippines, 01 September 2004-30 November 2004, Documentation and publication of technical information on indigenous vegetables collected through the ADB project.

Yazid Bostamam, Malaysia, 01 March 2004–29 May 2004, Seed germination test and moisture content determination.

Miguel Carlos R. Faylon, Philippines, 01 April 2004-30 May 2004, The effect of different culture media, length of storage, and type of explants on the immature yardlong bean embryo, *Vigna unguiculata* (L.) Walp. ssp. and *V. sesquipedalis* (L.) cultured in vitro.

Myeong-Cheoul Cho, Korea, 02 October 2004–30 October 2004, Effect of temperature on infection and symptom expression of chili veinal mottle virus (ChiVMV).

Haeng-Hoon Kim, Korea, 01 June 2004-09 June 2004, AVRDC-RDA Project on the development of technologies for the improvement of vegetable cultivars for the subtropical and temperate areas, and the exchange, evaluation, and preservation of germplasm.

Hannah C. Lacuanan, Philippines, 01 April 2004-30 May 2004, The epidermal pattern of the *Solanum nigrum* complex.

Hiew Lian Liaw, Malaysia, 02 March 2004-31 March 2004, Collecting indigenous vegetable germplasm in Sabah, Malaysia.

Jui-heng Lin, Taiwan, 01 July 2004-31 August 2004. Training report on GRSU.

Gloria P. Lanting, Philippines, 10 September 2004-30 November 2004, Regeneration, characterization, evaluation, and documentation of vegetable soybeans, other legumes, and some indigenous vegetables.

Catherine V. Magante, Philippines, 01 April 2004-30 May2004, Evaluation of antioxidant activity and diversity of amaranth, *Amaranthus* species and and culantro, *Eryngium foetidum*.

Karen Faith J. Manigbas, Philippines, 01 April 2004-30 May 2004, Morphological diversity of the *Solanum nigrum* complex species at the Asian Vegetable Research and Development Center.

Mabelle B. Palacio, Philippines, 01 April 2004-30 May 2004, The effect of different stages of immaturity on pigeonpea, *Cajanus cajan* (L.) Millsp., cultured in vitro.

Kwonseo Park, Korea, 01 December 2004-28 February 2005, Characterization and evaluation of tomato germplasm derived from *Lycopersicon esculentum* x *L. pimpinellifolium* cross.

Khamla Phengvong, Lao PDR, 02 November 2004-30 January 2005, Characterization, regeneration, and documentation of indigenous vegetables collected through the ADB project.

Shaw-wei Su, Taiwan, 01 July 2004-31 August 2004. Evaluation of antioxidants and antioxidant activity in indigenous vegetables and the influence of different harvesting time and thermal treatment after harvesting.

Quang H. Vu, Viet Nam, 04 November 2004-31 January 2004, Vegetable germplasm management and documentation system in MS Access.

Pepper

Kay O. Amable, Philippines, 01 April 2004-30 May 2004, Evaluation of resistant mechanism to anthracnose by histological and extraction method of fruit in different varieties of pepper (*Capsicum* spp.).

Soo-Young Chae, Korea, 25 October 2004-30 October 2004, AVRDC-RDA collaborative research projects on vegetables.

Yi-tsu Chen, Taiwan, 01 July 2004-31 August 2004, Latent infection on anthracnose of pepper.

Kil-Su Jang, Korea, 01 May 2004–30 July 2004, Regeneration and transformation of red pepper (*Capsicum annuum* L.) for shortened breeding duration.

Dae-Hyun Kim, Korea, 25 October 2004-30 October 2004, Familiarization of AVRDC's vegetable researches for conducting the collaborative research projects between AVRDC and RDA.

Hai T.H. Truong, Viet Nam, 01 September 2003–28 February 2004, Identification of molecular markers for resistance to pepper anthracnose by using AFLP.

Legumes

Chen-ju Chen, Taiwan, 01 July 2004-31 August 2004, Interspecific hybridization of *Vigna radiata* (L.) Wilczek and *Vigna mungo* (L.) Hepper.

Kyong-Ho Kim, Korea, 10 February 2004-10 July 2004, Generation advance and seed multiplication of Korean soybean breeding lines.

Lay Hout Leng, Cambodia, 02 September 2004-15 October 2004, Mungbean and soybean seeds production.

Tomato

Conrado H. Balatero, Philippines, 27 October 2004-29 October 2004, Areas of collaboration on bacterial wilt research in tomato; Overview of AVRDC's research efforts related to tomato yellow leaf curl virus (TYLCV); and Overview of AVRDC's pepper breeding programs.

Fung-chi Chen, Taiwan, 01 July 2004–31 August 2004, Effect of overexpressing AtHsfA1 gene on tomato growth and fruit setting.

Sz-ren Chen, Taiwan, 01 July 2004-31 August 2004, Genetic study of geminivirus resistance in cherry tomato.

Teng-yung Feng, Taiwan, 10 May 2004–16 May 2005, Evaluation of disease resistant spectrum of pflp-/hrap-transgenic tomato, development of pflp gene to be a selective marker for plant transformation, and establishment of high speed screening technology for seed industry.

Katherine R. Ramirez, Philippines, 01 October 2003-30 April 2004, Agrobacterium-mediated transformation of tomato (*Lycopersicon esculentum* L.) with tomato yellow leaf curl virus (TYLCV).

Melquiades Emmanuel C. Reyes, Philippines, 08 December 2004-27 February 2005, Preliminary work on the development of multiple-virus-resistant tomato.

Kanya Rotsianglum, Thailand, 01 December 2004-30 March 2005, Breeding for high yielding tomato hybrids with geminivirus resistance and good quality traits.

Tri Joko Santoso, Indonesia, 01 December 2004-28 February 2005, Initial hybridization for the development of Indonesia's multiple-virus-resistant tomato (as part of ABSP II Multiple Virus Resistant Tomato project).

Hai T.H. Truong, Viet Nam, 01 March 2004–31 January 2007, Identification of molecular markers for resistance to tomato anthracnose by using AFLP.

Entomology

Hui-chun Chiu, Taiwan, 01 July 2004-31 August 2004, Testing selected n-alkanes for their oviposition attraction properties against tomato fruitborer, *Helicoverpa armigera* (Lepidoptera:Noctuidae).

Clarinda V. Pile, Philippines, 19 October 2004-31 October 2004, Pheromone technologies to control insect pests.

Srinivasan Ramasamy, India, 08 May 2004-30 April 2006, Basic aspects of host mediated behaviour of tomato fruitworm (*Helicoverpa armigera*).

Chien-hua Wang, Taiwan, 01 July 2004-31 August 2004, 1.Study of effect of Z isomers of sex pheromone in trapping, calling behavior, and mating disruption in eggplant fruit and shoot borer.; 2.Study of mating and sex pheromone related behavior of cabbage webworm, *Hellula undalis* adults.

Bacteriology, Mycology, and Virology

Manjunatha Bettegowda, India, 01 December 2004-31 December 2004, Hands-on training in bacterial, fungal, and viral disease screening protocols, scoring methods, and disease diagnosis by serological and molecular tools.

Raymond F. Cerkauskas, Canada, 31 August 2003-24 July 2004, Vegetable disease field guide and fact sheets relating to the diagnosis and control of several vegetables.

Yi-shung Chen, Taiwan, 01 July 2004-31 August 2004, Determination of pathotype and metalaxyl sensitivity among single zoospore isolates of *Phytophthora capsici* obtained from pepper.

Heung Ling Choi, Hong Kong, 03 May 2004–08 May 2004, The culture of *Ralstonia solanacearum*.

Mounira Elbaz, Tunisia, 08 April 2004–01 October 2005, Bacteriology and mycology research reports.

Radhakrishnan Govindan, India, 01 December 2004-31 December 2004, Hands-on training in bacterial, fungal, and viral disease screening protocols, scoring methods, and disease diagnosis by serological and molecular tools.
Jing-shu Huang, Taiwan, 01 July 2004–31 August 2004, Development of bioassay system to evaluate biofumigation effect of *brassicae* species.
Jo-shi Lin, Taiwan, 01 July 2004–31 August 2004, Interactions between *Ralstonia solanacearum* strains with different aggressiveness in a susceptible tomato variety.
Jung Sup Lee, Korea, 01 July 2004-29 September 2004, Effect of potassium silicate amendments in nutrient solutions to suppress phytophthora blight (*Phytophtora capsici*) in pepper (*Capsicum annuum*).

Crop and Ecosystem Management

Dilip Yogi Gandhi, India, 12 September 2004-18 September 2004, Hands-on experience on AVRDC crop management technology for tomato, chili pepper, eggplant and selected indigenous vegetables; Techniques on off-season vegetable production which include grafting, raised beds, mulching and rain shelters and ; Setting up experiments using IDE's simple and low-cost microirrigation technology.
Channarong Rungsamer, Thailand, 01 December 2004-30 March 2005, I. Use of grafting technology for vegetable's seedling production; II.Effect of varying levels of soil moisture on the seed production of grafted sweet pepper, hot pepper, and tomato plants in open field.

Nutrition

Chih-cheng Chang, Taiwan, 01 July 2004-31 August 2004, Evaluation of oxalate content of under-utilized vegetables.
Jasper Karim Green, Taiwan, 15 September 2004-14 September 2005, Organic vegetable production practices.
Ming-dao Tu, Taiwan, 01 July 2004-31 August 2004, Effects of simulated digestation on antioxidant activities of *Moringa oleifera*, *Celosia argentea* and *Wedelia trilobata*.

Socio-economics

Nam V. Ngo, Viet Nam, 08 August 2004-07 October 2004, Socioeconomics studies.
Quan T. Nguyen, Viet Nam, 08 August 2004-07 October 2004, Socioeconomics studies.
Ha T.T. To, Viet Nam, 08 August 2004-07 October 2004, Socioeconomics studies.

International Cooperation

Manuel Q. Esguerra, Philippines, 15 February 2004-30 June 2005, Environmental adaptability, growth, and yield components in relation to yield performance and clientele accpetance of promising indigenous vegetables.
Lance Gerard R. Ledesma, Philippines, 15 February 2004-30 June 2005, Environmental adaptability, growth, and yield components in relation to yield performance and clientele acceptance of promising indigenous vegetables.
Albert Rouamba, Burkina Faso, 01 October 2004–26 October 2004, Familiarize with procedures on varietal testing , seed production, and nutrition seed kit development.

Communication and Training Office

Raymond F. Cerkauskas, Canada, 31 August 2003-24 July 2004, Vegetable disease field guide and fact sheets relating to the diagnosis and control of several vegetables.
Hui-chun Chang, Taiwan, 09 February 2004–12 February 2004, Training course on vegetable technologies, hot pepper production, and IPM.
Khanh H. Do, Viet Nam, 15 December 2004-22 December 2004, Safe vegetable production, food quality control, and market management.
Husnu Ekiz, Turkey, 19 December 2004-25 December 2004, Exchange of vegetable research information with emphasis on F1 hybrid development and technology transfer.
Hung V. Hoang, Viet Nam, 15 December 2004–22 December 2004, Safe vegetable production, food quality control, and market management.
Huong T.T. Le, Viet Nam, 15 December 2004–22 December 2004, Safe vegetable production, food quality control, and market management.
Hoa T. Nguyen, Viet Nam, 15 December 2004–22 December 2004, Safe vegetable production, food quality control, and market management.

Nursen Ozcalik, Turkey, 19 December 2004-25 December 2004, Exchange of vegetable research information with emphasis on F1 hybrid development and technology transfer.

Thanh T. Pham, Viet Nam, 15 December 2004-22 December 2004, Safe vegetable production, food quality control, and market management.

Thu K. Phung, Viet Nam, 15 December 2004-22 December 2004, Safe vegetable production, food quality control, and market management.

M.C. Rana, India, 19 July 2004-23 July 2004, Innovative technologies in sustainable vegetable production.

Bulent Sayal, Turkey, 19 December 2004–25 December 2004, Exchange of vegetable research information with emphasis on F1 hybrid development and technology transfer.

Suat Yilmaz, Turkey, 19 December 2004–25 December 2004, Exchange of vegetable research information with emphasis on F1 hybrid development and technology transfer.

Staff publications

Ali, M. and U. Farooq. 2004. Dietary diversity and rural labor productivity: evidence from Pakistan. In: Paper presented at the Conference on Economics and Human Biology held in Strasbourg, June 22-24, 2006. 35 pp. ref.

Ali, M., Abedullah, and U. Farooq. 2004. Diversification with vegetables to improve competitiveness in Asia. In: Agricultural diversification and international competitiveness; Report of the APO study meeting. Tokyo : APO. p.51-82 ref.

Anh, M.T.P., M. Ali, H.L. Anh, T.T.T. Ha. 2004. Urban and peri-urban agriculture in Hanoi: Opportunities and constraints for safe and sustainable food production. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. AVRDC Technical Bulletin No. 32, AVRDC Publication 04-601. vi, 66 pp. ref.

Arida, G.S., B.S. Punzal, C.C. Ravina, V.P. Gapud, E.G. Rajotte, and N.S. Talekar. 2004. Monitoring adult populations of two insect pests with sex pheromone traps for effective timing of interventions against the defoliators of onion (*Allium cepa* L.) growth after rice (*Oryza sativa* L.). Philippine Entomologist. ref.

Arida, G.S., C.C. Revina, B.S. Punzal, E.G. Rajotte, and N.S. Talekar. 2004. Response of the onion (*Allium cepa* L.) plant to simulated pest damage. Philippine Entomologist. v.18(2):151-162. ref.

AVRDC. 2004. AVRDC Report 2003. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. AVRDC Publication 04-599. 194 pp.

AVRDC. 2004. Application of molecular markers to broaden the genetic base of tomato for improved tropical adaptation and durable disease resistance: Workshop results. 14-16 April 2004. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. AVRDC Publication 04-570. 14 pp.

AVRDC. 2004. Global horticulture: Now is the time for action. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. AVRDC Publication 04-598. 30 pp.

AVRDC. 2004. Impact. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. AVRDC Publication 04-597, 4 pp.

AVRDC. 2004. Medium-Term Plan 2004-2006: Highlights. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. AVRDC Publication 04-566. 20 pp.

AVRDC. 2004. Proceedings of APSA-AVRDC Workshop, 6-7 May 2004. AVRDC - The World Vegetable Center. Shanhua, Tainan, Taiwan. AVRDC Publication 04-568. 26 pp.

Bull, S.E., W.S. Tsai, R.W. Briddon, P.G. Markham, J. Stanley, and S.K. Green. 2004. Diversity of begomovirus DNA Beta stellites of non-malvaceous plants in east and south east Asia. Archives of Virology. v.149(6):1193-1200. ref.

Cerkauskas, R. 2004. Pepper diseases, Alfalfa mosaic virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-590. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Anthracnose. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-574. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Bacterial soft rot. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-571. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Bacterial spot. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-572. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Bacterial wilt. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-573. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Blossom end rot. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-582. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, *Cercospora* leaf spot. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-575. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Chili veinal mottle virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-589. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, *Choanephora* blight. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-576. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Cucumber mosaic virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-593. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Damping-off. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-585. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Gray leaf spot. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-577. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Gray mold. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-578. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Pepper mottle virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-591. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Pepper veinal mottle virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-592. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, *Phytophthora* blight. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-579. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Potato virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-587. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Powdery mildew. Shanhua, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-580. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Root-knot nematode. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-584. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Sunscald. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-583. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Stem rot. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-586. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Tobacco etch virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-588. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Tomato mosaic virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-594. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Tomato spotted wilt virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-596. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, *Verticillium* wilt. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-581. 2 pp.

Cerkauskas, R. 2004. Pepper diseases, Whitefly-transmitted geminiviruses. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-595. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Anthracnose. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-607. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Bacterial spot. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-611. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Black leaf mold. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-606. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Blossom end rot. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-605. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Buckeye rot. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-612. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Catfacing. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-604. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Cucumber mosaic virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-608. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Graywall. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-602. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Powdery mildew. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-610. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Root-knot nematode. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-603. 2 pp.

Cerkauskas, R. 2004. Tomato diseases, Tomato mosaic virus. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. Fact Sheet, AVRDC Publication 04-609. 2 pp.

Chadha, M.L. and M.O. Oluoch. 2004. Vegetable soybean research and development in Africa. In: World Soybean Research Conference, 7th. Londrina: Brazilian Agricultural Research Corporation, National Soybean Research Center. p.921-928 ref.

Diongue, A., N.S. Talekar, Y.F. Chang, and P.Y. Lai. 2004. Ovipositional responses of the tomato fruitworm (*Helicoverpa armigera*) (Lepidoptera: Noctuidae) to the presence of eggs and to different stages of the tomato plant. Plant Protection Bulletin [TW]. v.46(4):303-314. ref.

Fan, M.J., S. Chen, and L.M. Engle. 2004. The study on genetic diversity of the core collection for *Capsicum* using random amplified polymorphic DNA. Journal of Agricultural Research of China. v.53(3):165-178. ref.

Gharuka, M., N.S. Talekar, and P.Y. Lai. 2004. Biological studies on *Microplitis plutellae* (Hymenoptera: Braconidae), a larval parasitoid of diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae). Formosan Entomologist. v.24(1):1-13. ref.

Gniffke, P. 2004. AVRDC's International Chili Pepper Nursery (ICPN) and International Sweet Pepper Nursery (ISPN). In: Proceedings of the APSA-AVRDC workshop. Shanhua: AVRDC -The World Vegetable Center. p.15

Gniffke, P. 2004. Development of heat-tolerant, desease-resistant sweet peppers. In: Proceedings of the APSA-AVRDC workshop. Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. p.16

Green, S. and G. Kuo. 2004. Geminivirus resistance in pepper. In: Proceedings of the APSA-AVRDC workshop. Shanhua, Tainan, Taiwan: AVRDC -The World Vegetable Center. p.17

Green, S. and G. Kuo. 2004. Search for tospovirus resistance in wild *Lycopersicon*. In: Proceedings of the APSA-AVRDC workshop. Shanhua, Tainan, Taiwan: AVRDC -The World Vegetable Center. p.18

Green, S.K., S.L. Shih, L.M. Lee, J.T. Wang, W.S. Tsai, J. T. Chen, H.M. Chen, C.A. Liu, and C.C. Ko. 2004. Multilocation testing of ToLCV resistance sources and resistant tomato hybrids in Taiwan. Plant Protection Bulletin [TW]. v.46(4):416-417.

Grover, D.K., K. Weinberger, and S. Shanmugasundaram, S. 2004. Mungbean cultivation in Punjab: status, potential & constraints. Productivity. v.44(4):669-676. ref.

Hamid, A., M. A. Afzal, M.M. Haque, and S. Shanmugasundaram. 2004. Registration of 'BUmug-1' mungbean. Crop Science. v.44(4):1489.

Hanson, P., R. Yang, S. Lin, S. Tsou, T. Lee, J. Wu, J. Shieh, P. Gniffke, and D. Ledesma. 2004. Variation for antioxidant activity and antioxidants in a subset of AVRDC-The World Vegetable Center *Capsicum* core collection. Plant Genetic Resources v.2(3):153-166.

Hanson, P., R. Yang, J. Wu, J. Chen, D. Ledesma, and S. Tsou. 2004. Variation for antioxidant activity and antioxidant in tomato. J. Amer. Soc. Hort. Sci. v.129 (5): 704-711.

Juroszek, P., S. Drews, D. Neuhoff, and U. Kopke. 2004. Effects of organic fertilisers on the development of weeds and winter wheat. Zeitschrift Fuer Pflanzenkrankheiten und Pflanzenschutz. v.19:611-618. ref.

Kirk, T.K., J.E. Carison, N. Ellstrand, A.R. Kapuscinski, T.A. Lumpkin, D.C. Magnus, D.B. Magraw, E.W. Nester, J.J. Peloquin, A.A. Snow, M.B. Sticklen, and P.E. Turner. 2004. Biological confinement of genetically engineered organisms. Washington, D.C.: The National Academies Press. xvi, 216p. ref.

Komatsu, K., S. Okuda, M. Takahashi, and R. Matsunaga. 2004. Antibiotic effect of insect-resistant soybean on common cutworm (*Spodoptera litura*) and its inheritance. Breeding Science. v.54(1):27-32. ref.

Lee, J.S., S.T. Seo, T.C. Wang, H.I. Jang, D.H. Pae, and L.M. Engle. 2004. Effect of potassium silicate amendments in nutrient solutions to suppress *Phytophthora* blight (*Phytophthora capsici*) in pepper (*Capsicum annuum*). Shanhua, Tainan, Taiwan: AVRDC - The World Vegetable Center. 12p. ref.

Lin, W.C., C.F. Lu, J.W. Wu, M.L. Cheng, Y.M. Lin, N.S. Yan, L. Black, S.K. Green, J.F. Wang, and C.P. Cheng. 2004. Transgenic tomato plants expressing the Arabidopsis NPR1 gene display enbanced resistance to a spectrum of fungal and bacterial diseases. Transgenic Research. v.13(6):567-581.

Liu, W.Y. and P.A. Gniffke. 2004. Stability of AVRDC's cytoplasmic male sterile (CMS) pepper lines grown under low temperatures. Capsicum & Eggplant Newsletter. no.23:85-88. ref.

Matsunami, T., A. Kaihatsu, T. Maekawa, M. Takahashi, and M. Kokubun. 2004. Characterization of vegetative growth of a supernodulating soybean genotype, Sakukei 4. Plant Production Science. v.7(2):165-171. ref.

Nakayama, N., S. Hashimoto, S. Shimada, M. Takahashi, Y.H. Kim, T. Oya, and J. Arihara. 2004. The effect of flooding stress at the germination stage on the growth of soyabean in relation to initial seed moisture content. Japanese Journal of Crop Science. v.73(3):323-329. ref.

Palada, M.C., B.N. Becker, and J. Mitchell. 2004. Cultivation of medicinal plants in alley cropping system with *Moringa oleifera* in the Virgin Islands. In: Annual agriculture and food fair of the U.S. Virgin Islands, 33rd, Feb. 14-16, 2004./ed. by Combie, V.; Clarke, C.C.; Kingshill, VI : University of the Virgin Islands Cooperative Exension Service. p.34-39 ref.

Palada, M.C., S.M. Crossman, and J. J. O'Donnell. 2004. Integrating high value horticultural crops into agroforestry systems in the tropics with focus on alley cropping. In: Proceedings symposium on celebrating minority professionals in forestry and natural resources conservation. Tallahassee, FL: Florida A&M University. 22 pp.

Palada, M.C., A.M. Davis, S.M.A. Crossman, C. Robles, and E.A. Chichester. 2004. Sustainable crop management practices for improving production of culinary herbs in the Virgin islands. Acta Horticulturae. no.629:289-298. ref.

Palada, M.C. and J.M. Mitchell. 2004. On-farm evaluation of cucumber cultivars for summer production in the U.S. Virgin Islands. In: Proceedings of the Caribbean Food Crops Society, 40th, 19-23 July, 2004. Caribbean Food Crops Society. p.16-21 ref.

Palada, M.C., J.M. Mitchell, and B.N. Becker. 2004. Growth and yield of hot pepper in hedgerow intercropping with *Morinda citrifolia* L. during early establishment. In: Proceedings of the Caribbean Food Crops Society, 40th, 19-23 July, 2004. Caribbean Food Crops Society. p.22-28 ref.

Rao, M.R. and M.C. Palada. 2004. Medicinal and aromatic plants in agroforestry systems. In: The overstory book: cultivating connections with trees./ed. by Elevitch, C.R.; Holualoa, HI: Permanent Agriculture Resources. p.282-290 ref.

Rao, M.R., M.C. Palada, and B.N. Becker. 2004. Medicinal and aromatic plants in agroforestry systems. Agroforestry Systems. v.61:107-122. ref.

Rao, M.R., M.C. Palada, and B.N. Becker. 2004. Medicinal and aromatic plants in agroforestry systems. In: New vistas in agroforestry: a compendium for the 1st world congress of agroforestry. Dordrecht : Kluwer Academic Publishers. p.107-122 ref.

Rao, M.R., M.C. Palada, and B.N. Becker. 2004. Medicinal and aromatic plants in agroforestry. APANEWS: Asia-Pacific Agroforestry Newsletter. no.24:4-6.

Shanmugasundaram, S., M.R. Yan, and T.C. Wang. 2004. Breeding for soybean rust resistance in Taiwan. In: World Soybean Research Conference, 7th. Londrina: Brazilian Agricultural Research Corporation, National Soybean Research Center. p.456-462 ref.

Shanmugasundaram, S. and M.R. Yan. 2004. Global expansion of high value vegetable soybean. In: World Soybean Research Conference, 7th. Londrina: Brazilian Agricultural Research Corporation, National Soybean Research Center. p.915-920 ref.

Shanmugasundaram, S., G. Singh, and H.S. Sekhon. 2004. Role of mungbean in Asian farming systems and relevance of coordinated research and development programs in Asia. In: Role of legumes in crop diversification and poverty reduction in Asia; Proceedings of./ed. by Gowda, C.; Pande, S.; Patancheru, Andhra Pradesh : ICRISAT. p.194-203 ref.

Shanmugasundaram, S., M.R. Yan, and T.C. Wang. 2004. Soybean rust in Taiwan. In: World Soybean Research Conference, 7th. Londrina: Brazilian Agricultural Research Corporation, National Soybean Research Center. p.365-368 ref.

Sheu, Z.M., F.I. Ho, Y.S. Chen, C.W. Wang, T.C. Wang, T.C., and L.L. Black. 2004. Characterization of *Phytophthora capsici* isolates associated with pepper *Phytophthora* blight in Taiwan. Plant Pathology Bulletin. v.13(4):341.

Shih, S.L., S.K. Green, L.M. Lee, J.T. Wang, W.S. Tsai, D.R. Ledesma, and J.T. Chen. 2004. On-farm evaluation of tomato leaf curl disease control measures in Taiwan. Plant Protection Bulletin [TW]. v.46(4):417-418.

Srinivasan, R. and S. Uthamasamy. 2004. Rapid plant screening technique - a novel tool for the evaluation of antixenosis resistance mechanism of tomato accessions to whitefly in laboratory condition. Resistant Pest Management Newsletter. v.14(1):4-5. ref.

Srisombun, S., S. Ratanarat, S. Kaswmeechai, and S. Shanmugasundaram. 2004. Vegetable soybean research and industry development in Thailand. In: World Soybean Research Conference, 7th. Londrina: Brazilian Agricultural Research Corporation, National Soybean Research Center. p.929-935 ref.

Tsai, W.S., S.L. Shih, S.K. Green, P. Hanson, and H.Y. Liu. 2004. First report of the occurrence of tomato chlorosis virus and tomato infectious chlorosis virus in Taiwan. Plant Disease. v.88(3):311. ref.

Wang, J.F. and T.C. Wang. 2004. Tomato lines with resistance to late blight. In: Proceedings of the APSA-AVRDC workshop. Shanhua: AVRDC - The World Vegetable Center. p.20

Wang, T.C., C.H. Chen, L.L. Black, P.M. Hanson, and J.T. Chen. 2004. Host plant resistance for control of tomato late blight. Plant Pathology Bulletin. v.13(4):340.

Weinberger, K. 2004. Micronutrient intake and labour productivity: evidence from a consumption and income survey among Indian agricultural labourers. Outlook on Agriculture. v.33(4):255-260. ref.

Workman, S., E. Ellis, M. Bannister, and M. Palada. 2004. Participatory survey and tree crop preferences on St. Croix, U.S. Virgin Islands. In: Proceedings of the Caribbean Food Crops Society, 40th, 19-23 July, 2004. Caribbean Food Crops Society. p.174-179 ref.

Financial information

Summary financial statement, 2004. (USD 000)

	Core		Project		Total		Budget (Board Approved)	
Revenues								
Grant	4,900		5,925		10,825		10,486	
Other revenues and support	646		0		646		405	
Total revenues	5,546	51%	5,925	49%	11,471	100%	10,891	
Expenditures								
Object Expenditures								
Personnel								
IRS	1,319		654		1,973	20%	2,245	17%
NRS	3,303		380		3,683	35%	3,450	32%
Operating expenses								
Field labor	497		253		751	7%	708	7%
Supplies	148		1,082		1,229	10%	913	11%
Travel	92		212		303	2%	272	3%
Training and workshop	19		661		681	8%	543	6%
General expenses	173		476		649	8%	888	6%
Contract outreach research	0		754		754	7%	1,411	7%
Equipment, facilities & renovations	0		1,452		1,452	3%	1,011	13%
Total	5,551		4,612		11,476	100%	11,441	100%
Strategic Themes								
1. Genetic improvement	1,163		2,305		3,468	21%	2,632	30%
2. Safe, year-round vegetables	1,161		957		2,119	22%	2,582	18%
3. Indigenous vegetables	227		715		942	18%	1,300	8%
4. Information dissemination	776		799		1,576	14%	1,314	14%
Administration and Services	2,224		1,148		3,372	26%	3,613	29%
Total expenses	5,551	52%	5,925	48%	11,476	100%	11,441	100%
Revenues less expenses	(5)		0		(5)		(550)	
Translation adjustment	(21)				(21)			
Changes in net assets	(26)				(26)			
Net assets beginning of the year	550		0		550		550	
Net assets at the end of the year[1]	524		0		524		0	

[1] Excludes working capital fund of $900,000 as end of 2004.

Breakdown of revenues, 2004 and 2005. (USD 000)

	2005 Proposed		2004 Actual		2004 (Board Approved)	
Core funds						
ROC	4,065		4,065		4,235	
Japan	77		77		96	
Korea	75		30		75	
Thailand	118		118		101	
Philippines			6		50	
France	96		76		76	
UK/DFID	528		527		540	
Other revenues (see below)	550		646		405	
Subtotal	5,509	48%	5,546	48%	5,578	51%
Project funds[1]						
Restricted						
ROC/COA & MOFA	1,086		1,462		1,011	
Donor Project						
ACIAR	0		39		12	
Asian Development Bank	802		364		548	
APSA	20		18		20	
European Union	2		1			
France/MOFA	41		90		54	
Farm Africa	37		51		212	
Germany/BMZ/GTZ	1,396		1,690		1,363	
IPGRI			28			
Japan	50		32		62	
JIRCAS			0		200	
Korea/RDA	71		44		20	
TOC	33		12			
ROC/MOFA, COA & NSC	833		1,067		723	
RALF	48		27			
Rockefeller	88					
Swiss/SDC	432		389		399	
UK/DFID	302		332		352	
USA/USAID	659		232		337	
USA/USDA			23			
Training and other	25		24			
Subtotal	5,925	52%	5,925	52%	5,313	49%
Contribution in-kind[2]						
France	[125]		[94]		[94]	
Japan	[220]		[120]		[120]	
Korea	[50]		[50]		[50]	
Total revenues	11,434	100%	11,471	100%	10,891	100%

Other		
Revenue on project support		525
Interest earned		73
Miscellaneous income		6
Refund on previous payment		21
Technical service		220
Training tuition fee and overhead		30
Total		646

[1] The grants are recognized as revenue based on the expenses actually incurred. Excess of grants received over expenses, representing grants applicable to succeeding year is classified as accounts payable.
[2] Total salary of outposted scientist/s.

Statement of financial position, 2004. (USD)

		Totals
Current Assets		
Cash		4,733,448
Petty cash		2,545
Deposit paid		29
Accounts Receivable		857,603
Employees	40,253	
Regional centers	817,350	
Advance payment		1,184,095
Donor projects	1,166,093	
Prepaid expenses	18,002	
Inventories		5,260
Fixed Assets		98,187
Total Assets		6,881,166
Current Liabilities		
Accounts payable		2,323,081
Grant received in advance	1,764,599	
Accrued expenses	558,482	
Total Liabilities		2,323,081
Net Assets (assets less liabilities and translation adjustment)		3,659,281
Operation fund	524,164	
Working capital fund	900,000	
Appropriated fund	2,235,117	
Total Net Assets		3,659,281
Translation Adjustment		898,804
Total Liabilities and Net Assets		6,881,166

Meteorological information

Data (monthly mean) collected at the AVRDC weather station, Shanhua Taiwan, 2004.

	Daily avg humidity	Daily air temp.		Daily soil temperature				Daily avg wind velocity	Daily avg solar radiation	Monthly precipitation	Daily avg evaporation
				10 cm		30 cm					
		max	min	max	min	max	min				
	(%)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	(W-hour/m^2)	(mm)	(mm)
January	69	23.7	13.7	25.7	19.1	22.8	21.4	2.65	3359	5.0	3.5
February	75	23.8	14.6	26.8	19.4	23.1	21.4	2.09	3784	5.0	3.4
March	75	26.0	17.1	29.8	22.4	26.0	24.3	2.34	3721	19.0	3.8
April	74	29.1	20.3	31.3	23.6	27.3	25.4	1.86	4940	49.0	4.8
May	69	32.8	24.1	30.4	26.9	29.1	28.1	2.09	5286	63.0	5.5
June	66	33.3	25.4	31.7	28.3	30.1	29.2	2.17	5108	81.0	5.6
July	72	32.8	25.3	31.6	28.3	30.3	29.2	2.35	4727	392.5	4.4
August	70	32.9	25.3	32.0	29.0	30.6	29.8	2.18	4730	323.0	4.9
September	72	31.6	24.4	30.6	28.1	29.7	29.0	1.92	4404	254.0	4.4
October	63	29.5	19.6	28.2	25.1	27.4	26.7	1.99	4501	3.0	4.6
November	64	28.7	18.3	26.8	23.9	26.1	25.4	1.37	3488	0	3.4
December	64	24.9	15.6	23.2	20.8	23.1	22.5	2.06	3358	116.0	3.1

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