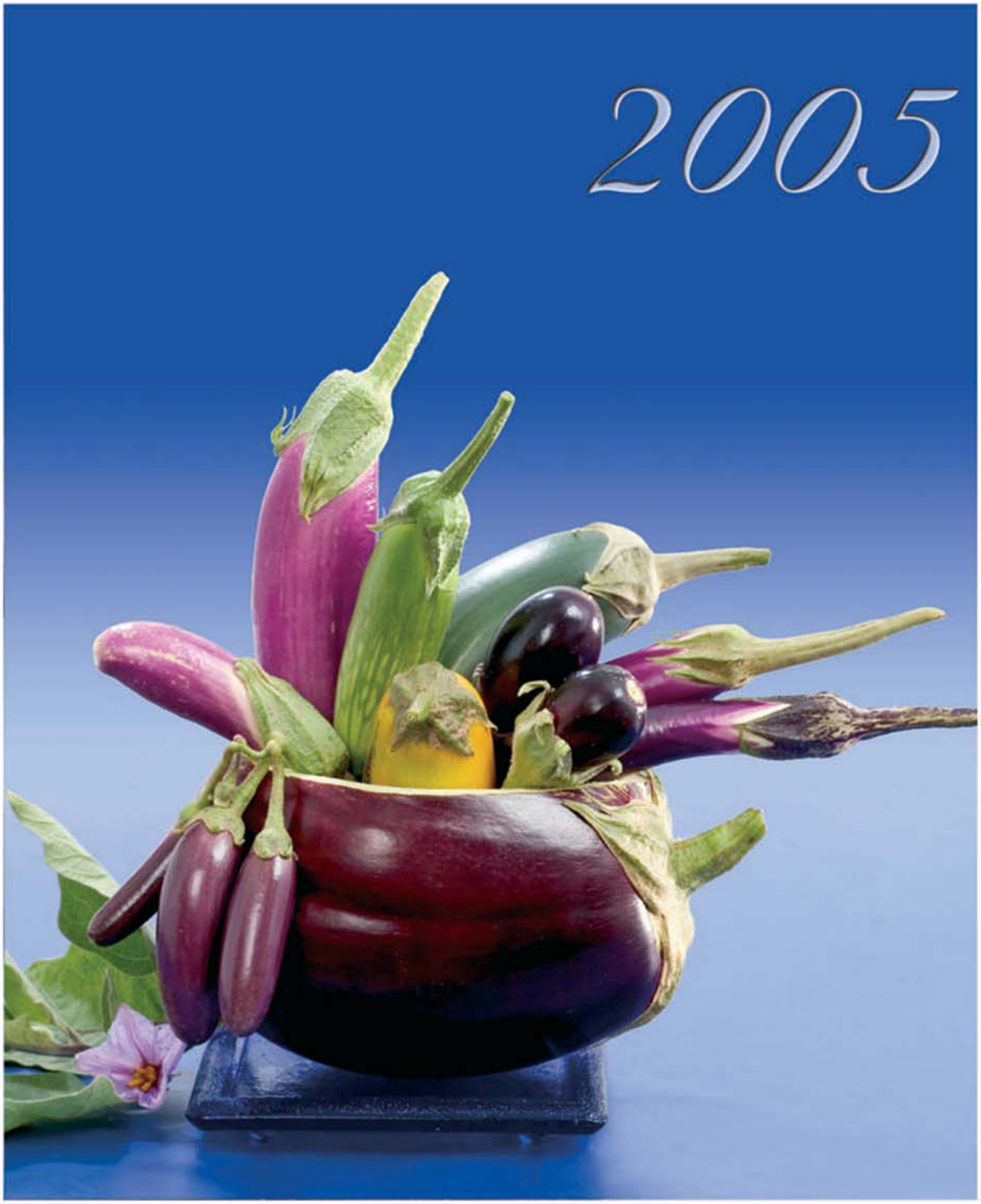
AVRDC Report



AVRDC
The World Vegetable Center

AVRDC Report 2005

AVRDC
The World Vegetable Center

AVRDC–The World Vegetable Center
PO Box 42, Shanhua, Tainan, Taiwan 74199
Tel: +886 6 583 7801
Fax: +886 6 583 0009
E-mail: avrdcbox@avrdc.org.tw
www.avrdc.org

AVRDC publication 08-702
ISSN 0258-3089

Acknowledgements:
AVRDC acknowledges the assistance of its staff in the preparation of this document, specifically Dr. Warwick Easdown for managing the production process and for editing the manuscript, Ms. Christie Clavero for editing and layout, Ms. Dolores Ledesma for the statistical review, and Mr. Chen Ming-che for the cover photo and design. Progress reports and inside photos were contributed by AVRDC scientists and staff.

Suggested citation:
AVRDC. 2008. AVRDC Report 2005. AVRDC Publication Number 08-702. Shanhua, Taiwan: AVRDC–The World Vegetable Center. viii, 196 p.

About the cover:
AVRDC holds a vast collection of eggplant germplasm and has developed integrated pest management practices as an alternative to 80 or more pesticide applications used by many smallholder farmers to control eggplant fruit and shoot borer, a major crop pest. Eggplant is the fifth most important vegetable crop in the world.

Contents

Foreword iv

Acronyms v

Genetic Enhancement

Genetic Resources and Seed, 1

Safeguarding biodiversity of major indigenous vegetables in eight countries to support research and utilization, 1

Training in vegetable genebank management, germplasm conservation, and evaluation, 2

Promoting conservation and utilization of indigenous vegetables through participatory evaluation, women training, and school gardens, 2

Seed distribution, 10

Biotechnology, 12

Development of Tomato yellow leaf curl virus-resistant transgenic tomato, 12

Development of molecular markers for bruchid and Mungbean yellow mosaic virus resistance genes with mungbean recombinant inbred lines, 14

Genetic diversity analysis of AVRDC's *Ipomoea* accessions, 15

Crucifer, 20

High-yielding broccoli for the hot-wet season, 20

Legumes, 23

Development of high-yielding and good quality vegetable soybeans, 23

New crossing of vegetable soybeans, 26

Development of mungbean lines with high methionine content, 27

AVRDC mungbean project in India, 27

Distribution of promising legume lines, 29

Tomato, 30

Tomatoes for specialty markets, 30

Geminivirus-resistant determinate tomato lines, 31

Evaluation of *Lycopersicon hirsutum* introgression lines for yield and fruit characters, 32

Preliminary evaluation of LA1777 introgression lines for early blight resistance, 34

Plant Protection

Entomology, 37

Nucleopolyhedrovirus for the control of legume pod borer, *Maruca vitrata* (F.) (syn. *M. testulalis*) (Lepidoptera: Pyralidae), 37

Susceptibility of legume pod borer, *M. vitrata,* to the δ-endotoxins of *Bacillus thuringiensis* (Bt), 39

Studies on the parasitoids of legume pod borer, *M. vitrata, 40*

Integrated crop management system for safer tomato production, 41

Bacteriology, 43

Phylotype identification and phylogenic relationships of *Ralstonia solanacearum* strains isolated from different hosts in Taiwan, 43

Managing tomato bacterial wilt with resistant rootstocks in combination with urea and slacked lime mixture in the field, 45

Mapping quantitative trait loci associated with resistance to bacterial wilt in tomato line Hawaii 7996, 47

Mycology, 49

Summary of tomato late blight studies at AVRDC from 1991 to 2005, 49

Characterization of Taiwan isolates of *Fusarium oxysporum* f.sp. *lycopersici* and evaluation of commercial tomato cultivars for resistance to Fusarium wilt, 52

Virology, 55

The role of weeds in the epidemiology of tomato begomoviruses, 55

Diversity of begomoviruses of legumes in South and Southeast Asia, 57

Crop and Ecosystem Management

Management of cauliflower, lettuce, chili pepper, sweet pepper, and tomato, 59

Managing soil with Starter Solution Technology, 66

Organic vegetable production, 70

Integrated pest management, 73

Nutrition

Screening of edible plants for antimicrobial activities against food-borne pathogens, 74

Phenolic profiles of leafy sweet potato varieties for two harvests, 76

Socioeconomics

Urbanization and demand for food quality in Hanoi, 80

Analysis of the vegetable sector in Central Asia and the Caucasus Region, 83

Setting vegetable research and development priorities in Central Asia and the Caucasus region for a market-oriented production system, 89

Postharvest loss in priority vegetable crops in Cambodia, 93

Quality management in horticultural exports from Vietnam, 96

Role of indigenous vegetables for micronutrient consumption in Southern Tagalog, Philippines, 98

Communications, Training, and Information

Publications and multimedia presentations, 103

Training, 104

AVRDC website and Learning Center, 105

Collecting and sharing tropical vegetable information, 105

Visitors, 106

Global Outreach

International Cooperation, 107

Regional yield trials, 107

The first AVRDC Tomato leaf curl virus-resistant fresh market tomato hybrid released in Taiwan, 111

Development and extension of indigenous vegetables as new vegetable crops, 111

Training workshop on evaluation of promising vegetables, 113

Grant Development, 118

Vegetable seed kits for the survivors of the Tsunami, 118

AVRDC-Asian Regional Center, 120

Collaborative vegetable research network for Cambodia, Lao PDR, and Vietnam, 120

Human resource development for the Mekong region, 120

Physiological functionalities of indigenous vegetables in Southeast Asian countries, 121

Effect of biological liquid manure on growth of Chinese kale and water convolvulus, 122

Yield trial of selected vegetable soybean line , 123

Large-scale methods of storing soybean seeds using baked limestone and Burned Rice Straw, 124

Inheritance of Bruchid (Coleoptera: Bruchidae) resistance in mungbean (*Vigna radiata* (L.) Wilczek), 124

Screening of AVRDC eggplant accessions for resistance to eggplant fruit and shoot borer damages, 124

A new high yielding mungbean line 'VC 6506-127' resistant to Cercospora leaf spot disease, 126

The relationship of pod-synchronized maturity and degree of determinate in advanced mungbean lines, 126

Training, 126

AVRDC-Regional Center for Africa, 128

Evaluation of neem kernel extract as an alternative to synthetic chemicals to control diamondback moth on cabbage, 128

Effects of plant population on yield adaptation and horticultural characteristics of promising nightshade lines, 130

Studies on Ethiopian mustard, 132

Effects of plant population on horticultural characteristics of promising African eggplant lines, 141

Effect of green manure on amaranth production, 143

Evaluation of spiderplant lines, 145

Determination of cultural requirements for amaranth, 147

Evaluation of onion lines for yield and horticultural characteristics, 149

Influence of spacing and fertilizer on agronomic yield of onion, 151

Study on soil treatment methods for seedling stand establishment, 151

Effect of insecticide and irrigation scheduling on onion thrips control, 154

Training, 156

Central Asia and Caucasus, 157

Characterization of asparagus lines in Azerbaijan and Uzbekistan, 157

Studies of non-heading Chinese cabbage in Uzbekistan and Azerbaijan, 157

Reproductive growth of non-heading Chinese cabbage under the climatic conditions of Azerbaijan and Uzbekistan, 159

Yield trials of cucumber accessions in Azerbaijan and Uzbekistan, 160

Characterization of AVRDC mungbean lines in Uzbekistan, 161

Evaluation trial of AVRDC vegetable soybean lines in Azerbaijan and Uzbekistan, 163

Yield and horticultural characteristics of AVRDC tomato lines in Azerbaijan and Uzbekistan, 165

Afghanistan, 167

Vegetable research on Model Research Plot, 167

Vegetable demonstration/research in districts, 170

Drip irrigation technology in vegetable production, 174

Testing imported vegetable varieties, 174

Training collaborating and lead farmers in vegetable production technology, 175

Socioeconomic baseline survey, 175

Role of the RALF-0104 Project on capacity building, 176

Organizational statement, 178

Board members, 179

Staff, 180

Trainees, 183

Staff publications, 190

Financial information, 195

Meteorological information, 196

Foreword

AVRDC–The World Vegetable Center is pleased to present its accomplishments for 2005. This year has been a time of preparation. The Center began assessing its environment and forming large networks particularly with the CGIAR and other strategic partners through our Global Horticulture Initiative, which has brought recognition of the key role of vegetables in supplying the micronutrients and antioxidants necessary for a balanced diet. Our efforts sensitized the donor community, even those preferring to support cereal research, to give more support to the neglected vegetable sector.

2005 also has been a year of planting. We sowed seeds of hope and peace in some of the earth's most challenged communities. With the support of the Asia & Pacific Seed Association, over 5 tons of seeds and gardening supplies were delivered to bring relief to the victims of the December 2004 Tsunami in Indonesia and Sri Lanka. In war-torn Afghanistan, our programs provided alternative crops to opium poppy. We have extended the center's technologies to other new territories that have recently opened to the outside world—Central Asia and the Caucasus and North Korea.

Last but not least, this year has been a season of harvest. Our breeding program made significant strides in the development of tomato varieties resistant to leaf curl virus, a major constraint to tomato production in the tropics. Total varieties released from AVRDC's breeding work increased, from one variety in 2002 to 11 this year. Germplasm was distributed in more than 80 countries and increased from 6,000 to 19,000 requests. There was a 13% increase in publications from 2004, with the highest number published in 2005 compared to the last five years. In headquarters alone, the number of trainees increased by more than 50%. New micro-irrigation and postharvest initiatives were launched. Renovation of laboratories began, high-tech equipment was procured, and manpower strengthened to bring the Center to the cutting edge of science. Efforts to produce transgenic tomatoes resistant to geminiviruses and molecular markers for bruchid and Mungbean yellow mosaic virus have been pursued. Screening of more than 120 species of indigenous vegetables last year included further investigation of Chinese cedar, drought-tolerant moringa, and cyclone/flood-resilient sweet potato, all of which were found to have high levels of antioxidant activity and vitamins.

Indeed, 2005 was a time of tremendous progress at the Center. I welcome you to learn about our accomplishments, celebrate our successes, and look forward with us to the challenges ahead.

Thomas A. Lumpkin
Director General

Acronyms

AARNET	ASEAN-AVRDC Regional Network for Vegetable Research and Development
AB-QTL	advanced backcross-quantitative trait loci
ADB	Asian Development Bank
AFLP	amplified fragment length polymorphism (markers)
ANOVA	analysis of variance
APSA	Asia & Pacific Seed Association
ARC	Asian Regional Center
AS	acetosyringone
AUDPC	area under disease progress curve
AVGRIS	AVRDC Vegetable Genetic Resources Information System
AVRDC	AVRDC–The World Vegetable Center
AYT	advanced yield trial
BAW	beet armyworm
BER	blossom end rot
BeYDV	Bean yellow dwarf virus
BMZ	German Federal Ministry of Economic Cooperation and Development
BPI-LBNCRDC	Bureau of Plant Industry, Los Baños National Crop Research and Development Center
Bt	*Bacillus thuringiensis*
BW	bacterial wilt
CAC	Central Asia and the Caucasus
CAP	cleaved amplified polymorphic (markers)
CAPS	cleaved amplified polymorphic sequences (markers)
CEC	cation exchange capacity
CHC	cabbage head caterpillar
CIA	Central Intelligence Agency
CIRAD	Centre de coopération inter-nationale en recherche agronomique pour le développement
CL	Chunglin of Hsinchu
CLH	cotton leaf hopper
CLVNET	Collaborative Vegetable Research Network for Cambodia, Lao PDR, and Vietnam
CLV	Cambodia, Lao PDR, and Vietnam
CMC	Crop Multiplication Center
CMV	Cucumber mosaic virus
COA	Council of Agriculture
CPGMV	Cowpea golden mosaic virus
CRALS	Creating Restoring Alternative Livelihood Sources
CRD	completely randomized design
CRSP	Collaborative Research Support Project
CTAB	hexadecyltrimethyl ammonium bromide
CTO	Communication and Training Office
CVMV	Cucumber veinal mottle virus
DAALI	Department of Agronomy and Agricultural Land Improvement (Cambodia)
DAIS	Tainan District Agriculture Improvement Station
DArT	diversity arrays technology markers

DAS	days after sowing
DAT	days after transplanting
DBM	diamondback moth
DD	degree of determination
DRI	Dietary Reference Intake
DSR	disease severity rating
DTF	food diversity index
EB	Early blight
EFSB	eggplant fruit and fruit borer
ET	evaluation trial
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FFS	Farmers' Field School
FM	fresh matter
FNRI	Food and Nutrition Research Institute
FOL	*Fusarium oxysporum* f. sp. *lycopersici*
FW	Fusarium wilt
GAE	gallic acid equivalents
GD	genetic distances
GMS	Greater Mekong Subregion
Gpi	glucose-6-phosphate isozyme
GRSU	Genetic Resources and Seed Unit
GTZ	German Technical Cooperation
HACCP	Hazard Analysis and Critical Control Points
HHRC	Hatdokkeo Horticulture Research Center
HPLC	high performance liquid chromatography
HRDP-IV	Human Resource Development Project for the Mekong Region Phase IV
IAARD	Indonesian Agency for Agricultural Research and Development
ICARDA	International Center for Agricultural Research in the Dry Areas
ICIPE	Insect Physiology and Ecology
ICO	International Cooperation Office
ICP	insecticidal crystal protein
IDA	Iron Deficiency Anemia
IDE	International Development Enterprises
IGR	Research Institute of Genetic Resources (Azerbaijan)
IGS	intergenic spacer
IL	introgression line
INRA	French National Institute for Agricultural Research
IOM	Food and Nutrition Board, Institute of Medicine
IPM	integrated pest management
ISO	International Organization for Standardization
ITS	internal transcribed spacer
IV	Indigenous Vegetable
IVegRI	Indonesian Vegetable Research Institute
IYT	intermediate yield trial

JIRCAS	Japan International Research Center for Agricultural Sciences
KKVRS	Kbal Koh Vegetable Research Station
KT	Kuantien of Tainan
LB	Late blight
LC50	median lethal concentration
LPB	legume pod borer
LSD	least significant difference
MARDI	Malaysian Agricultural Research and Development Institute
*Mavi*NPV	*Maruca vitrata* multiple nucleopolyhedrovirus
MIC	minimal inhibitory concentrations
mtDNA	mitochondrial genome
MYMV	Mungbean yellow mosaic virus
NAH	nucleic acid hybridization
NARES	National Agricultural Research and Extension System
NARS	National Agricultural Research System
nit	nitrate non-utilizing
NPK	nitrogen, phosphorus, and potassium
NU	Nangarhar University
OBs	occlusion bodies
OF	organic fertilizer
PCARRD	Philippine Council for Agricultural Resources Research and Development
PCR	polymerase chain reaction
Pep	peptidase
PHTC	Post Harvest Technology Center (Lao PDR)
PVY	Potato virus Y
PYT	preliminary yield trial
QTL	quantitative trait loci
R&D	research and development
RAE	retinol activity equivalent
RAPD	random amplified polymorphic DNA markers
RAUDPC	Relative area under disease progress curve
RCA	Regional Center for Africa
RCBD	randomized complete block design
RD	recommended dose
RDA	Recommended Dietary Allowance
RE	retinol equivalent
RFLP	restriction fragment length polymorphism (markers)
RH	relative humidity
RI	Relief International
RIFAV	Research Institute of Fruit and Vegetable (Vietnam)
RILs	recombinant inbred lines
RO	reverse osmosis
RYT	regional yield trial
SA	soil amendment
SAHN	sequential agglomerative hierarchical non-overlapping

SAS	Statistical Analysis System
SDC	Swiss Agency for Development and Cooperation
SDI	Selective Dissemination of Information
SINGER	System-wide Information Network for Genetic Resources
SI	standard inorganic
SLCARP	Sri Lanka Council for Agricultural Research Policy
SPL	Sweet potato leaves
SSR	single sequence repeat markers
SST	Starter Solution Technology
TAE	Tris-acetate-EDTA buffer
TEM	transmission electron microscopic
TGRC	Tomato Genetics Cooperative Report
ToLCTWV	Tomato leaf curl Taiwan virus
ToLCV	Tomato leaf curl virus
ToMV	Tomato mosaic virus
TP	total phenolics
TSS	Taiwan Seed Multiplication and Propagation Station
TSW	1000-seed weight
TuMV	Turnip mosaic virus
TVRC	Tropical Vegetable Research Center
TYLCV	Tomato yellow leaf curl virus
UC	University of California
UPGMA	unweighted pair-group method, arithmetic average
USAID	United States Agency for International Development
UzRIPI	Uzbek Research Institute of Plant Industry
VAD	Vitamin A Deficiency
VC	vegetative compatibility
WAT	weeks after transplanting
WHO	World Health Organization
WTG	whitefly-transmitted geminivirus
WTO	World Trade Organization
WUE	water use efficiency
YLB	yardlong bean

Genetic Resources and Seed

Safeguarding biodiversity of major indigenous vegetables in eight countries to support research and utilization

Through projects funded by the Asian Development Bank (ADB), collecting expeditions were conducted in eight countries to assemble vegetable germplasm indigenous to South and Southeast Asia. The objectives of the project include safeguarding biodiversity of major indigenous vegetables to support research and utilization. From these expeditions, a total of 2772 accessions were transferred for long-term conservation to AVRDC by five countries that participated in the project: 'Collection, Characterization, and Utilization of Indigenous Vegetables' (RETA 5839). Through a second ADB-funded project: 'Promoting Utilization of Indigenous Vegetables for Improved Nutrition of Resource-Poor Households in Asia' (RETA 6067), another 1554 accessions were added to the collection. The total number of accessions transferred to AVRDC is now 4326.

The materials added in 2005 included 103 accessions of *Lablab purpureus* and 87 accessions of *Cucurbita moschata*; brought to AVRDC by a research fellow from Bangladesh studying the genetic diversity of the Bangladesh germplasm collection.

A collecting expedition in Cambodia in January 2005 added 212 accessions of indigenous vegetables to the collection. The expedition covered the villages of Battambang, Bantley Mean Chuey, and Siem Reap. Cambodian farmers shared their heirloom seeds of indigenous vegetables for long-term preservation at AVRDC through the ADB RETA 6067 Project (Figure 1). According to information gathered by the collecting team, some of these varieties were handed down through succeeding generation of families for over 60 years. Indigenous knowledge on indigenous vegetables and their production were also gathered during visits to home gardens.

The collection from Lao PDR included one accession of *Basella alba* known for its mild taste. Safflower (*Carthamus tinctorius*) seeds were donated by the Thai Indigenous Vegetable (IV) Team to the AVRDC collection.

Figure 1. Cambodian farmers sharing their heirloom seeds of indigenous vegetables for long-term preservation at AVRDC–The World Vegetable Center through the ADB RETA 6067 Project.

Table 1 shows the number of accessions of IV germplasm transferred so far to AVRDC through RETA 5839 and RETA 6067. The materials are now conserved in medium-term (5^{o}C, 45% RH) at the Genetic Resources and Seed Unit (GRSU) of AVRDC to wait for further regeneration and characterization. Collected information is also stored at GRSU. The collected materials are conserved both in AVRDC and the country of origin. These are maintained not only for conservation purposes but also to support research and utilization.

Table 1. Summary of number of germplasm transferred to AVRDC through ADB-funded projects

Country	RETA 5839	RETA 6067 (in 2003)	RETA 6067 (in 2004)	RETA 6067 (in 2005)	Total
Bangladesh	703	-	73	218	994
Cambodia	-	-	137	195	332
Indonesia	-	-	-	-	-
Lao PDR	-	178	434	1	613
Malaysia	-	-	285	-	285
Philippines	147	-	-	23	170
Thailand	1,388	-	-	1	1,389
Vietnam	534	-	9	-	543
Total	2,772	178	938	438	3,888

Regeneration and characterization of the collected materials are being conducted both at AVRDC headquarters and the participating countries in collaboration with the national activities and other collaborating projects using standardized sets of descriptors. Regeneration procedures are based on a standard protocol that considers the breeding structure of each species to preserve the genetic integrity of the original population in the regenerated materials.

The diverse array of indigenous vegetable germplasm collected provides materials from which one can choose genotypes that can be used to diversify production systems for income generation, to diversify diet for improved health and nutrition, and to serve as a source of novel varieties for the development of new crops for commercialization.

Training in vegetable genebank management, germplasm conservation, and evaluation

In 2005, training at AVRDC was provided to 12 persons, totaling 53.5 man-months for all national agricultural research systems (NARSs) of six countries.

Two Lao trainees came to AVRDC for a three-month-long training in crop management.

From the Philippines, one research intern completed training on the design improvement of the AVRDC Vegetable Genetic Resources Information System (AVGRIS), testing the GRSU database as part of the System-wide Information Network for Genetic Resources (SINGER), identifying problems related to the testing and providing solutions to them, deploying GRSU databases on the intranet and internet, organizing the data generated by the indigenous vegetable project in manageable form, facilitating the incorporation of the indigenous vegetable work in Southeast Asia into the ASEAN-AVRDC Regional Network for Vegetable Research and Development (AARNET) homepage, initiating the use of the bar-code system to manage genebank holdings, and developing user-customized data presentation forms.

One research staff of the Tropical Vegetable Research Center (TVRC), Kasetsart University, Thailand came to AVRDC in May to study genetic diversity in the Southeast Asian collection of *Solanum*. Another research staff of TVRC completed her training at AVRDC on screening techniques for fungal diseases of chili.

Four undergraduate students from different universities in Taiwan did their summer internships at GRSU, AVRDC. They studied the effect of storage on germination and the drying behavior of some crop species.

Promoting conservation and utilization of indigenous vegetables through participatory evaluation, women training, and school gardens

The ADB-funded project ‘Promoting Indigenous Vegetables for Improved Nutrition of Resource-Poor Households in Asia’ used three strategies to promote conservation and utilization of indigenous vegetables. These strategies were conducted through field demonstrations and participatory evaluation, women training on home gardening schemes, seed production and food preparation, and pilot indigenous vegetable school gardens. Indigenous vegetable seed kits (RETA 6067 IV SEED KITS) consisting of about 50 different species and varieties were distributed to participating countries for use in the promotional activities. The seed kit included amaranths, jute, kangkong, Malabar spinach, eggplant, ivy gourd, bitter gourd, bottle gourd, snake gourd, pumpkin, okra, eggplant, false coriander, and roselle. Indigenous vegetables from local collections were also added. Criteria used for inclusion in the seed kit were field performance, functional properties, preliminary result of participatory evaluation, and country selection. Seeds of open-pollinated high beta-carotene cherry tomato and vegetable soybean selections were also included because of their high nutritional value.

The participatory evaluation of indigenous vegetables, the women training, and the school garden components of RETA 6067 all sparked interests in indigenous vegetables. These promotional activities earned the IV family the title ‘guardians of biodiversity.’

Participatory evaluation of indigenous vegetables

Indigenous vegetables from the IV seed kits were planted in demonstration fields. Vegetable farmers, growers, traders, vendors, school children, and other consumers were invited during field days to look at the different indigenous vegetables, taste different food preparations using indigenous vegetables, and answer survey questionnaires for the participatory evaluation. Over 700 participants joined the field evaluation

(Table 2). The demonstration and participatory evaluation were designed to stimulate awareness and interest among the target clients to increase use of indigenous vegetables for a healthy diet as well as additional source of income for farmers and vendors.

Table 2. Participatory evaluation for indigenous vegetables conducted through RETA 6067

Country	Location	Number of participants
Cambodia	Kbal Koh Vegetable Research Station	50
Indonesia	IVegRI, Lembang	48
	Cibodas	48
	Subang	50
Malaysia	Seremban	42
Philippines	Mariano Marcos State University	196
	Nueva Vizcaya State University	197
	BPI-LBNCRDC, Los Baños	87[a]
Vietnam	Da Bac	Not reported

[a]An additional 228 pupils and 11 teachers visited the demonstration fields.

Cambodia. A participatory evaluation was held in August 2005 at the Kbal Koh Vegetable Research Station (KKVRS) as shown in Figure 2. The crops in the demonstration field included local RETA 6067 collections (41 acc including 4 bitter gourds, 5 wax gourds, 6 yardlong beans, 3 kangkongs, 5 smooth luffas, 5 angled luffas, 6 eggplants, 1 okra, 1 green mustard, 5 chilis) and the KKVRS-Department of Agronomy and Agricultural Land Improvement (DAALI) selections which included soybean DT 84, tomato TNK2 (CLN 1462 A), tomato TNK1, cherry tomato (15611), cherry tomato (CLN 1561 K), Capsicum (Xiampan #6) Capsicum (KK promotional material), long eggplant (RETA 6067 selection for KK promotion), and ICRISAT peanut (KK promotional material). At least 50 vegetable farmers or growers, vendors, and housekeepers or consumers from six villages (Prek Thmey, Rotieng, Dounsor, Ta Reap, York Barth, Chon Lork, and Banthey Dek) participated in the field evaluation. Participants identified selections that they preferred (Figures 3 and 4).

Figure 2. Mr. Mong Vanndy (RETA 6067 PI) introducing local IVs during the participatory evaluation held at KKVRS, Cambodia on 23 August 2005.

Figure 3. The shape and color most preferred for eggplant, depending on its use, according to the results of the participatory evaluation in Cambodia.

Figure 4. The preferred size, color, and shape of a bitter gourd accession according to the majority of the Cambodians during the participatory evaluation.

Indonesia. Demonstration and participatory evaluation (Figure 5) were held in three locations: the Indonesian Vegetable Research Institute (IVegRI) research station (1200 m a.s.l.), a farmer's field in Cibodas (1300 m a.s.l.), and in Subang (100 m a.s.l.).

A total of 79 accessions of 17 species were planted. The selections included amaranth (27 acc), kangkong (3 acc), jute (1 acc), katuk (1 acc), ridged gourd (2 acc), bitter gourd (3 acc), snake gourd (2 acc), okra (2 acc), basella (2–3 acc), pumpkin (2 acc), roselle (1 acc), winged bean (3 acc), chayote (4 acc), false coriander (5 acc), and ivy gourd (1 acc). Vegetable soybean (11 acc) and cherry tomatoes (9 acc) were also included.

Large variation among species and among accessions within the same species in terms of adaptability and yield potential was observed. In some cases, variation in morphological characteristics was also observed. For example, the pumpkin from the RETA 6067 IV SEED KIT was almost round in shape whereas the local variety was elongated. The local variety had heavier fruit weight than the introduced varieties. Ridged gourd from the seed kit had much longer fruit compared to the local variety. However, the local variety of snake gourd was longer than TOT 6244. The local okra gave fewer fruits. The fruits were also longer and thinner in diameter than the introduced ones.

Five accessions of false coriander were promoted under RETA 6067. This crop is not yet well known in Indonesia. Preparation of seedling materials consisted of sowing the fine seeds mixed with fine soil evenly in seedling boxes, transferring the one-month old seedlings in banana leaf pots, then transplanting them in the field one month later. TOT 4030 was identified as adapted to the Cibodas, Lembang area.

Interviews with 48 participants (23 farmers, 15 consumers, and 10 vendors) during the participatory evaluation showed that among the indigenous vegetables in the RETA 6067 SEED KIT, the most popularly grown vegetables by farmers in Cibodas were tomatoes (100% of the respondents), chayote (70%), soybean (17%), bitter gourd (13%), and amaranth (13%). Tomatoes, soybean, and chayote were grown as cash crops. Luffa, amaranth, kangkong, sauropus, snake gourd, and pumpkin were mainly grown for home consumption. Snake gourd was consumed in small quantity due to the participants' unfamiliarity with the crop. Selling to direct buyers who often come to the field where they do the transaction with the farmers was the most common method of marketing IVs. Ten percent of the vendors buy the vegetables. The vendors provided the farmers with some resources such as seeds, chemicals, and some money for labor.

Most participants were impressed with roselle, another unknown crop to the villagers in the area (Figure 6). The Indonesian IV Team demonstrated how to make syrup from roselle. At the end of the field day, the participants were served roselle syrup.

Figure 5. Indonesian participants are enjoying a bite of winged bean.

Figure 6. Indonesian participants preparing and enjoying a drink made from the syrup of roselle (*Hibiscus sabdariffa*), an indigenous vegetable unknown in Cibodas.

They all gave good comments about the syrup. Some planned to sell the syrup to school children. As a result of the ADB RETA 6067 promotional activities, this is now a popular drink in the district.

During the participatory evaluation done in Lembang and Cibodas, organoleptic tests of dishes prepared from indigenous vegetables were conducted. Eight main dishes (sauropus and pumpkin in coconut milk, red bean soup with coriander, luffa soup with vermicelli, roulade sauropus with tofu, spicy snake gourd with shrimp, stir-fried chayote with bilis, stuffed bitter gourd with meat and terancam), 10 steamed indigenous vegetables (green amaranth, red amaranth, winged bean, basella, pumpkin, chayote, sauropus, kangkong, jute, and okra), raw IV (tomato, bitter gourd, winged bean), and seven sauces (shrimp paste, peanut, fermented soybean, coconut, fermented peanut, tomato, mayonnaise) were prepared. Red bean soup with false coriander, sauropus, and pumpkin in coconut milk, and roulade sauropus with tofu were generally the preferred preparations by the farmers, consumers, and vendors. Steamed chayote, green amaranth, and winged bean were preferred over steamed basella, red amaranth, okra, jute, bitter gourd, pumpkin, and kangkong. Among the seven sauce preparations that were served to go with the steamed indigenous vegetables, shrimp paste was the most preferred. Among the steamed preparations of five fruit types of pumpkin tested in Cibodas, the green oblong variety was preferred over the dark green round type, grey round type, yellow spotted round type, and white oblong type.

In Subang, 50 respondents consisting of farmers, consumers, vendors, and journalists attended the participatory evaluation. Bitter gourd was consistently selected as first in ranking by farmers, consumers, and vendors probably because of its business potential. Other vegetables selected were pumpkin, sauropus, luffa, and snake gourd. These were thought to be good cash crops. Ivy gourd was selected as a new introduction. Farmers were curious about it and thought that it also looked good as an ornamental. Had roselle been introduced before the survey, the participants would have selected it also. Chayote was selected only by the consumers.

Interviews showed that the respondents liked bitter gourd, pumpkin, luffa, snake gourd, and sauropus. Among the crops being evaluated, the most grown in the area were luffa (26%), pumpkin (22%), bitter gourd (17%), and soybean (17%). None of the respondents grew snake gourd or chayote. The most popularly consumed (87–100%) were kangkong, tomatoes, sauropus, bitter gourd, and chayote. Of the 11 vegetables, the most traded (67%) were bitter gourd, luffa, and soybean.

In Lembang, there were 48 respondents (17 farmers, 21 consumers, and 10 vendors). The most widely grown among the demonstration crops were tomato (100%), winged beans (24%), chayote (12%), pumpkin (12%), sauropus (6%), and kangkong (6%). Tomatoes covered 70% of the land area in Lembang. The most consumed were tomato (100%), chayote (90% of the respondents), pumpkin (71%), soybean (67%), amaranth (62%), bitter gourd (57%), and kangkong (52%). The most traded were tomatoes, bitter gourd, amaranth, kangkong, chayote, and luffa.

Promotion at IVegRI was also done through the demonstration of preparing meals with indigenous vegetables as main ingredients. Among those who attended were women or housewives, students, mixed members of society, and others. These activities were done in collaboration with the Research Service Section of IVegRI. A short questionnaire was distributed to collect information on the response of the participants to the meals as part of the organoleptic tests. Leaflets on the recipes were distributed as well. Meals and promotional events were arranged depending on the availability of materials from the ongoing research activities.

Malaysia. Accessions from RETA 6067 IV SEED KIT were planted in Miri, Sarawak. Despite the very hot and dry weather in Miri throughout the trial period, the Malaysian IV Team observed the adaptability and potential of vegetable soybean, kangkong, basella, jute, roselle, and a local Kacang Panjang for large-scale planting in the Miri area.

Field demonstrations and participatory evaluation of indigenous vegetables were conducted in Kampung Pantai in the state of Negeri Sembilan from August 2005 to December 2005. A total of 83 accessions of indigenous vegetables were evaluated. It was attended by 42 individuals representing vegetable farmers; herb growers from nearby villages; and staff of the Federal Agricultural and Marketing Authority, the Malaysian Agricultural Research and Development Institute (MARDI), and the Department of Agriculture in Sabah and Sarawak. The participants were requested to select potential and highly acceptable accessions among those evaluated in the trial. The following were chosen to have potential for commercialization: DINO 03-0178 (*Capsicum annuum*), TOT 6765 (*Ipomoea aquatica*), TOT 3886 (*Abelmoschus esculentus*), DINO 03-0122 (*Abelmoschus esculentus*), and TOT 3578 (*Basella alba*). Some accessions were considered as having medicinal value: TOT 4868 (*Amaranthus spp*.), TOT 2272 (*Amaranthus spp*.), TOT 5473 (*Amaranthus spp*.), and TOT 3886 (*Abelmoschus esculentus*).

Philippines. Demonstrations and participatory evaluation were conducted in three sites in the Philippines. For the dry season in 2005, a total of 55 accessions of 10 kinds of indigenous vegetables were planted at the research station of the Bureau of Plant Industry, Los Baños National Crop Research and Development Center (BPI-LBNCRDC), Los Baños, Laguna for demonstration purposes, seed production, and for the conduct of participatory evaluation. These were amaranths (26 acc), basella (2 acc), kangkong (2 acc), roselle (1 acc), and snake gourd (1 acc). Vegetable soybean (12 acc) and tomatoes (9 acc) were included. The participatory evaluation was attended by 49 consumers, 32 traders, and 20 farmers. Sample produce was brought to the target clientele, such as market vendors, who could not visit the fields for evaluation (Figure 7).

A majority of the consumers, traders, and farmers were familiar with and were utilizing six species from the seed kit, namely: kangkong, basella, jute, tomato, okra, and ridged gourd. However, many of them were not familiar with roselle, ivy gourd, and snake gourd. Nutritional value, taste, and shelf life were the common qualities identified by the participants in selecting indigenous vegetables for promotion. Unavailability in the market and lack of awareness about the nutritional value and common recipes or ways of food preparation were among the perceived limiting factors in the utilization of indigenous vegetables.

Figure 7. Participation in the evaluation and selection of IV's by vendors in Batong Malake, Los Baños, Laguna, Philippines.

Organoleptic tests were done on some common vegetables (tomato, okra, vegetable soybean, ridged gourd, snake gourd, and okra). The tomato varieties selected by Grades IV & V pupils were: CLN 2026 D; CLN 2123 A, and CLN 5915-206-D4-2-2-0. Chosen as the most liked varieties by the adult consumers were PSB Tm 9, CHT 154, and CLN 2123 A for tomato, Acc 402 for vegetable soybean, and TOT 3662 for ridged gourd.

During the preliminary evaluation, the promising accessions selected based on yield and field observation on resistance to pest and diseases were TV 06407 for pole sitao, TOT 7335-2 and TOT 7335-4 for bottle gourd, and TOT 3662 for ridged gourd. TV 06407 from Bangladesh was recommended for further screening and inclusion in the varietal development activities.

The participatory evaluation in Mariano Marcos State University, Ilocos Norte was held in March 2005. Fifty-six farmers, 36 researchers, and 61 consumers, including 43 school children participated. Participants and visitors were excited to see vegetables that were new to them or vegetables that they used to be familiar with but do not see anymore. For example, the farmers in Ilocos Norte were excited to see roselle. They said that they knew the plant in the past but that they do not see it anymore. A lot of the visitors gathered around the roselle plants and started tasting and smelling the different parts of the plants. They were told about the different ways roselle can be used. Young flower buds can be dried and used for tea preparations and fresh ones can be used to make sinigang (a kind of sour soup). Leaves can be used like any other leafy vegetables. Flower buds with the calyx can be used to make juice and wine. A lot of them asked for seeds to plant. This reintroduction of roselle signals the comeback of a plant that had been forgotten.

Among the 26 varieties of amaranth, the consistent choice of farmers and consumers in the visual evaluation were TOT 1810, TOT 4096, and TOT 2253. In the organoleptic test, TOT 2272, a white leaf amaranth, was consistently chosen followed by TOT 2353, TOT 1810, and TOT 4685. Results of the participatory evaluation indicated that most of the respondents were familiar with indigenous vegetables and use them. Most of the farmer respondents (88%) were planting indigenous vegetables for home consumption. Overall appearance, nutritional value, shelf life, and freshness were the common qualities considered by consumers, farmers, and traders in the selection of indigenous vegetables for promotion. Marketability was also given highest priority by traders. Unfamiliarity, unavailability, and unsuitable taste were the identified common limiting factors in the consumption of IVs.

The participatory evaluation at the Nueva Vizcaya State University, also conducted in March 2005, was attended by 57 farmers, 120 consumers, 2 traders, and 18 elementary pupils. The attractive display of the indigenous vegetables which were free from insect damage impressed farmers. Based on visual assessment and field evaluation, the accessions selected were TOT 5472, TOT 4510 and TOT 4868 for amaranth; CLN 2026 D for tomato; AGS 400 vegetable soybean; TOT 1586 for basella; and TOT 6765 for kangkong. Other species selected were bitter gourd (TOT 7098), jute (TOT 6667), snake gourd (TOT 6244), and ridged gourd (TOT 3662). Farmers in Nueva Vizcaya were excited about roselle after hearing what the organizers said about it and wanted to bring the seeds home to plant in their home gardens. For the various amaranths, the participants preferred green varieties with big leaves but most of them chose the green and light green with intermediate-sized leaves. However, one farmer chose the variegated accession (TOT 2337) for its dual purpose as an ornamental and as a vegetable.

Results of the organoleptic evaluation indicated that the accessions preferred by adult consumers, farmers, and pupils were BD 8251 and BD 8272 for amaranth; CLN 2070A and CLN 5915-206-D4-2-0 for tomato; AGS 400 and AGS 292 for vegetable soybean, TOT 1586 for basella, and TOT 6765 for kangkong. Accessions of jute (TOT 6667) and ridged gourd (TOT 3662) were also preferred by the participants. Based on the survey, consumers, and farmers gave more emphasis on nutritional value in the selection of indigenous vegetables for promotion.

Seeds of amaranth accessions, upland kangkong, jute, and snake gourd that were harvested from the first trial were distributed to 11 municipalities of Nueva Vizcaya through their respective municipal agriculturists.

RETA 6067 also attracted the attention of those involved in disaster and relief operations. The San Roque Corporation, which takes care of the new dam that was put up in the area, has designated a 1.5 ha demonstration area for the 50 families of mostly displaced gold panners as well as visitors of the project. They are also setting aside a variety trial area and will adopt the school garden activity of RETA 6067 in the elementary school. The Allied Botanical seed company and AVRDC will provide the technical assistance and seeds of indigenous vegetables.

Vietnam. Farmers of four villages (Tra, Co Phay, Tat, Cang, and Yen) in the highland district of Da Bac participated in the promotion and evaluation of IVs. Promising varieties of *Luffa cylindrica*, *Luffa acutangula*, *Trichosanthes cucumerina, Abelmoschus esculentus, Trichosanthes cucumerina*, and vegetable sweet potato (*Ipomoea batatas*) were identified.

Through linkage with local extension workers, technical assistance was provided to farmers who cultivated the released IV varieties. Two varieties of *Luffa aegyptiaca*, two *Luffa acutangula*, one *Trichosanthes cucumerina*, four *Abelmoschus esculentus*, two vegetable sweet potatoes, and one *Moringa oleifera* were promoted as promising varieties for production in four villages (Tra, Cophay, Tat, Cang, and Yen) in the highland district.

Women training on home gardening schemes, seed production, conservation, and nutrition

In-country training was held to enhance the capacity of women members of rural households in home gardening, seed production, conservation, and nutrition. The training course was designed following the Farmers' Field School (FFS) model. This model specifically promotes a philosophy of 'learning by doing.' Exchange of knowledge between the trainers and the participants was encouraged. In this way, the project also was able to document indigenous knowledge and practices related to the use of indigenous vegetables handed down by the old folks to the younger generation parents.

At least 12 groups or a total of 363 persons were trained comprising of 308 women and 55 men (Table 3).

Table 3. Summary of the in-country training for women on home gardening schemes, seed production, and nutrition conducted through RETA 6067

Country	Number of participants		
	Female	Male	Total
Cambodia	25	6	31
	30	10	40
	58	7	65
Indonesia	10		10
Lao PDR	32		32
	29	2	31
Philippines	23	5	28
	23	15	38
	17	3	20
	35	1	36
	26	6	32
Vietnam			Not reported
Total			363

Cambodia. Three-day sessions of in-country training were conducted twice in April 2005. The director and two other staff members of the National Nutrition Program under the Ministry of Health of Cambodia served as resource persons on the aspects of food and nutrition. In addition, a member of the Philippine IV Team acted as facilitator. The first session was attended by 31 participants consisting of 25 female and 6 male villagers, while the second session had 40 participants, 30 female and 10 male. The 71 participants came from seven villages, namely, Yorkbata Village, Rotieng Village Preak Themey, Don Sor, Phom Thom, Banthey Dek, and Korki. They represented 40 farmers or housekeepers, 30 teachers, and one extension worker.

At the end of the training, five kinds of indigenous vegetable seeds were distributed to the participants for them to grow in their home gardens. The indigenous vegetables consisted of local collections of green amaranth, long purple eggplant, green mustard, and pak-choi. Seeds of a table-type tomato derived from AVRDC CLN 1462 A were also given.

Preliminary evaluation showed that the participants gained new knowledge of indigenous vegetables and the importance of each of the different indigenous vegetable species. They obtained information on how and where to grow the seeds and conserve them; they learned how to grow them in home gardens and utilize them as a food source rich in vitamins and minerals. After the training, the participants expressed the need to promote the use of indigenous vegetables in the family households and to consider them as essential food for the family, especially the children.

To the Cambodians, okra and jute were new crops that could be added to their meals. The participants were not familiar with these vegetables and their uses. During the training, they realized that the jute they see growing as weeds along the Mekong river banks and being grazed by buffaloes and cows could be cooked and eaten.

The third in-country training held at the Kbal Koh Research Station in August 2005 was attended by 65 participants from six villages (Prek Thmey, Rotieng, Dounsor, Ta Reap, York Barth, and Banthey Dek). Students from the National Agricultural School, Kampong Cham who were doing a three-month practicum on germplasm management (collecting, characterization, regeneration, and documentation) and seed production also joined the training course. The participants listed the following as the most important indigenous vegetables: kangkong, wax gourd, sweet or hoary basil, papaya, branching onion, lemon grass, pumpkin, ivy gourd, tomato, and banana. During the cooking session, the participants prepared ‘Somlor Malhur Khmer,’ ‘Charbouk’ (mixed fried vegetables), and ‘Kapik Parve Soup.’

Among the participants, 16 out of 65 had home gardens with lemon grass, eggplant, ivy gourd and chili as the common indigenous vegetable. The participants were not familiar with roselle, okra, and jute. Participants preferred the broad-leaf type kangkong over the bamboo-leaf type, which according to the participants had smaller harder stems and shorter internodes compared to the broad-leaf type. Long-angled luffa was preferred over the shorter smooth luffa. In the case of *Moringa*, Cambodians are only familiar with eating its leaves.

Participants shared information on indigenous vegetables. To preserve musk melon for a long period of time, young fruits are soaked in 10 liters of water and 2.5 kg of salt overnight and then dried under the sun the following day. The following night, the same batch of melons is soaked again. The cycle is repeated 3–4 times. Some species are thought to have medicinal value. Young unpeeled banana fruits are sliced thinly and dried under the sun. The dried banana slices are ground into powder and kept in a bottle. One tablespoon of banana is taken before eating, followed by a glass of water. Young leaves of lemon grass help injured chicken heal when the leaves are tied around the injury. Eating the leaves of ivy gourd may make people sleep soundly. Wax gourd is good to eat especially during the hot and dry season. It makes the body feel cool, energetic, and makes people easily fall asleep. *Amaranthus* root concoction with water may ease up aching joints and muscles. Amaranth stem water extract keeps the natural color of cooked vegetables.

Seeds of indigenous vegetables from the local collection were provided to the participants. The women's training in Cambodia was aired over two TV channels during the evening news telecast.

Indonesia. Four groups of women with 10 members in each group have been trained for cultural practices, seed production and processing, and management for small-scale home industry (27 June 2005). Participants learned food processing; received information guides on soybean, amaranth, and lima beans; and were provided soybean and amaranth seeds to plant in their home garden.

Lao PDR. Two batches of women attended the three-day in-country trainings conducted in September 2005. A staff of the National Nutrition Program under the Ministry of Public Health of Lao PDR served as a resource person on the aspects of food and nutrition in Lao PDR. Three facilitators from the Thai IV Team were also invited to take part on the topic of indigenous vegetables and their role in the nutritional security of households, setting up an indigenous vegetable home garden, seed production, simple and practical ways of storing seeds of indigenous vegetables, and cooking methods to reduce loss of vitamins and minerals. Practices in other countries, cultural management and diversity of indigenous vegetables in Southeast Asia were also discussed. The first batch consisted of 32 women participants from seven villages, while the second batch had 31 participants with 29 females and two males from four villages. Among 63 participants, there were 22 farmers, 25 parents of students, 9 teachers, 3 students, and 4 technicians of the Hat Dok Keo Horticultural Research Center.

Dr. Phengdy of the Ministry of Health cited in her lecture that 59% of the mortality in Lao children (0–5 years old) was associated with malnutrition. Thirty percent of Lao women of childbearing age and 46% of children below five years old suffer from iron-deficiency anemia. About 46% of the Lao population suffer from vitamin A deficiency. She shared with the participants her observation on the practice of Lao women in cooking leafy indigenous vegetables, boiling them mainly in water. She pointed out that such manner of cooking will not maximize the availability of vitamin A in the food preparation. Therefore, in the national program, they are emphasizing that leafy vegetables also be cooked with oil to make vitamin A readily available to the body.

From the assessment at the end of each batch, it was found that the participants gained new knowledge of indigenous vegetables and learned the importance of the different indigenous vegetable species not only as a source of food, but mainly as a source of vitamins and essential minerals. Knowledge of the participants also increased in regard to treating vegetables during cooking to keep the vitamins and minerals from unexpected losses, such as cooking green vegetables with oil to make more vitamin A in food available. The participants showed interest in home gardening and planting these indigenous vegetables in the home garden.

Philippines. In-country training was provided to three batches of women in Bay, Laguna. The 1st batch with 28 participants was conducted in Tranca Elementary School in January; the 2nd batch with 38 participants in Paciano Rizal Elementary School in February, and the 3rd batch with 20 participants at the Barangay Hall of Masaya in Bay, Laguna in May. The training kit for the in-country training comprised of three modules: Module A—Indigenous vegetables and their role in household nutritional security, Module B—Setting up an IV home garden and Module C—Food preparation of IVs. The participants in the three in-country trainings developed a total of 19 IV recipes.

Another two batches (4th and 5th) were given training in October and November 2005. The fourth batch was trained at BPI-LBNCRDC with 36 participants, and the fifth batch was trained at the FAITH (Food Always in the Home) Training Center and at BPI-LBNCRDC in November with 32 participants. A total of 14 recipes using indigenous vegetables were developed during the trainings and are being compiled into a recipe booklet for publication.

After the in-country training, one of the participants led the establishment of a community garden in her neighborhood. Since then they have been growing indigenous vegetables with the technical assistance of the Philippine IV Team. A nutritionist and dietician from the University Health Service of the University of the

Philippines Los Baños established an indigenous vegetable garden in the vacant lot of the hospital to provide clean and safe vegetables to the patients. Seeds brought home by the participants were welcomed by family members as they can now have free vegetables from their garden. Local government officials who were invited as guests were impressed and promised to take a look at the possibility of putting up community indigenous vegetable gardens.

Radio broadcasts about the project were very effective. After the project was featured in a 15-minute segment of a radio program, the radio station was inundated with phone calls from listeners inquiring about sources of indigenous vegetable seeds.

Vietnam. Women farmers of Tra, Co Phay, Tat, Cang, Yen, and Tu Ly town suburbs of four villages in Da Bac district were trained on indigenous vegetable cultivation and indigenous vegetable product processing.

Pilot school gardens

The activity is envisioned to lead to the institutionalization of the conservation and utilization of indigenous vegetables in the school garden curriculum of elementary schools**.** Instead of the planned three countries (Bangladesh, Philippines, and Thailand), six countries are now participating in the pilot school garden project. Cambodia indicated interest in the pilot school garden and would like to propose a project later on school gardens to be supported by the government. RETA 6067 provided them experience on school gardens and the data on its effectiveness. Lao PDR also indicated interest because they believe that the school garden will play a very important role in promoting vegetable utilization. In a meeting in December 2004, a school garden project was also proposed for Malaysia.

Philippines. Different indigenous vegetables were raised and harvested in the school gardens from January to April 2005. Planting was stopped in May to fallow the area. Reestablishment of the pilot gardens was done in June 2005 at the start of the school year. Seventeen species of different indigenous vegetables were planted in both pilot school gardens in Tranca and Paciano Rizal in the latter part of June 2005. These were upland kangkong, amaranth, jute, cowpea, vegetable soybean, hot pepper, eggplant, okra, pole sitao, bottle gourd, bitter gourd, basella, snake gourd, roselle, tomato, ridged gourd, and sweet potato.

A follow-up orientation seminar for Grades 5 and 6 teachers and pupils of both schools was held. They were given an overview of RETA 6067 project, their role in the project's activities, and the inclusion of the project in the 'Edukasyon Pantahanan at Pangkabuhayan Curriculum' (Home Economics).

The pilot gardens were monitored regularly and cultural maintenance was done, whenever necessary. Crop rotation was practiced after each harvest. A total of 90.55 kg and 43.60 kg of fresh indigenous vegetables were harvested in Tranca and Paciano Rizal, respectively. The entire harvests were divided and distributed to the Grade V and VI pupils of the two schools. The parents were asked to cook and serve the vegetables during meals.

A second assessment of child data was conducted halfway through the project in August 2005. A total of 219 pupils from Grades V and VI were interviewed and their hemoglobin counts taken. It was observed that most of the pupils are now aware of the different indigenous vegetables and their hemoglobin counts improved as compared to the initial assessment.

Seed distribution

Seed distribution remains a major function of the Genetic Resources and Seed Unit of AVRDC. Seeds that go out of the center pass through GRSU for monitoring and quarantine purposes. In 2005, a total of 18,704 seed packets were distributed (Table 4). About 30% were germplasm accessions of which half went to eight countries participating in the ADB-funded project RETA 6067 'Promoting Utilization of Indigenous Vegetables for Improved Nutrition of Resource-Poor Households in Asia' (Table 5).

Table 4. Recipients of germplasm from AVRDC in 2005

Recipient	Number of samples	Total
External		18,181
Korea	3,691	
Philippines	3,416	
India	1,433	
Thailand	1,243	
USA	1,061	
Vietnam	726	
China	546	
Indonesia	455	
Taiwan	384	
Cambodia	325	
Others (71)[a]	4,901	
Regional Center/Program		253
ARC	65	
RCA	188	
Internal		270
Bacteriology	30	
Bulb Alliums Unit	1	
Crop and Ecosystem Management	5	
Crucifer Unit	28	
Entomology	1	
International Cooperation Office	2	
Legume Unit	9	
Mycology	98	
Pepper Unit	5	
Physiology	3	
Virology	88	
Total		18,704

[a1] Afghanistan, Australia, Azerbaijan, Bangladesh, Barbados, Belgium, Belize, Benin, Bolivia, Botswana, Burkina Faso, Cameroon, Canada, Congo, Cote d'Ivoire, Denmark, Ecuador, Egypt, Ethiopia, Fiji, France, Germany, Ghana, Guatemala, Honduras, Hong Kong, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Korea (Democratic People's Republic), Lao People's Democratic Republic, Lesotho, Malawi, Malaysia, Mali, Martinique, Mauritania, Mauritius, Mongolia, Myanmar, Namibia, Nepal, Netherlands, Nicaragua, Nigeria, Northern Mariana Islands, Pakistan, Papua Mew Guinea, Saudi Arabia, Seychelles, Sierra Leone, Singapore, South Africa, Spain, Sri Lanka, Sudan, Tanzania, Tonga, Turkey, Turkmenistan, Uganda, United Kingdom, Uruguay, Uzbekistan, Venezuela, Zambia, and Zimbabwe.

Table 5. Recipients of germplasm accessions from the Genetic Resources and Seed Unit in 2004

Classification	No.	Number of samples	Purpose
AVRDC-ARC	1	25	Research, evaluation for pod borer resistance
AVRDC-RCA	1	4	Trial
Internal seed distribution	11	270	Trials, production under organic conditions, screening for resistance to insect pests and diseases, flood tolerance
Genebank	2	493	Duplicate storage, expansion of genebank collections
Government organization	33	2,979	ADB RETA 6067—IV garden, observation trial, screening for disease resistance
Non-government organization	4	88	Research and trial
Private company	2	6	Experiment and observation
Private individual	3	37	Research and observation trial
Seed company	16	708	Observation trial, disease screening, to increase germplasm diversity
University	27	1,104	Disease resistance screening, lipid content analysis, biochemical and nutritional studies
Total		5,714	

Contact: Liwayway Engle

Development of Tomato yellow leaf curl virus-resistant transgenic tomato

Tomato yellow leaf curl virus (TYLCV) is a plant pathogen that belongs to the family Geminiviridae, which affects tomato production in tropical and subtropical areas. Management of TYLCV in tomato production is very difficult and expensive; options are limited. Several host plant resistance sources to TYLCV have been identified, but to develop TYLCV-resistant varieties with traditional breeding methods will take at least 3–5 years. The level of resistance varies with different regions and some of the resistance sources have been overcome and/or broken down by new strains of TYLCV. Genetic transformation and pathogen-derived resistance have been proven to be effective against virus diseases, and genetically modified tomato might be able to provide another alternative to combat the infection of TYLCV and complement traditional breeding. The objective of this study is to genetically transform tomato with transformation vectors containing various components of TYLCV genome and evaluate the levels of resistance of transgenic tomatoes against TYLCV.

Thirteen different gene fragments of TYLCV including C1, C2, C3, C4, V1, and V2 regions of TYLCV genome were cloned into the *Agrobacterium tumefaciens* binary vector, pTWBI, or pGA482G. These 13 constructs consisted of six anti-sense gene fragments (four of C1 and two of C2), and seven fragments were linked with silencer DNA (Figures 8 and 9). The vectors contain kanamycin resistance gene, which was used as a selection marker for transgenic plants. The binary vector with the respective gene fragment was transformed into *Agrobacterium tumefaciens* C58 or LBA4404 by $CaCl_2$ chemically-based direct transformation.

Seeds of tomato (*Lycopersicon esculentum*) line CLN1558A were surface-sterilized for 40 seconds in 70% ethyl alcohol and 10 minutes in 20% domestic bleach solution (Clorox, containing 5.25% sodium hypochlorite) with 0.1% of Tween-20. Seeds were washed with sterilized reverse osmosis (RO) water three times after sterilization with the ethyl alcohol solution and four times after the bleach solution. Sterilized seeds were cultured on a 1/2 MS solid medium and germinated under 16L/8D photoperiod at

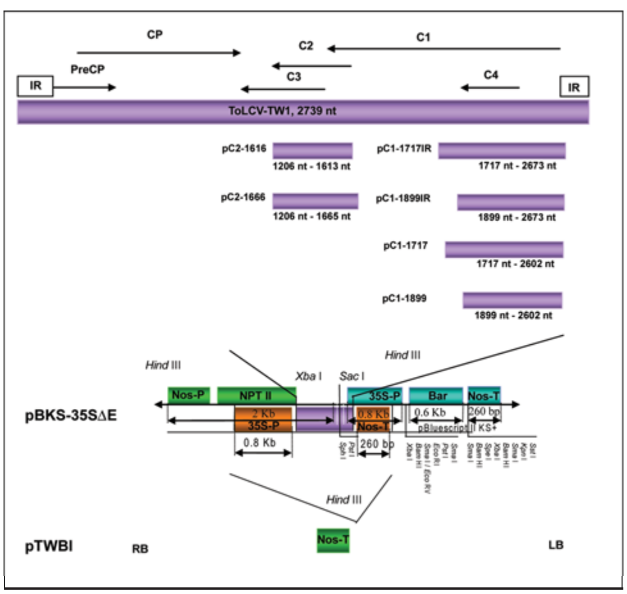


Figure 8. Map of the anti-sense constructs pC1-1717, pC1-1717IR, pC1-1899, pC1-1899IR, pC2-1616, and pC2-1666.

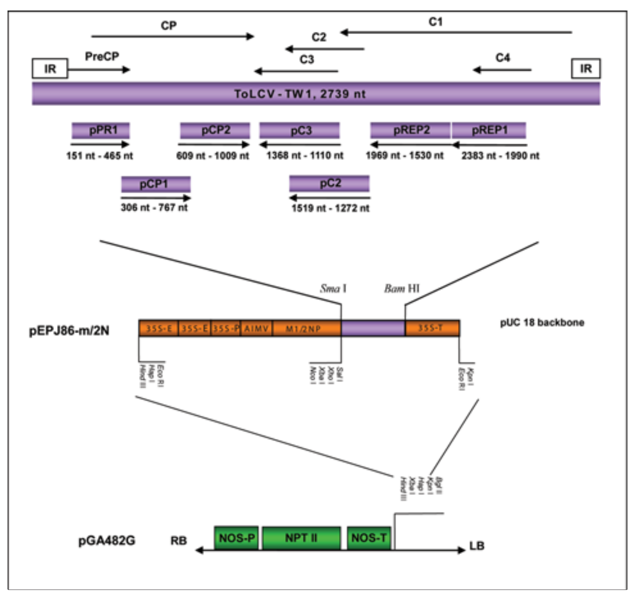


Figure 9. Map of the constructs of virus gene fragments linked with silencer DNA.

25.5°C. Cotyledonary leaves were used as transformation materials seven days after germination. Explants were precultured on solid MS medium containing 2 mg/l BA (6-benzylaminopurine) and 0.5 mg/l IAA (indole-3-acetic acid) for two days before agroinfection.

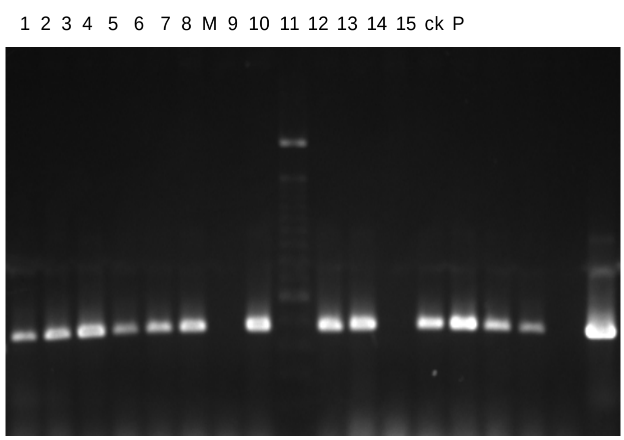
Agrobacterium with the respective transformation vector was cultured in solid YEP medium containing 50 mg/l kanamycin and 25 mg/l streptomycin for 2–3 days at 28.5°C. Single colony of *Agrobacterium* strain was inoculated and cultured in YEP broth medium supplemented with 50 mg/l kanamycin and 25 mg/l streptomycin. Bacterium was cultured at 28.5°C for 24 hours with continuous shaking at 135 rpm. Before agroinfection, bacterial culture was supplemented with 200 µM acetosyringone (AS) and then cultured under the same condition for another four hours to enhance the infection. The bacterial culture was centrifuged for 5 min at 6000 rpm. The bacterial pellet was resuspended in liquid MS medium and was adjusted to OD_{600nm} = 0.5 as an agroinfection medium. Before agroinfection, 200 µM AS was added to the agroinfection medium.

Placed in the agroinfection medium were two-day-old explants which were continuously shaken for 5 min to facilitate the infection. Infected explants were transferred to a nonselective MS mediun containing 2 mg/l BA, 0.5 mg/l IAA, and 200 µMAS for co-cultivation two days at 25.5°C under 16L/8D photoperiod. After cocultivation, explants were washed with 500 mg/l carbenecillin and 100 mg/l cefotaxime for 10 minutes to kill excessive *Agrobacterium*. Explants were then transferred to a selective MS medium containing 2 mg/l BA, 0.5 mg/l IAA, 50 mg/l kanamycin, 500 mg/l carbenecillin, and 50 mg/l cefotaxime under the same growth condition. Subculturing was done every two weeks on the same growth medium and condition until calli are formed. Explants were washed with 500 mg/l carbenecillin and 100 mg/l cefotaxime for five minutes before subculture to eliminate the remaining *Agrobacterium*.

Shoot buds were cut from cotyledons and cultured in solid MS medium containing 0.25 mg/l BA, 0.25 mg/l GA_3 (gibberellin A_3), 50 mg/l kanamycin, 250 mg/l carbenecillin, and 50 mg/l cefotaxime for shoot elongation under the same growth condition. Shoots about 3 to 4 cm tall were then transferred to solid MS medium containing 0.15 mg/l NAA (α-naphthalene acetic acid), 25 mg/l kanamycin, 100 mg/l carbenecillin, and 50 mg/l cefotaxime for rooting. After rooting, regenerated plants were grown in the transgenic greenhouse for molecular analysis and subsequent seed production.

The transformed tomato plants were confirmed by polymerase chain reaction (PCR). Plant genomic DNA isolation from young leaves followed the standard hexadecyltrimethyl ammonium bromide (CTAB) method. Transgene in transgenic tomato was confirmed by PCR with specific primers respective to the gene construct. The PCR reactions were carried out in a total volume of 25 µL comprising 50 ng genomic DNA, 50 mM KCl, 10 mM Tris-HCl (pH8.3), 1.5 mM $MgCl_2$, 200 µM dNTPs, 1.25 U of Tag DNA polymerase, and 25 pmole of each primer, under the following conditions: 2 cycles of 1 min at 94°C, 1 min at 55°C, 2 min at 72 °C, then 35 cycles of 30 sec at 94°C, 30 sec at 55°C, 1 min at 72°C, elongation at 72°C for 5 min, and hold at 4°C. The PCR products were fractionated by 1.5% agarose gel electrophoresis.

There have been 156 regenerated tomato plants and 107 of them were confirmed to be transgenic by PCR analysis (Figure 10). The transgenic tomatoes consisted of 12 different gene constructs (Table 6). These R_0 transgenic plants were self-pollinated to harvest R_1 seeds for further resistance evaluation against TYLCV and molecular analysis.



Lane 1~15 = putative transgenic tomatoes; P = positive plasmid control; ck = non-transgenic tomato; M = molecular weight marker

Figure 10. PCR analysis of transgenic tomatoes with *TyLCV CP1T gene*.

Table 6. PCR confirmation of R_0 transgenic tomatoes

Plasmid	Regenerated plants (no.)	Transgenic plants (no.)
C2 1666-1206	16	11
C2 1616-1206	1	1
C1 2627-1899	12	10
C1 2601-1899	37	35
C1 2627-1717	10	7
C1 2601-1717	0	0
REP1T	1	0
REP2T	22	1
CP1T	16	13
CP2T	20	10
PR1T	5	4
C2T	16	15
Total	156	107

To determine the level of resistance of transgenic tomatoes against TYLCV, 17 of the 107 confirmed transgenic tomatoes have been grafted onto TYLCV-diseased tomato scions. Six weeks after the grafting and virus inoculation, the presence of TYLCV was detected by PCR with primers respective to specific gene constructs. Twelve of the 17 transgenic tomatoes were confirmed to be resistant so far (Table 7).

Table 7. Resistance assay of R_O transgenic tomatoes

Plasmid	Tested R_0 (no.)	R_0 with resistance (no.)
C2 1666-1206	4	1
REP1T	5	4
REP2T	8	7
Total	17	12

Development of molecular markers for bruchid and Mungbean yellow mosaic virus resistance genes with mungbean recombinant inbred lines

Bruchid infestation and Mungbean yellow mosaic virus (MYMV) infection are two of the major productivity constraints and have created severe damage to mungbean production in South and Southeast Asia. Development of molecular markers for respective resistance genes against bruchid and MYMV can facilitate the breeding to incorporate and pyramid the resistance genes into commercial varieties. To develop molecular marker for bruchid and MYMV resistance genes, a set of recombinant inbred lines (RILs) had been generated to complement this approach. The F_{11} RILs, derived from the cross between NM92 (an MYMV-resistant variety) and TC 1966 (a bruchid-resistant wild mungbean species), demonstrated a random combination of various traits inherited from both parents, including resistance to bruchid and MYMV. The homozygosity within each individual line makes maintenance of the whole population possible and easy. The population can thus be employed as a mapping population and allow screening for different traits at various locations. The objective of this study is to develop molecular markers for bruchid and MYMV resistance genes and verify their validity on the identification of resistant individual plants.

Through bulked segregant analysis of two resistant (0% damage) and two susceptible (80–90% damage) RILs, 10 random amplified polymorphic (RAPD) DNA markers associated with mungbean bruchid resistance have been identified. Further efforts have been made to convert these RAPD markers into more consistent and easy-to-use PCR-based marker for reproducible analysis in future application. Three bruchid resistant-linked RAPD fragments, that is, UBC223a7, OPU11a4, and OPW02a4, were excised from 1.5% agarose gel and cloned into the pDrive cloning vector using QIAGEN PCR Cloning kit (QIAGEN Inc.). After confirmation, the inserts of cloned RAPD fragment were sequenced using an ABI 373 DNA Sequencer. Primers were then designed based on sequence embracing the fragments. Afterward, various restriction enzymes were tested to generate suitable primer sets and enzyme combinations for cleaved amplified polymorphic (CAP) markers. Sequences for abovementioned RAPDs have compatible size as produced by RAPD analysis. CAP analysis with W02a4 primer set and *Hae*III enzyme identified two codominant markers for bruchid resistance gene (Figure 11). After testing on 200 RILs, this marker was shown to be reproducible and more closely linked with major gene of bruchid resistance as indicated by higher RSq value (Table 8).

Amplified fragment length polymorphism (AFLP) analysis has also been conducted with 84 RILs for the identification of molecular markers for MYMV resistance gene. A total of 201 AFLP fragments were obtained employing 30 *Pst*I/*Mse*I primer sets. Correlation analysis was performed between total markers (102 RAPDs, 12 CAPs, and 201 AFLPs) and bruchid or MYMV reactions by QGene program. The results indicated two CAP markers highly associated

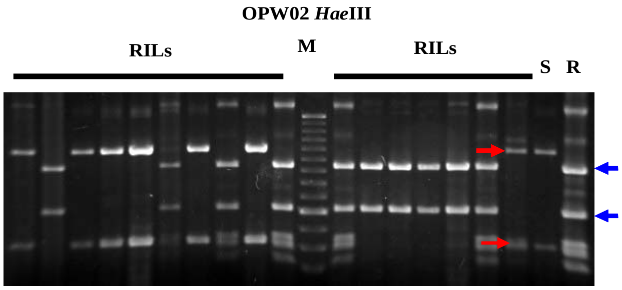


Figure 11. Confirmation of codominant CAP markers associated with bruchid resistance gene.

Table 8. Analysis of molecular markers associated with bruchid resistance by QGene program

Marker	R^2	*P*-value	Bruchid damage-NM92 (%)[a]	Bruchid damage-TC1966 (%)[b]	Additive effect
w02s11	0.9238	0	97.09	7.09	44.99
w02s10	0.9238	0	97.09	7.09	44.99
w02s4	0.9121	0	95.95	6.13	44.91
w02s3	0.9121	0	95.95	6.13	44.91
w02s9	0.9061	0	95.83	6.30	44.76
w02s2	0.8955	0	94.73	5.28	44.72
m1pgg256	0.8503	0	94.69	7.97	43.36
w02a4	0.7799	0	92.38	8.91	41.73

[a] Mean value of of bruchid damage percentage on RILs demonstrating homozygous genotype for the specific marker as that on the resistant parent NM92.

[b] Mean value of of bruchid damage percentage on RILs demonstrating homozygous genotype for the specific marker as that on the susceptible parent TC1966.

with bruchid resistance and three AFLP markers associated with MYMV resistance (Table 9). Three MYMV related markers were generated by same m4-pcc primer combination. Linkage maps of the above-mentioned molecular markers have also been constructed with the MapMaker program. The above studies suggest that two genetic regions from both parental sources contribute to MYMV resistance (Table 9). In addition to the MYMV-tolerant parent NM92 (linkage 4), the susceptible TC1966 also contributes to MYMV resistance (linkage 7). This corresponds with the phenotype data which reveals that about one-third of the 200 RILs performed better than tolerant parent NM92. The data also indicate the clustering of bruchid and MYMV related genes at linkage 4. At present, a combination of 125 molecular markers has successfully been mapped into 10 linkage groups by MapMaker 3.0, which covered for about 752 cM of the mungbean genome.

Table 9. Analysis of molecular markers associated with MYMV resistance by QGene program

Marker	R^2	*P*-value	Bruchid damage-NM92 (%)[a]	Bruchid damage-TC1966 (%)[b]	Additive effect
Linkage group 4					
m4pcc585	0.3287	0	4.98	7.09	-1.05
m4pcc579	0.3267	0	5.06	7.24	-1.08
m4pcc417	0.3162	0	5.09	7.25	-1.08
m4pct504	0.3066	0	4.20	6.38	-1.08
m5pca382	0.3022	0	4.93	6.92	-0.99
m1pgg256	0.2764	0	4.99	6.89	-0.95
w02s9	0.2749	0	4.99	6.89	-0.94
w02s10	0.2703	0	4.98	6.85	-0.93
Linkage group 7					
m3pca506	0.2023	0	6.40	4.77	0.81
w02a14	0.1917	0	6.30	4.63	0.83
M13AG686	0.1901	0	6.86	5.21	0.82
w02a10	0.1820	0.0001	6.36	4.79	0.78

[a]Mean value of of bruchid damage percentage on RILs demonstrating homozygous genotype for the specific marker as that on the resistant parent NM92.

[b]Mean value of of bruchid damage percentage on RILs demonstrating homozygous genotype for the specific marker as that on the susceptible parent TC1966.

CAP markers were generated by OPW02 primer sets followed by *Hae*III digestion. S: susceptible parent, NM92; R: resistant parent, TC1966; M: molecular weight marker; red arrow points out the CAP markers associated with susceptibility, and the blue arrow, resistance of bruchid.

Genetic diversity analysis of AVRDC's *Ipomoea* accessions

Water spinach (*Ipomoea aquatica* Forsk.), a member of the Convolvulaceae, is native to Taiwan, Malaysia, and other southeastern Asian countries. Water spinach has been widely cultivated as a vegetable in much of the tropics of the Old World. The cultivation of this species has also been reported from Arabia and western Africa, Egypt, and India. Due to its rapid and prolific growth, however, water spinach has often become weedy even in its native range, in rice paddies, fish ponds, irrigation canals, and other aquatic systems. The objective of this study is to evaluate the molecular phylogenetic relationships of water spinach accessions collected by AVRDC, and understand the genetic diversity of these collections.

A total of 63 randomly selected prominent *Ipomoea* accessions were provided by GRSU of AVRDC (Table 10). Fifty-one of the 63 accessions were obtained from southeastern Asia. The remainder were collected from Taiwan (8), Bangladesh (3), China (1), and Japan (1). Five seeds per accession were directly sown into 10-cm diameter pots with growth medium in the greenhouse. DNA was extracted from the young leaves using the CTAB method with minor modifications. Young leaf tissues (0.5 g) were ground in liquid nitrogen and mixed with 5 ml CTAB buffer (3% CTAB, 1.4 M NaCl, 0.2% β-mercaptoethanol, 20 mM EDTA pH8.0, 100 mM Tris-HCl pH8.0), which had been incubated at 65°C for 60 min. Samples were extracted with equal volume of chloroform/isoamyl alcohol (24:1 v/v); aqueous phase was then poured out and mixed with 2/3 volume of chilled isopropanol. Precipitated DNA was collected by centrifugation and

Table 10. Analysis of molecular markers associated with bruchid resistance by QGene program

Accession (no.)	Origin[a]	Species	Stem color	Flower color
TOT3593	Vietnam (VN)	*Ipomoea aquatica*	white	white
TOT3594-1	Vietnam (VN)	*Ipomoea aquatica*	light green	white
TOT3594-2	Vietnam (VN)	*Ipomoea aquatica*	light green	white
TOT3590	Vietnam (VN)	*Ipomoea aquatica*	White	white
TOT3973	China (CN)	*Ipomoea aquatica*	white	—[b]
TOT3976	Taiwan (TW)	*Ipomoea aquatica*	light green	white
TOT4031	Vietnam(VN)	*Ipomoea aquatica*	light green	white
TOT4038	Vietnam(VN)	*Ipomoea aquatica*	light green	white
TOT4211	Thailand (TH)	*Ipomoea aquatica*	light green	white
TOT4212	Thailand (TH)	*Ipomoea aquatica*	light green	white
TOT4258	Bangladesh (BD)	*Ipomoea aquatica*	light green	white
TOT4596	Bangladesh (BD)	*Ipomoea aquatica*	light green	white
TOT5465	Thailand (TH)	*Ipomoea aquatica*	red purple	pale pink
TOT5874	Japan (JP)	*Ipomoea aquatica*	light green	white
TOT5875	Taiwan (TW)	*Ipomoea aquatica*	light green	white
TOT5915	Thailand (TH)	*Ipomoea aquatica*	white	white
TOT5916	Thailand (TH)	*Ipomoea aquatica*	light green	white
TOT5917	Thailand (TH)	*Ipomoea aquatica*	light green	white
TOT5981	Taiwan (TW)	*Ipomoea aquatica*	light green	white
TOT6053	Taiwan (TW)	*Ipomoea aquatica*	white	white
TOT6496	Taiwan (TW)	*Ipomoea aquatica*	white	white
TOT6152	Thailand (TH)	*Ipomoea aquatica*	white	white
TOT6153	Thailand (TH)	*Ipomoea aquatica*	white	white
TOT6154	Thailand (TH)	*Ipomoea aquatica*	white	white
TOT6155	Thailand (TH)	*Ipomoea aquatica*	white	white
TOT6157	Thailand (TH)	*Ipomoea aquatica*	red purple	pale pink
TOT6158	Thailand (TH)	*Ipomoea aquatica*	red purple	pale pink
TOT6159	Thailand (TH)	*Ipomoea aquatica*	red purple	—
TOT6160	Thailand (TH)	*Ipomoea aquatica*	red purple	—
TOT6161	Thailand (TH)	*Ipomoea aquatica*	white	—
TOT6162	Thailand (TH)	*Ipomoea aquatica*	white	white
TOT6163	Thailand (TH)	*Ipomoea aquatica*	red purple	—
TOT6164	Thailand (TH)	*Ipomoea aquatica*	white	—
TOT6165	Thailand (TH)	*Ipomoea aquatica*	red purple	—
TOT6166	Thailand (TH)	*Ipomoea aquatica*	red purple	pale pink
TOT6167	Thailand (TH)	*Ipomoea aquatica*	red purple	—
TOT6168	Thailand (TH)	*Ipomoea aquatica*	red purple	pale pink
TOT6169	Thailand (TH)	*Ipomoea aquatica*	red purple	pale pink
TOT6765	Taiwan (TW)	*Ipomoea aquatica*	light green	—
TI00472	Malaysia (MA)	*Ipomoea aquatica*	light green	white

Table 10. Continued

Accession (no.)	Origin[a]	Species	Stem color	Flower color
TI00473	Malaysia (MA)	*Ipomoea aquatica*	light green	white
TOT0049	Malaysia (MA)	*Ipomoea aquatica*	light green	white
TOT0050	Malaysia (MA)	*Ipomoea aquatica*	white	—
TOT0051	Malaysia (MA)	*Ipomoea aquatica*	light green	—
TOT0108	Malaysia (MA)	*Ipomoea aquatica*	green	—
TOT0491	Thailand (TH)	*Ipomoea aquatica*	light green	white
TOT0511	Bangladesh (BD)	*Ipomoea aquatica*	light green	white
TOT1917	Indonesia (ID)	*Ipomoea aquatica*	light green	white
TOT1918	Indonesia (ID)	*Ipomoea aquatica*	light green	white
TOT1919	Indonesia(ID)	*Ipomoea aquatica*	light green	white
TOT1920	Indonesia(ID)	*Ipomoea aquatica*	light green	white
TOT1921	Indonesia(ID)	*Ipomoea aquatica*	light green	white
TOT1922	Indonesia(ID)	*Ipomoea aquatica*	light green	white
TOT1923	Indonesia(ID)	*Ipomoea aquatica*	light green	white
TOT1924	Indonesia(ID)	*Ipomoea aquatica*	light green	white
TOT1925	Indonesia(ID)	*Ipomoea aquatica*	light green	white
TOT1926	Indonesia(ID)	*Ipomoea aquatica*	white	white
TOT1927	Indonesia(ID)	*Ipomoea aquatica*	light green	pale pink
TOT1928	Indonesia(ID)	*Ipomoea aquatica*	light green	pale pink
TOT1929	Indonesia(ID)	*Ipomoea aquatica*	white	pale pink
TOT3512	Lao PDR (LA)	*Ipomoea aquatica*	white	—
TOT3515	Lao PDR (LA)	(*Ipomoea pes-caprae*?)	red purple	—
TOT5943	Taiwan (TW)	*Ipomoea pes-caprae*	light green	—

[a] Parentheses show the designated abbreviation of countries used by GRSU.
[b] Not investigated due to late flowering.

washed with 70% ethanol. DNA was air-dried and resuspended in 400 µl TNE buffer. Later it was treated with RNase A (1 µg/µl) for 30 min at 37°C and purified using 500 µl of equilibrate phenol and 750 µl of chloroform/isoamyl alcohol (24:1 v/v). The purified DNA was reprecipitated from the aqueous phase using chilled ethanol, air-dried, and resuspended in 200 µl TE buffer. DNA concentration was determined by AlphaImage 2000 (Alpha Innotech Cooperation, USA) using 50 ng/µl, 100 ng/µl, and 200 ng/µl λ DNA as standard.

RAPDs reactions were performed in reaction buffer containing 10 mM Tris-HCl (PH8.0), 2.5 mM $MgCl_2$, 50 mM KCl, 0.1 mM each dATP, dCTP, dGTP and dTTP, 0.2 mM primer (Operon and UBC), 0.02 U/µl Taq DNA polymerase, and 0.5 ng/µl of genomic DNA. Reactions were amplified in a total volume of 25 µl overlaid with mineral oil. DNA amplification was performed using an Eppendorf thermal cycler with the following program: one cycle at 94°C for 5 min; 45 cycles at 94°C for 1 min, 37°C for 2 min, and 72°C for 2 min; and one cycle at 72°C for 5 min. PCR products were visualized by electrophoresing 20 µl aliquots on 1.5% agarose gels with 1 × TBE buffer. Gels were stained with ethidium bromide and photographed with a digital camera. Primers were screened for their ability to generate clear and reproducible products (bands). Loci were scored as presence (1) or absence (0) of bands, and characterized by the primer used, followed by the size in base pairs as determined by reference to a 100 bp DNA ladder. Amplifications were replicated at least three times. Dice similarity matrices and the corresponding unweighted pair-group method arithmetic average (UPGMA) with the sequential agglomerative hierarchical non-overlapping (SAHN) phenograms were generated in the NTSYS-pc (v 2.0) program (Exeter Software, Setauket, NY) and analyzed by the method SIMQUAL (similarity for qualitative data) with Jaccard's similarity coefficient.

Thirty-eight primers producing polymorphic and scorable bands with reproducibility were selected for further amplification of DNA from all accessions (Table 11). A total of 253 RAPD fragments were produced, of which 248 (98.02%) were polymorphic

Table 11. List of scorable RAPD bands generated by each primer

Primer no.	Sequence (5'→3')	Mono-[a]	Poly-[b]	Total[c]
OPA-01	CAGGCCCTTC	0	10	10
OPA-14	TCTGTGCTGG	0	2	2
OPA-15	TTCCGAACCC	0	4	4
OPA-17	GACCGCTTGT	0	5	5
OPA-18	AGGTGACCGT	0	7	7
OPA-19	CAAACGTCGG	0	8	8
OPC-08	TGGACCGGTG	0	6	6
OPC-10	TGTCTGGGTG	0	5	5
OPC-11	AAAGCTGCGG	0	4	4
OPE-04	GTGACATGCC	0	5	5
OPF-09	CCAAGCTTCC	1	7	8
OPF-10	GGAAGCTTGG	0	9	9
OPF-14	TGCTGCAGGT	0	9	9
OPG-12	CAGCTCACGA	0	3	3
OPJ-07	CCTCTCGACA	0	13	13
OPK-01	CATTCGAGCC	0	2	2
OPT-02	GGAGAGACTC	1	6	7
OPT-08	AACGGCGACA	1	5	6
OPT-16	GGTGAACGCT	0	8	8
UBC-82	GGGCCCGAGG	0	10	10
UBC-105	CTCGGGTGGG	0	13	13
UBC-112	GCTTGTGAAG	0	3	3
UBC-150	GGAGGCTCTG	0	1	1
UBC-164	CCAAGATGCT	1	5	6
UBC-175	TGGTGCTGAT	1	5	6
UBC-180	GGGCCACGCT	0	13	13
UBC-184	CAAACGGCAC	0	9	9
UBC-247	TACCGACGGA	0	2	2
UBC-514	CGGTTAGACG	0	4	4
UBC-515	GGGGGCCTCA	0	8	8
UBC-518	TGCTGGTCCA	0	2	2
UBC-519	ACCGGACACT	0	9	9
UBC-521	CCGCCCCACT	0	6	6
UBC-523	ACAGGCAGAC	0	8	8
UBC-525	GCTGGTTGGA	0	6	6
UBC-526	AACGGGCACC	0	10	10
UBC-530	AATAACCGCC	0	12	12
UBC-535	CCACCAACAG	0	4	4
Total		5	248	253

[a] Number of total bands/per primer within all 63 accessions.

[b] Number of monomorphic bands/per primer within all 63 accessions.

[c] Number of polymorphic bands/per primer within all 63 accessions.

and only 1.98% were common bands. The scorable band size ranged from 250 to 2150 bp. Six clusters were identified from the UPGMA dendrogram (Figure 12). Low similarity was found between *Ipomoea aquatica* and *Ipomoea pes-caprae* with the Jaccard's similarity coefficient of 0.134. At a similarity coefficient value of 0.744, two major groups were evident in UPGMA dendrogram. The first major group contains cluster I, II, III, and IV. The accession TOT3593, TOT3973, TOT1921, and TOT3512 were consistently assigned to I cluster with a genetic distances (GD) of 0.765 and 0.822 between them. This result suggests a similar genetic base for this entire group. The GD range of Cluster II is from 0.813 to 0.966, cluster III is from 0.783 to 0.862, and cluster IV is from 0.723 to 0.769. The lowest GD were observed among the TOT3594-1 and TOT3594-2 (GD: G0.965), since these two samples belong to the same accession TOT3594. The high genetic diversity among plants from the same accession of *Ipomoea aquatica* suggests that the occasional outcrossing of this species do not necessarily generate a high degree of genetic diversity.

The second major group contains cluster V. Similarity levels between *Ipomoea aquatica* accessions ranged from 0.744 to 0.965. This suggested that the water spinach grown in several countries has a narrow genetic background. The dendrogram shows that the genetic diversity of *Ipomoea aquatica* has high correlation with geographical origin. Accessions collected from Thailand are grouped in clusters IV and V. Some accessions collected from Thailand and Indonesia are grouped with Malaysia, Bangladesh, and Taiwan in cluster II. In accordance with this dendrogram, it confirms that the hybridization system of *Ipomoea aquatica* is primarily autogamous with occasional outcrossing. The accessions MA-TOT0108 and TH-TOT0491 collected from Malaysia and Thailand, respectively, were diverted into the same group with GD value of 0.958 suggesting that these should be in the same line and were possibly an introduction from the other country.

The RAPD data of TW-TOT5943 and LA-TOT3515 showed that the largest GD value compared to the rest of the accessions (GD : G0.234) are grouped in cluster VI. These results indicate that the TW-TOT5943 has high genetic correlation with LA-TOT3515 and suggest that TW-TOT5943 should be classified into *Ipomoea pes-caprae.* The high similarity of their morphology also supported this inference. Their leaves are distinctly different from those of *Ipomoea aquatica* whose leaves have notches at the apex, creating two equal lobes, rounded and without teeth, but leaves of *Ipomoea aquatica* are ovate to elliptic with an acute tip and a cordate or sagittate base.

The morphological characters investigated were flower color, stem color, and leaf shape. According to the RAPD data, all accessions divided into six main groups with morphological character of red purple stem such as, TOT6157, TOT6159, TOT6165, TOT6166, TOT6167, TOT6168, while TOT6169 were divided into five groups (V). Therefore, stem color had high correlation with genetic relationship while other morphological characters had low correlation.

This results show that RAPD analysis is a useful tool for *Ipomoea* germplasm diversity analysis and genotypic identification. It can provide base information on genetic relationships among these *Ipomoea* accessions. The molecular information on genetic diversity can assist on the understanding of the collection and the identification of areas where more collection and germplasm preservation of *Ipomoea aquatica* should be emphasized.

Contact: Chien-an Liu

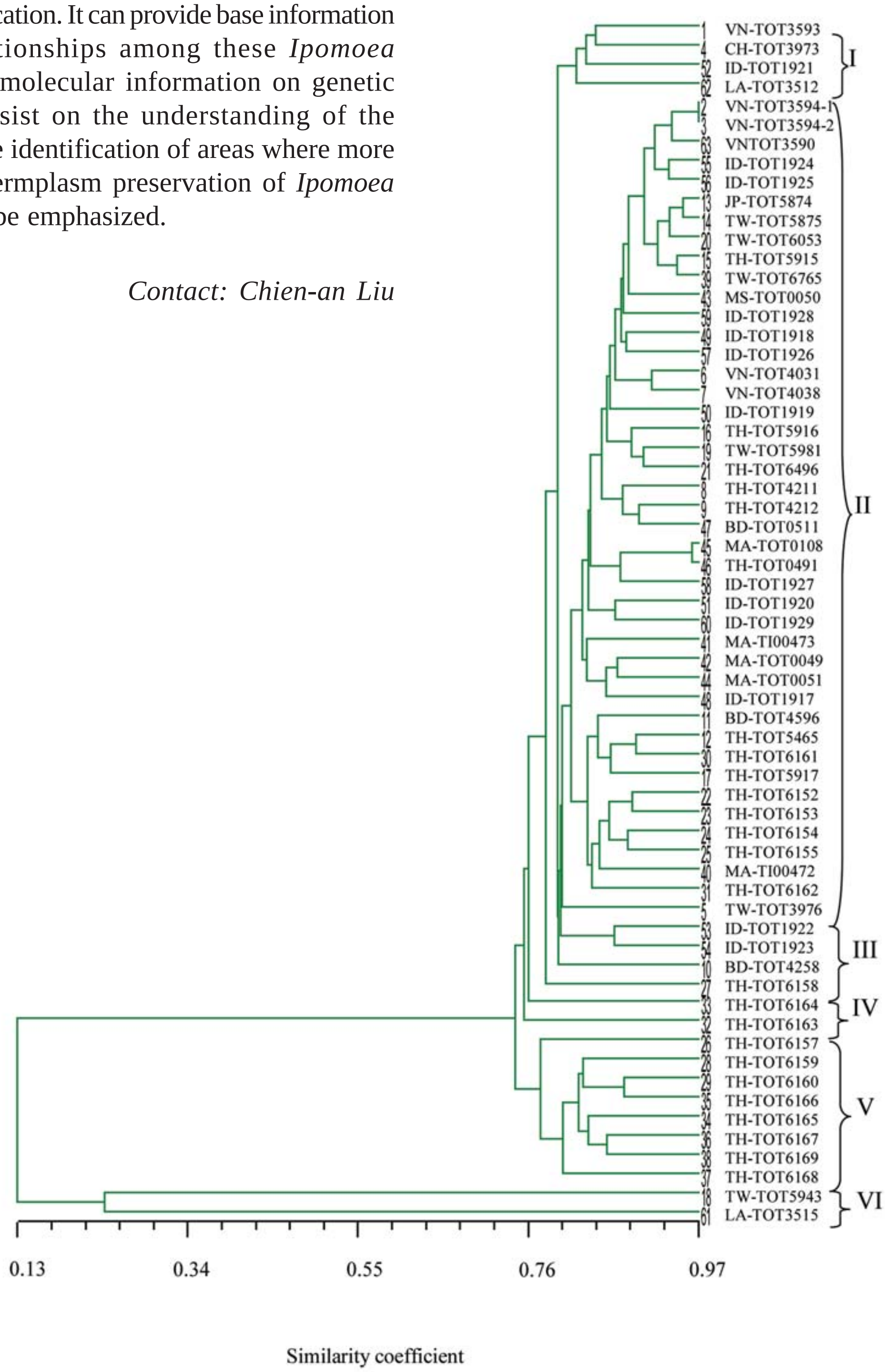


Figure 12. Dendrogram showing the relationships and cluster analysis among 63 water spinach accessions revealed by Jaccard's similarity coefficient based on 253 RAPD bands.

Crucifer

High-yielding broccoli for the hot-wet season

Broccoli is increasingly popular because of its flavor, nutritional qualities, and high glucosinolate content associated with lower cancer risk. The crop is best adapted to dry and cool environments. 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. However, broccoli prices increase dramatically in the off-season. Thus, varieties better adapted to the hot-wet summer could enable off-season broccoli production and increase farmer income.

AVRDC conducted an advanced yield trial (AYT) and an evaluation trial (ET) which were conducted on three dates during summer 2005 to identify summer adapted broccoli varieties. The AYT included nine outstanding entries selected from the 2004 summer trials and a check variety Satomidori (Table 12). Seed of AYT entries were sown in the greenhouse on 29 April, 15 June, and 28 July, and transplanted to the field on 24 May, 12 July, and 8 September 2005, respectively. The first planting was not harvested. The second planting was harvested 6–22 September, and the third planting was harvested from 19 October–4 November. Plots consisted of two 150-cm-wide and 5-m-long raised beds. Plants were grown in double rows with 50 cm between rows and 50 cm between plants within rows (total of 40 plants per plot). Entries were arranged according to a randomized complete block design (RCBD) with three replications. Beds were mulched with rice straw, and pesticides were applied weekly to manage insects and diseases. Yield and days from transplanting to harvest were recorded for each entry. The chlorophyll content index of mature leaves and heads was measured at harvest by a chlorophyll meter (Field Scout CM 1000 of Spectrum Technologies, Inc.) under natural sunlight. The ET included 102, 119, and 149 entries that were sown on 29 April, 15 June, and 28 July, and transplanted to the field on 24 May, 13 July, and 8 September 2005. Entries planted on dates two and three were harvested 6–22 July and 19 October–7 November. Plots were the same as the AYT except that one bed was used instead of two, and entries were nonreplicated.

Table 12. Maturity, yield, and mean head weight of AYT broccoli entries evaluated over two plantings, AVRDC, summer 2005[a]

		Second planting (I)			Third planting (III)		
Entry	Company	Maturity (DAT)[b]	Yield (t/ha)	Head weight (g)	Maturity (DAT)	Yield (t/ha)	Head weight (g)
Satomidori	Nozaki	57 ab	3.0 bc	130 bc	50 b	11.2 c	421 c
SF1202	Singflow	58 ab	3.8 abc	178 ab	48 c	13.3 ab	498 ab
CNB-45	Chingnong	61 a	3.4 bc	173 ab	46 d	9.7 d	363 d
CNB-50	Chingnong	56 b	3.1 bc	145 b	47 cd	9.2 de	346 de
DG473	Denggie	58 ab	4.1 ab	154 ab	48 bc	11.2 c	420 c
SF1203	Singflow	58 ab	4.1 ab	177 ab	46 d	12.3 bc	462 bc
DG134	Denggie	56 b	3.3 bc	127 bc	48 c	12.1 bc	455 bc
SF1208	Singflow	59 ab	5.4 a	206 a	48 bc	13.7 a	512 a
RN0413	Raynong	59 ab	2.2 c	127 bc	53 a	11.5 c	430 c
RN0425	Raynong	56 b	0.5 d	77 c	43 e	8.1 e	304 e

[a] Date sown: I = 29 April 2005; II = 15 June 2005; III = 28 July 2005 at AVRDC.
Date transplanted: I = 24 May 2005; II = 12 July 2005; III = 8 September 2005 at AVRDC.
Planting I was destroyed by flooding.
[b] Mean separation within columns by Duncan's Multiple Range Test at $P < 0.05$.

The first AYT planting was destroyed by heavy rains (1239 mm) and flooding that occurred between 11–17 June. Plants of the second AYT planting sustained damage from heavy rains brought by typhoons Haitong (18 July) and Talim (1 September). SF1208 yielded only 5.4 t/ha (Tables 12 and 13) but performed better than other entries—including SF1203, the leading variety of the 2004 summer trials. SF1208 also produced a large head and small beads (Table 13). The third AYT planting was also buffeted by passing typhoons. Nevertheless, seven of the ten entries yielded more than 10 t/ha and SF1208 produced the top yield (13.7 t/ha). Based on the successful AYT, three varieties were identified that were relatively tolerant of tropical lowland summer conditions: SF1208, SF1203, and DG473 with a good dome head shape. The first planting of the ET suffered the same fate as that of the AYT. In the second ET planting, 59 entries out of 119 were harvested for yield. The top-yielding entry SB20, produced only 4.6 t/ha (Tables 14 and 15). A total of 126 entries were harvested from the third ET planting and 41 entries showed heat tolerance and early maturity. These entries produced over 10 t marketable curds per hectare. RN0521 yielded 18.7 t/ha within 50 days after transplanting and was considered the best entry of the third planting. Entries SB20, SS-40, and SS-44 were identical to SF1203, DG474 and SF1202, respectively, but with different names and were dropped because they were already in the AYT. From the ET, three new elite varieties, RN0521, GA501, and GA506, were selected for inclusion in 2006 confirmation trials.

Table 13. Horticultural characteristics of AYT broccoli entries evaluated over two planting dates, AVRDC, summer 2005[a]

Entry	Company	Stem width (cm)	Head thickness (cm)	Head length (cm)	Head width (cm)	Bead size	Chlorophyll[b] Head score	Chlorophyll[b] Leaf score	Side shoot production (number per plant)
Satomidori	Nozaki	3.2	5.6	14.3	18.1	Moderate	268	296	1–3
SF1202	Singflow	3.3	5.3	12.0	18.5	Moderate	288	322	1–3
CNB-45	Chingnong	3.5	4.7	13.6	17.2	Large	247	310	4–7
CNB-50	Chingnong	3.1	4.9	12.3	15.8	Fine–moderate	270	316	> 8
DG473	Denggie	3.2	4.8	11.9	18.2	Moderate	277	326	4–7
SF1203	Singflow	2.7	5.5	13.3	18.7	Fine–moderate	267	313	1–3
DG134	Denggie	3.0	5.5	14.3	18.7	Fine–moderate	261	309	1–3
SF1208	Singflow	3.1	6.5	15.2	19.0	Fine	230	282	1–3
RN0413	Raynong	3.2	5.0	11.5	18.3	Moderate	271	297	1–3
RN0425	Raynong	2.8	6.1	14.5	17.6	Fine–moderate	235	268	1–3

[a] Data from two trials transplanted 12 July and 8 September 2005 at AVRDC.
[b] Index mean of chlorophyll content for five sampled plants measured by Field Scout CM-1000 chlorophyll meter (Spectrum Technologies, Springfield, Illinois, USA).

Table 14. Maturity, yield, and mean head weight of 10 selected broccoli accessions in two evaluation trials, AVRDC, summer 2005[a]

Entry	Company	Second planting (II) Maturity (DAT)	Yield (t/ha)	Head weight (g)	Third planting (III) Maturity (DAT)	Yield (t/ha)	Head weight (g)
Satomidori	Nozaki	55	2.2	102	49	11.8	441
Green Magic	Sakata	-	-	-	53	16.9	634
Green Wind	Nozaki	-	-	-	49	16.4	614
DG194	Denggie	-	-	-	57	18.0	675
SB 20	Sungbao	55	4.6	173	47	15.3	572
SS-40	Seminis	55	3.4	126	49	13.1	490
SS-44	Seminis	55	2.8	110	50	14.4	541
RN0521	Raynong	58	1.9	190	49	18.7	703
GA501	G and A	55	1.5	152	47	13.7	515
GA506	G and A	55	2.7	125	49	13.2	493

[a] Date sown: I = 29 April 2005; II = 15 June 2005; III = 28 July 2005 at AVRDC.
Date transplanted: I = 24 May 2005; II = 12 July 2005; III = 8 September 2005 at AVRDC.
Planting I was destroyed by flooding.

Table 15. Horticultural characteristics of 10 selected broccoli entries measured during the third planting, AVRDC, summer 2005[a]

Entry	Company	Stem width (cm)	Head thickness (cm)	Head length (cm)	Head width (cm)	Bead size	Chlorophyll[b] Head score	Chlorophyll[b] Leaf score	Side shoot production (number per plant)
Satomidori	Nozaki	3.2	4.8	15.3	18.8	Moderate	272	326	1–3
Green Magic	Sakata	3.7	5.2	11.0	18.4	Fine	267	361	> 8
Green Wind	Nozaki	3.4	5.2	13.8	20.2	Fine	198	315	> 8
DG194	Denggie	3.8	4.9	11.8	18.1	Moderate	252	349	4–7
SB 20	Sungbao	2.6	6.8	18.8	18.7	Fine–moderate	272	303	1–3
SS-40	Seminis	3.2	5.2	14.0	18.7	Moderate	250	285	4–7
SS-44	Seminis	3.4	6.1	14.1	19.1	Moderate	280	288	1–3
RN0521	Raynong	3.4	6.5	15.0	22.2	Fine	240	274	1–3
GA501	G and A	2.9	5.2	13.2	16.8	Moderate	348	336	1–3
GA506	G and A	2.7	5.9	12.0	18.0	Moderate	269	278	1–3

[a] Data from the third evaluation trial transplanted on 8 September 2005 at AVRDC.
[b] Index mean of chlorophyll content for five sampled plants measured by Field Scout CM-1000 chlorophyll meter (Spectrum Technologies, Springfield, Illinois, USA).

Contact: Lien-Chung Chang

Legumes

Development of high-yielding and good quality vegetable soybeans

The AVRDC vegetable soybean breeding program has sought to develop improved lines that provide high yield and high quality under the environmental conditions of the tropics and the subtropics. Vegetable soybean lines should have large pod and seed size, and resistance to diseases including downy mildew, powdery mildew, and bacterial pustule. The center's breeding program is attempting to incorporate several additional traits, such as basmati flavor, high isoflavone content, high sucrose content, and high maltose productivity after boiling glabrous pod and supernodulation. A part of this breeding program has been conducted as the ROC Council of Agriculture (COA) project. It also includes the collaborative project with the Japan International Research Center for Agricultural Sciences (JIRCAS).

Advanced yield trials in 2005

Breeding lines found promising in intermediate trials were tested in advanced yield trials (AYTs). Two sets of advanced yield trial, AYT-1 and AYT-2, were conducted in the spring and autumn of 2005. AYT-2 was a part of COA project. Fourteen breeding lines and three check varieties were examined in each AYT. Seeds were sown on 10 March and 12 September, in plots 5 m × 2 m, with four rows per plot. Plant population density was approximately 330,000 plants/ha. The experiments used RCBD with four replications. Graded pod yield, total pod yield, total biomass, 100-green bean weight, pod size, sugar content in seed, and other agricultural characters were recorded.

In spring, seven of the 14 selections in AYT-1 had significantly higher graded pod yield than the check variety, KS #5 (Table 16). Among these seven lines, GC99009-2S-22-1-1 and GC99009-2S-22-1-3 are glabrous genotypes, which have smooth pods. These are expected to be resistant to soybean pod borer (*Grapholitha glycinivorella*), a major constraint in vegetable soybean production. GC98004-2S-4-1-1, GC98010-2S-2-1-1, and GC98004-18-1-1-2 had significantly larger 100-green bean weight than KS #5. Among lines other than these seven selections, GC99003-58-3-1-1 had high sugar content though its graded pod yield was similar to that of KS #5 (Table 16). This line also had significantly greater 100-green bean weight and pod length than KS #5.

Table 16. Promising selection from AYT-1, spring season, 2005

Entry	Graded pod yield (t/ha)	100-green bean weight (g)	Days to harvest[a]	Length of pod[b] (cm)	Sugar (%)
GC99001-10-1-1	11,675	88.4	81.0	5.7	6.3
GC98004-2S-4-1-1	11,032	102.1	81.0	5.6	7.0
GC98010-2S-2-1-1	10,995	96.5	88.0	5.1	6.4
GC99001-2S-35-2-1	10,195	88.4	89.0	6.0	6.7
GC99009-2S-22-1-1	10,105	81.2	89.0	5.3	4.7
GC99009-2S-22-1-3	9,420	81.7	89.0	5.3	4.8
GC98004-18-1-1-2	9,405	100.3	83.0	5.4	7.6
GC99003-58-3-1-1	8,920	93.5	78.5	5.8	8.9
KS #5 (check)	7,910	88.2	77.0	5.4	6.4
LSD(5%)	1,473	4.3	0.3	0.3	0.6

[a] Days from sowing to proper harvest time for vegetable soybeans.
[b] Length of two-seed pods.

In AYT-1 in autumn, 10 of the selections had significantly higher graded pod yield than KS #5 (Table 17). GC99009-22-1-1-1, GC99009-2S-22-1-3, and GC99009-2S-22-1-1 are all glabrous genotypes. GC99003-58-3-1-1, GC98006-41-3-1-2, GC98010-2S-2-1-1, GC99009-2S-22-1-3, GC99001-10-1-1, and GC99004-21-2-1-1 had significantly greater 100-green bean weight and pod length than KS #5.

In AYT-2 in spring, eight of the 14 selections gave significantly higher graded pod yield than KS #5 (Table 18). Among these selections, GC99009-6-3-1-1, which is a glabrous genotype, had significantly larger 100-green bean weight, pod length, and higher sugar content than KS #5. GC98006-123-3-2-1 had significantly larger 100-green bean weight and pod length than KS #5, and had the highest sugar content among all the entries. GC98003-11-1-1-1, GC99001-26-1-1-1, and GC99007-116-2-1-1 gave significantly larger 100-green bean weight and pod length than KS #5.

In AYT-2 in autumn, four of the selections had significantly higher graded pod yield than KS #5 (Table 19). Among these four entries, GC99007-116-2-1-1, GC99007-2S-97-1-1, and GC99003-10-1-2-1 also had significantly larger 100-green bean weight than KS #5.

Table 17. Promising selection from AYT-1, autumn season, 2005

Entry	Graded pod yield (t/ha)	100-green bean weight (g)	Days to harvest[a]	Length of pod[b] (cm)
GC99003-58-3-1-1	10,519	90.0	77.0	5.7
GC98006-41-3-1-2	10,273	86.4	73.0	6.1
GC98004-2S-4-1-1	9,673	81.5	71.0	5.3
GC99009-22-1-1-1	9,555	79.5	79.0	5.5
GC98010-2S-2-1-1	9,182	82.8	74.0	5.6
GC99009-2S-22-1-3	8,992	79.6	79.0	5.6
GC99001-10-1-1	8,957	80.3	77.0	5.6
GC98006-123-2-1-2	8,687	75.2	70.0	5.8
GC99004-21-2-1-1	8,540	99.8	77.0	6.2
GC99009-2S-22-1-1	8,496	74.9	79.0	5.5
KS #5 (check)	5,935	72.3	70.0	5.4
LSD (5%)	1,664	4.5	0.3	0.2

[a] Days from sowing to proper harvest time for vegetable soybeans.
[b] Length of two-seed pods.

Table 18. Promising selection from AYT-2, spring season, 2005

Entry	Graded pod yield (t/ha)	100-green bean weight (g)	Days to harvest[a]	Length of pod[b] (cm)	Sugar (%)
GC99003-10-1-2-1	11,305	103.0	81.0	5.6	7.3
GC99007-2S-97-1-1	10,880	85.5	83.0	5.4	6.0
GC98003-11-1-1-1	10,785	92.3	90.0	6.0	5.2
GC99001-26-1-1-1	10,375	88.6	89.0	5.7	6.7
GC99007-116-2-1-1	10,280	88.8	83.0	5.7	4.2
GC99007-107-2-1-1	9,725	82.3	81.0	5.3	5.2
GC98006-123-3-2-1	9,670	94.6	83.0	5.8	8.9
GC99009-6-3-1-1	9,645	107.6	90.0	6.0	8.1
KS #5 (check)	8,350	85.1	77.0	5.4	6.6
LSD (5%)	1,206	3.4	0.0	0.3	0.6

[a] Days from sowing to proper harvest time for vegetable soybeans.
[b] Length of two-seed pods.

Table 19. Promising selection from AYT-2, autumn season, 2005

Entry	Graded pod yield (t/ha)	100-green bean weight (g)	Days to harvest[a]	Length of pod[b] (cm)
GC99007-107-2-1-1	10,687	81.6	77.0	5.5
GC99007-116-2-1-1	10,646	90.9	77.0	5.9
GC99007-2S-97-1-1	9,819	94.8	77.0	5.7
GC99003-10-1-2-1	9,780	97.1	73.0	5.8
KS #5 (check)	8,173	83.5	70.0	5.7
LSD (5%)	1,521	5.9	0.7	0.3

[a] Days from sowing to proper harvest time for vegetable soybeans.
[b] Length of two-seed pods.

Intermediate yield trials in 2005

Two intermediate yield trials (IYTs), IYT-1 and IYT-2, were conducted in the spring and autumn of 2005. Seeds were sown on 10 March and 12 September. Thirty-six breeding lines and three check varieties were examined in IYT-1, and 39 breeding lines and three check varieties were examined in IYT-2 (COA project). Each trial used RCBD with two replications. Each plot was 2 m × 2 m with four rows. Plant population density was approximately 330,000 plants/ha.

In IYT-1 in spring, nine of the 36 entries had significantly higher graded pod yield than the check variety KS #5. Nine of the entries in autumn had significantly higher graded pod yield than KS #5. Fourteen promising lines were selected for the materials of AYT-1 2006 (Table 20). GC00210-42-1-2-2, GC00206-40, and GC00210-2-1-1-2 gave significantly higher graded pod yield than KS #5 both in spring and autumn trials. GC99019-51-3-2-1 and GC98016-ImBr(B)-24-1-1 had significantly larger 100-green bean weight than KS #5 both in spring and autumn. Sugar content of GC98019-22 and GC00211-7-1-2-1 was significantly higher than that of KS #5. GC98017-205-2-1-2 has black seed coats and GC99010-35-1-2-2 has glabrous pods.

Table 20. Promising selections from IYT-1, spring and autumn season, 2005

Entry	Graded pod yield (t/ha)		100-green bean weight (g)		Days to harvest[a]		Sugar (%)
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring
GC00210-2-1-1-2	15,325	12,145	84.5	91.2	84.0	74.0	6.9
GC00210-42-1-2-2	14,943	15,125	96.4	82.7	84.0	74.0	7.0
GC98019-22	14,550	11,020	88.1	80.6	82.0	71.0	8.1
GC00206-40	13,280	12,485	68.8	75.6	84.0	80.0	6.7
GC99010-35-1-2-2	12,985	10,645	82.3	74.1	84.0	74.0	8.0
GC99019-51-3-2-1	12,768	9,510	108.5	100.2	84.0	78.0	7.6
GC00209-4-1-1	12,118	11,035	84.0	85.2	84.0	74.0	6.5
GC98016-ImBr(B)-24-1-1	12,025	7,310	95.9	92.9	78.0	71.0	7.8
GC98017-6-73-1-1	11,600	10,170	86.2	91.0	82.0	71.0	6.4
GC00212-29-1-2-2	11,500	10,585	89.5	89.3	78.0	71.0	6.9
GC98017-205-2-1-1	11,475	8,120	89.6	94.4	78.0	71.0	6.4
GC98017-205-2-1-2	11,013	9,130	92.8	87.8	78.0	71.0	6.5
GC98017-7-196-1-2	10,525	9,690	88.7	107.5	78.0	71.0	6.7
GC00211-7-1-2-1	9,650	10,750	88.4	91.4	78.0	71.0	9.2
KS #5 (check)	10,013	8,763	86.6	82.6	78.0	70.5	6.9
LSD (5%)	2,600	2,883	7.8	8.6	0.5	1.5	1.1

[a] Days from sowing to proper harvest time for vegetable soybeans.

In IYT-2 in spring, 27 of the 39 selections gave significantly higher graded pod yield than KS #5. Two of the entries in autumn had significantly higher graded pod yield than KS #5. Seventeen entries were selected for the materials of AYT-2 2006 (Table 21). GC99003-28-1-1-1 had significantly higher graded pod yield, 100-green bean weight, and sugar content than KS #5 in spring trial.

Table 21. Promising selections from IYT-2, spring and autumn season, 2005

Entry	Graded pod yield (t/ha)		100-green bean weight (g)		Days to harvest[a]		Sugar (%)
	Spring	Autumn	Spring	Autumn	Spring	Autumn	spring
GC99007-203-1-1-3	14,975	12,470	83.5	88.6	88.0	78.0	5.5
GC99007-203-1-1-1	14,275	11,485	87.9	90.5	88.0	78.0	5.4
GC99003-28-1-1-1	13,775	9,790	100.8	89.9	82.0	71.0	7.8
GC99007-2S-43-1-2	13,525	10,040	87.8	81.2	82.0	71.0	5.7
GC99009-62-1-3-1	12,625	12,470	91.9	86.8	88.0	78.0	5.4
GC99007-156-1-2-1	12,400	10,925	77.7	79.3	82.0	71.0	5.8
GC99007-44-1-1-1	12,350	12,175	88.1	84.5	82.0	74.0	5.7
GC99020-45-1-1-1	11,850	8,910	90.0	80.1	82.0	74.0	6.0
GC99007-140-2-1-1	11,725	9,170	87.6	83.1	82.0	71.0	5.8
GC98003-11-1-1-3	11,650	10,390	84.5	81.4	88.0	74.0	5.4
GC99009-159-2	11,625	11,960	76.2	84.6	82.0	80.0	6.5
GC99002-2S-21-1-1	11,475	10,125	86.5	79.3	78.0	71.0	6.8
GC99009-149-3-2	11,475	9,925	92.1	87.2	88.0	78.0	4.4
GC99009-78-3-2	11,125	10,995	73.6	73.9	88.0	80.0	5.9
GC99009-120-1-2	10,600	8,740	92.8	99.5	88.0	80.0	6.4
GC00201-114-1-1	9,750	12,273	91.3	92.2	88.0	80.0	6.2
GC98006-124-2-1-1	9,600	8,300	79.6	81.2	82.0	74.0	6.0
KS #5 (check)	8,720	10,250	88.7	84.0	78.0	70.0	6.5
LSD (5%)	1,826	2,714	9.1	9.1	0.0	0.2	0.8

[a] Days from sowing to proper harvest time for vegetable soybeans.

New crossing of vegetable soybeans

A total of 51 crosses were made and approximately 2000 F_1 seeds were obtained in 2005. The aim of these crosses was incorporation of basmati flavor (15 combinations), high isoflavone content (2 combinations), high sucrose and maltose content (9 combinations), supernodulation (5 combinations) and other traits (20 combinations).

Supernodulating soybean

Supernodulating soybeans that form more than several times as many nodules as normal genotypes have been expected to enhance soybean productivity through their high nitrogen fixation potential. However, their growth and yield are, in general, inferior to those of normal genotypes. The National Institute of Crop Science in Japan recently managed to develop a cultivar 'Sakukei 4,' presently 'Kanto 100,' with improved growth and high nitrogen fixation potential.

It has generally been believed that soybean planting always increases the soil nitrogen fertility. In fact, because about 75% of N is accumulated in seed and taken away from the field by harvest when the dependence on N fixation of soybean is low, soil N should be reduced by soybean planting. If the high nitrogen fixation ability of this cultivar can be introduced into vegetable soybean lines, it will be highly beneficial to the advance of sustainable agriculture.

In AVRDC, crosses between Sakukei 4 and the vegetable soybean lines adapted to the tropical environmental conditions have been made.

Development of mungbean lines with high methionine content

Blackgram, which belongs to the same genus as mungbean, has high methionine content. Increased methionine content in mungbean through the use of interspecific crosses between mungbean and blackgram has been expected. In 1998, AVRDC introduced inbred lines from a cross between mungbean and blackgram from Australia. These introduced lines were crossed with two mungbean lines, VC 6372 (45-8-1) and NM 92, in 2003. To develop practical mungbean cultivars, further backcrosses were required. F_3 lines were crossed with two mungbean lines, NM 92 and NM94, in 2004 and 82 F_1 seeds were obtained. These 82 progenies were crossed again with NM 92 and NM94 in summer 2005 and 769 F_1 seeds were produced. Individuals with high methionine content will be selected from their F_2 progenies in 2006.

AVRDC mungbean project in India

An AVRDC-supported mungbean project in India, with collaborators in Punjab (Punjab Agricultural University), Rajasthan (Agricultural Research Station, Rajasthan Agricultural University), and Bihar (Tirhut College of Agriculture, Rajendra Agriculture University), were conducted. The name of the project is 'Popularization of Extra-Short Duration Mungbean Cultivars for Poverty Alleviation and Improved Nutrition in Bihar and Rajasthan, India, based on the Punjab Model.'

AVRDC and collaborators developed new mungbean cultivars, including SML 668, which have high yield potential, short growth-duration, synchronous maturity, and tolerance to Mungbean yellow mosaic virus. Its short growth duration has enabled farmers to plant these not only in the rainy season but also in the summer season, especially in fallow of rice-wheat cropping systems. In the Punjab state, PAU has already succeeded in extending these new cultivars to farmers.

The farmers in other states such as Rajasthan and Bihar, however, have not yet received the benefits of the new cultivars. Rajasthan and Bihar are very poor states where protein and iron malnutrition are widespread. The objective of the project is to transfer the success of the new mungbean cultivars in Punjab to Rajasthan and Bihar.

In the summer season of 2005, 10 field experiments for developing production technology, 2 experiments on microbiology, 11 experiments on entomology, and 9 experiments for evaluation of new cultivars were conducted in Rajasthan, Bihar, and Punjab. Furthermore, 35, 25, and 60 field demonstrations were done in Rajasthan, Bihar, and Punjab, respectively. At all locations, new cultivar SML 668 showed very good performance. The results of this project in summer season of 2005 are summarized as follows.

Results in Rajasthan

Field experiments in Agricultural Research Station. The sowing on 10 March gave significantly higher grain yield (962 kg/ha) than 10 April sowing (796 kg/ha) (Table 22). Increase in seed rate from 25 kg/ha to 30 and 35 kg/ha significantly increased grain yield, and the highest grain yield (929 kg/ha) was recorded with 35 kg/ha (Table 22). Among the genotypes, SML 668 gave the significantly highest grain yield (940 kg/ha) (Table 22).

Significantly higher yield of SML 668 (834 kg/ha) was recorded with tillage than no-tillage treatment (720 kg/ha) (Table 23). Grain yields were also influenced significantly by fertilizer levels (Table 23). An increase in level of fertilizers increased the yields. The highest yield of 847 kg/ha was recorded with 125% recommended dose (RD) of N and P. The results showed that N and P should be fertilized at least 75% and preferably 125% of the RD.

Table 22. Effect of dates of sowing and seed rates in summer mungbean genotypes on grain yield in Rajasthan, India, 2005

Treatment	Grain yield (kg/ha)
Date of sowing	
10 Mar	962
10 Apr	796
C.D. (0.05)	40
Seed rate (kg/ha)	
25	777
30	912
35	929
40	898
C.D. (0.05)	57
Genotypes	
SML 668	940
Pusa Vishal	882
Samarat	814
C.D. (0.05)	46

Table 23. Effect of tillage practices and fertility levels on grain yield in summer mungbean var. SML 668 in Rajasthan, India, 2005

Treatment	Grain yield (kg/ha)
Tillage	
No-tillage	720
Tillage	834
C.D. (0.05)	92
Fertilizer levels	
No fertilizer	693
75% RD of NP	776
100% RD of NP[a]	794
125% RD of NP	847
C.D. (0.05)	95

[a]100% RD (recommended dose): 20 kg N and 40 kg P_2O_5/ha.

Demonstration in farmers' fields. The grain yields in the farmers' demonstration fields ranged from 100 kg/ha to 800 kg/ha (on an average of 282 kg/ha). The difference of the grain yields between the farmers' fields and the Agricultural Research Station's field (1571 kg/ha at the maximum) was very large. Probably the leading cause of the poor yield in the demonstration fields was the shortage of irrigation water in the canal. In Rajasthan, to boost the production of summer mungbean, establishing the irrigation techniques that are effective with minimum water consumption will be indispensable.

Farmers of the demonstration fields in Rajasthan were impressed with SML 668, which has higher seed weight, longer pod length, and extremely early maturity.

Results in Bihar

Field experiments in Tirhut College of Agriculture, Rajendra Agriculture University. The sowing on 20 March gave significantly higher grain yield than the 10 April sowing (Table 24) because of the acute shortage of moisture at the time of seeding. Grain yield significantly increased with increasing seed rates up to 40 kg/ha (Table 24). Among the genotypes, SML 668 and Pusa Vishal gave almost the same high grain yield (1309 and 1301 kg/ha, respectively) (Table 24).

In SML 668, a significantly higher yield of 1012 kg/ha was recorded with tillage (Table 25) than no-tillage (819 kg/ha), probably due to more crop weed competition in no-tillage treatment. SML 668 responded well to fertilizer application. The fertilizer dose at 25% higher than RD gave maximum yield (1025 kg/ha), but the significant difference between 125% RD and 100% RD was not observed. The difference between 75% RD and 100% RD was not significant either. Grain yield recorded under 75% RD was significantly superior to no application.

The interaction effect between irrigation and planting methods on the grain yield was significant. Grain yield in SML 668 progressively tended to increase up to three irrigations in both flat bed sowing and raised bed sowing (Table 26). However, the differences between one and two irrigations in flat bed sowing,

Table 24. Effect of dates of sowing and seed rates in summer mungbean genotypes on grain yield in Bihar, India, 2005

Treatment	Grain yield (kg/ha)
Date of sowing	
20 Mar	1,637
10 Apr	891
C.D. (0.05)	351
Seed rate (kg/ha)	
25	1,099
30	1,248
35	1,378
40	1,476
C.D. (0.05)	33
Genotypes	
SML 668	1,309
Pusa Vishal	1,301
Samarat	1,195
C.D. (0.05)	29

Table 25. Effect of tillage practices and fertility levels on grain yield in summer mungbean var. SML 668 in Bihar, India, 2005

Treatment	Grain yield (kg/ha)
Tillage	
No-Tillage	819
Tillage	1,012
C.D. (0.05)	151
Fertilizer levels	
No fertilizer	762
75% RD of NP	903
100% RD of NP[a]	972
125% RD of NP	1,025
C.D. (0.05)	106

[a] 100% RD (recommended dose): 20 kg N and 40 kg P_2O_5/ha.

Table 26. Effect of irrigation and planting methods on grain yield in summer mungbean var. SML 668 in Bihar, India, 2005

Number of irrigations	Grain yield (kg/ha)	
	Flat bed	Raised bed
0	1,535	1,487
1	1,810	2,084
2	1,939	2,100
3	2,214	2,246
C.D. (0.05)	Irrigation at same level of planting method: 157	
	Planting method at same level of irrigation: 407	

and one and two irrigations and two and three irrigations in raised bed sowing were not significant.

Demonstration in farmers' fields. Twenty-five field demonstrations were done in Bihar. The grain yields of 32 irrigated fields ranged from 910 kg/ha to 2406 kg/ha (on average 1241 kg/ha). Three demonstrations had less than 374 kg/ha yield due to lack of irrigation.

In farmers' fields, SML 668 showed excellent performance such as higher yield, extra-early maturity, and comparatively more MYMV disease-free than others. Technically, some problems still remain. The mungbeans were sown using broadcast methods and plant population was below normal. There seems to be a great potential to boost the productivity through the improvement of production technologies that are lacking in the state.

Results in Punjab

Field experiments in PAU, Punjub. Flat bed sowing gave significantly higher grain yield than raised bed sowing. Because of light (loamy sand) soil and high temperatures, plants in raised bed plots wilted faster than those in flat beds during midday. *Rhizobium* inoculation produced higher yield than no inoculation.

Grain yield was almost the same in tillage and non-tillage plots, while straw incorporation tended to reduce the yield. The application of 12.5 kg N and 40 kg P_2O_5/ha (RD) gave higher grain yield than 75% RD and no-fertilizer. The addition of 25% higher dose of fertilizer did not improve the grain yield. The application of four irrigations: 15, 25, 35, and 45 days after sowing (DAS) gave significantly higher grain yield than two irrigations (20 and 40 DAS) and three irrigations (20, 30, and 40 DAS).

Apart from SML 668, some other mungbean lines were found promising. Some AVRDC lines were also promising not only in grain yield but also in nodulation and leghaemoglobin content.

Demonstration in farmers' fields. Fifty field demonstrations were done in Punjab. The grain yields ranged from 1200 kg/ha to 2000 kg/ha (on the average of 1560 kg/ha). It also showed very high yield potentials when sown after potatoes.

On the other hand, no spraying is done to control insect pests in Rajasthan and Bihar because some progressive farmers in Punjab are already aware of plant protection measures. However, there still seems to be a need to educate farmers to narrow this gap.

Distribution of promising legume lines

In 2005, 25 AVRDC vegetable soybean evaluation trial sets (250 breeding lines were included) and 241 accessions and breeding lines were distributed to 44 cooperators in 29 countries around the world. In addition, 22 cooperators from 15 countries received 299 grain soybean accessions and breeding lines. Using AVRDC breeding lines, ROC released a new vegetable soybean cultivar, Tainan-AVRDC-No.2, in 2005. The advantages of this cultivar reported by the Tainan District Agricultural Research and Extension Station are as follows:

Its graded pod yield was 22% higher in regional yield trial in spring and 16% higher in autumn than that of the check variety, KS #5. It tasted better than KS #5. Its pod size and pod color were similar to those of KS #5. It was relatively tolerant to powdery mildew and downy mildew.

Four hundred twenty-seven (427) packages of mungbean accessions and breeding lines were also distributed to 18 cooperators in 15 countries. Utilizing AVRDC breeding lines, Nepal will soon release mungbean cultivars NM94 as Kalyan and VC6372 (45-8-1) as Prateeksha. Both cultivars are characterized as high-yielding, Mungbean yellow mosaic virus-tolerant, early synchronous pod-maturing, and bold-seeded.

Contact: Motoki Takahashi

Tomato

Tomatoes for specialty markets

Taiwan tomato consumers prefer large-fruited, dark green-shouldered varieties. An advanced yield trial of indeterminate fresh market tomato hybrids was carried out at AVRDC during the fall to identify those suitable for potential release in the host country. All FMTT-prefixed entries are resistant to geminivirus, Tomato mosaic virus (ToMV), and bacterial wilt (Table 27). The AYT was sown on 5 August 2004, transplanted 2 September, and harvested six times from 12 December to 14 February 2005. Plots included two 1.5-m-wide beds with two 2.4-m-long-row per bed. Plants were staked and pruned. Entries were replicated three times and plots were arranged in RCBD. FMTT 1029, FMTT 1047, FMTT 1048, and FMTT 1098 were recommended for regional yield trials and fruit characters based on yield, fruit size, and shape, and were selected for extension to the Taiwan District Agricultural Research Extension stations.

Cherry tomato hybrids were evaluated in a late summer preliminary yield trial (PYT) as part of a COA-funded project to select potential hybrids for release in Taiwan. Entries with the CHT prefix are resistant to the Taiwan geminivirus and ToMV (Table 28). The PYT was sown 16 August 2004, transplanted 16 September 2004, and harvested eight times between 21 December 2004 and 1 April 2005. 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. No significant differences were found for marketable yield and solids although values for solids in several entries exceeded 5.0; high solids are associated with good taste. CHT 1569 is clearly a high beta-carotene type. The other entries produced relatively more lycopene than beta-carotene although beta-carotene values were greater than 1.0. Based on solids, lycopene, beta-carotene contents and fruit shape, hybrids CHT 1569, CHT 1572, CHT 1573, and CHT 1576 will be included in AYT trials at AVRDC for 2006.

Table 27. Yield and horticultural characteristics of Tomato leaf curl virus (ToLCV)-resistant fresh market tomato hybrids in advanced yield trial, AVRDC, summer 2004[a]

Entry	Marketable yield (t/ha)	Fruit set %	Days to maturity	Fruit weight (g)	Fruit no./plant	Solids (°Brix)	Acid[b] (%)	Color[c] (a/b)	Disease resistance[d]
FMTT1031	110.6	48	124	111	32	4.43	0.26	2.01	WTG, ToMV, F-1
FMTT1029	109.4	46	124	108	39	4.43	0.29	1.96	WTG, ToMV, F-1
FMTT1034	107.8	45	124	110	31	4.37	0.29	2.10	WTG, ToMV, F-1
FMTT1027	103.1	52	124	113	27	4.40	0.28	1.99	WTG, ToMV, F-1
FMTT1053	97.7	46	124	87	33	4.76	0.29	2.10	WTG, ToMV, F-1
FMTT1098	95.7	49	125	123	26	4.56	0.36	1.27	WTG, ToMV, F-1
FMTT1047	95.0	45	124	106	35	4.87	0.32	2.10	WTG, ToMV, F-1
FMTT1048	89.9	42	124	109	35	4.40	0.34	2.08	WTG, ToMV, F-1
Taichung ASVEG #4 (check)	104.9	35	125	106	30	4.96	0.36	2.02	ToMV, F-1
Taichung ASVEG #10 (check)	91.6	41	125	131	24	4.47	0.37	2.13	ToMV, F-1
Mean of all entries	100.6	45	124	111	31	4.56	0.32	1.98	
LSD (5%)	ns	13	1	17	8	ns	0.05	0.15	

[a] Transplanted 2 September 2004 at AVRDC.
[b] Equivalent of citric acid.
[c] 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.
[d] ToMV = Tomato mosaic virus; WTG = whitefly-transmitted geminivirus; F-1 = Fusarium wilt race 1.

Table 28. Yield and other horticultural characteristics of ToLCV-resistant cherry tomato hybrids and check cultivars in preliminary yield trial, AVRDC, summer 2004[a]

Entry	Marketable yield (t/ha)	Fruit set %	Days to maturity	Fruit weight (g)	Fruit no./plant	Solids (°Brix)	Acid[b] (%)	Color[c] (a/b)	Lycopene (mg/100 g)	ß-carotene (mg/100 g)	Disease resistance[d]
CHT1569	89.7	93	81	11	218	5.35	0.36	0.71	1.20	2.73	WTG, ToMV, F-1
CHT1570	76.8	73	82	11	254	4.90	0.36	1.11	3.28	1.58	WTG, ToMV, F-1
CHT1572	82.2	84	81	13	219	5.20	0.37	0.99	3.03	1.92	WTG, ToMV, F-1
CHT1573	82.8	90	81	14	252	5.60	0.35	0.91	2.41	2.36	WTG, ToMV, F-1
CHT1574	103.8	89	81	15	274	4.95	0.34	1.30	3.32	1.93	WTG, ToMV, F-1
CHT1576	81.7	75	82	15	215	5.25	0.39	1.41	5.34	1.29	WTG, ToMV, F-1
CHT1578	72.7	81	81	15	247	4.90	0.38	1.12	3.45	1.72	WTG, ToMV, F-1
CHT1591	87.7	66	82	12	232	4.65	0.35	1.26	4.20	1.12	WTG, ToMV, F-1
Tainan ASVEG #6 (check)	89.7	67	82	12	179	4.80	0.39	1.33	4.46	1.15	ToMV, F-1, F-2
Hua-Lien ASVEG #13 (check)	59.2	72	81	14	202	5.20	0.41	0.94	2.67	1.69	ToMV, F-1, F-2
Mean of all entries	82.6	79	81	13	230	5.08	0.37	1.09	3.37	1.75	
LSD (5%)	ns	35	1	5	88	ns	0.09	0.64	3.46	1.78	

[a] Transplanted 16 September 2004 at AVRDC.
[b] Equivalent of citric acid.
[c] 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.
[d] ToMV = Tomato mosaic virus; WTG = whitefly-transmitted geminivirus; F-1 and F-2 = Fusarium wilt race 1 and 2.

Contact: Jen-tzu Chen

Geminivirus-resistant determinate tomato lines

Whitefly-transmitted geminiviruses continue to threaten tomato production in all tropical areas, especially warm-dry environments. In South and Southeast Asia, West Africa, and other regions, tomato varieties should carry both bacterial wilt and geminivirus resistance. Because of the vast diversity among tomato-infecting geminiviruses, development of varieties with stable resistance is difficult. Most AVRDC lines are incorporated with the 'Ty-2' allele on chromosome 11 derived from the Indian tomato variety H24. Ty-2 is effective against some monopartite geminiviruses but is susceptible to the bipartite forms that prevail in the Americas and parts of Asia. Consequently, diversification of resistance sources in crosses to broaden geminivirus resistance in our lines is a high priority. FLA456, developed by Jay Scott at the University of Florida, has demonstrated resistance to many monopartite and bipartite geminiviruses and is among the new resistance sources used as a parent in AVRDC crosses. Some of the lines evaluated in this trial were derived from crosses involving FLA456 as a parent.

One preliminary yield trial was conducted at AVRDC from 2005–2006 dry season to evaluate the yield and horticultural characters of geminivirus-resistant fresh market determinate lines. Five PYT entries, coded CLN2585 and CLN2498, possess Ty-2 resistance (Table 29). Entries coded CLN2714 are lines derived from the cross [(CLN1466J x FLA456) x CLN2418A]; and CLN1466J and CLN2418A are BW-resistant AVRDC lines. The CLN2679-coded lines are selections from the cross [NS1945 x (CLN2114 DC1F1-2-16-8-2-17 x FLA456). NS1945 is a hybrid from Namdhari Seed in India, and CLN2114 is an AVRDC breeding line. The PYT was sown 26 September 2005 and transplanted on 12 October. 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 17 January, 13 February, and 13 March 2006.

Entries demonstrated high levels of resistance to the Tomato leaf curl Taiwan virus (ToLCTWV), although disease pressure was moderate during the trial. Presence of the Ty-2 allele in the CLN2585 lines was confirmed by molecular marker testing. The

Table 29. Yield and horticultural characteristics of determinate fresh market tomato lines in a preliminary yield trial, AVRDC, October 2005–January 2006

Entry	Marketable yield (t/ha)	Geminivirus resistance	Days to maturity	Fruit weight (g)	Fruit no./ plant	Solids (°Brix)	Acid[a] (%)	Color[b] (a/b)	BW[c] (% survival)	Additional resistances[d]
CLN2714H (51315)	128	Non-Ty-2	77	98	11	4.3	0.39	1.98	80	TMV, F-1, St
CLN2714L (51322)	114	Non-Ty-2	78	100	14	4.3	0.37	1.85	75	TMV, F-1, St
CLN2714J (51320)	111	Non-Ty-2	75	79	15	4.0	0.36	1.60	75	TMV, F-1, St
CLN2714G (51311)	102	Non-Ty-2	80	107	13	4.3	0.38	1.90	84	TMV, F-1, St
CLN2714K (51321)	106	Non-Ty-2	79	94	11	4.2	0.37	1.90	75	TMV, F-1, St
CLN2585C (51335)	97	Ty-2	77	92	13	4.3	0.34	2.34	100	TMV, F-1
CLN2585E (51337)	81	Ty-2	77	80	9	3.9	0.26	2.24	95	TMV, F-1
CLN2585D (51336)	81	Ty-2	75	82	10	4.5	0.34	2.41	95	TMV, F-1
CLN2585A 51332	80	Ty-2	77	86	10	4.4	0.33	2.28	100	TMV, F-1
CLN2679F 51314	75	Non-Ty-2	92	81	9	4.2	0.42	2.02	70	F-1, F-2,St, EB
CLN2679E 51313	74	Non-Ty-2	92	85	12	4.2	0.39	2.03	70	F-1, F-2, St, EB
CLN2498D (check)	171	Ty-2	94	87	15	3.9	0.32	1.45	-	TMV, F-1, S
Mean (all entries)	83	-	81	89	11	4.1	0.35	1.95	-	
CV (%)	17	-	6	16	22	7.9	8.43	5.31	-	
LSD (5%)	29	-	9	16	ns	ns	0.06	0.21	-	

[a] Equivalent of citric acid.
[b] 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.
[c] Percentage of healthy plants after drench inoculation with the bacterial wilt pathogen in a separate greenhouse trial.
[d] ToMV = Tomato mosaic virus conditioned by Tm2[2] allele; F-1, F-2 = race 1 and race 2, respectively, of the Fusarium wilt pathogen (*Fusarium oxysporum* f sp. *lycopersici*) and EB = moderate foliar resistance to the early blight pathogen (*Alternaria solani*).
Transplanted 12 October 2005 and harvested 17 January, 13 February and March 13 2006.

genomic locations of geminivirus resistance genes in FLA456 and available markers linked to these resistance genes are not yet known. Hence, the number and locations of geminivirus resistance genes in the CLN2714 and CLN2679-coded entries need to be determined later. In addition to geminivirus resistance, all entries showed moderate to high bacterial wilt resistance. CLN2714 entries produced moderately firm fruit in the 80–100 g range with good color. CLN2714H yielded the highest among the new lines but significantly less than the check CLN2498D. Although not exceptional for yield, the two CLN2679 lines showed moderate early blight resistance in a growth room trial. Early blight is an important disease in mid-altitude regions of South Asia and Africa. The CLN2585 lines were also not exceptionally high-yielding but fruit color values were very high, indicating high lycopene content.

Evaluation of *Lycopersicon hirsutum* introgression lines for yield and fruit characters

The wild relatives of tomato have been valuable sources of new genes to improve cultivated tomato, *Lycopersicon esculentum*. Although wild tomato species have been exploited primarily for disease resistance, there is strong evidence that wild species possess beneficial genes for yield, insect resistance, high soluble solids, and other characters. The advanced backcross-quantitative trait loci (AB-QTL) method developed by Cornell University harnesses molecular markers to measure the effects of individual wild genes in interspecific mapping populations, to identify favorable genes, and quickly backcross them into elite cultivars. Gene discovery and transfer are carried out simultaneously, reducing the time needed for crop improvement. Cornell University, through the Tomato Genetics Resource Center at the University of California at Davis, has made available a population of introgression lines (IL) consisting of mapped fragments of *Lycopersicon hirsutum* (LA1777) DNA incorporated into California processing line E6203. Each IL contains one or a few pieces of wild DNA in an *L. esculentum* background. Since the ILs differ only in the *L. hirsutum* fragments they carry, it should be straightforward to identify wild alleles that improve tomato. This study was carried out as part of a GTZ-funded project to identify beneficial genes from wild tomato to improve tropical tomato.

A preliminary yield trial was conducted at AVRDC in the late 2005 cool-dry season to evaluate the yield and horticultural characters of 64 lines of the *L. hirsutum* IL population with the prefix 'LA.' Because most IL's are susceptible to geminivirus, a chronic disease problem at AVRDC, each of the 64 IL's was crossed to CLN2498E, an AVRDC fresh market line resistant to the Taiwan geminivirus. The 64 hybrids and checks E6203, CLN2498E, and BMZ65 (E6203 x CLN2498E) were sown on 15 September 2004 and transplanted on 13 October 2004. Plots consisted of one 1.5-m-wide bed with one 4.8-m-long row per bed (12 plants). Plants were staked and pruned. Entries were replicated twice and plots were arranged in RCBD. Plots were harvested three times from January–March 2005. Entries were evaluated for yield, horticultural characters, and fruit qualities.

Data of checks and 21 selected IL hybrids are given in Table 30. Geminivirus infection of E6203 was probably the major cause for its low yield. CLN2498E and the IL hybrids demonstrated geminivirus resistance, thus allowing yield and other traits to be expressed.

Table 30. Yield and horticultural characteristics of introgression hybrids and checks in a preliminary yield trial, AVRDC, October 2004–March 2005

Entry	Female parent[a]	Introgression location[b] (chromosome)	Marketable yield (t/ha)	Fruit weight (g)	Solids (°Brix)	Solids yield[c] (t/ha)	Lycopene content (mg/100)	Color[d] (a/b)
BMZ1	LA3913	1	102	78	4.30	4.37	6.160	1.845
BMZ17	LA3933	4	91	83	3.80	3.44	7.090	1.985
BMZ18	LA3934	4	95	85	4.65	4.49	8.595	2.165
BMZ19	LA3936	4	85	81	4.40	3.73	7.280	2.030
BMZ2	LA3914	1	98	89	4.85	4.75	6.965	2.000
BMZ20	LA3937	4	100	78	4.55	4.56	8.450	2.155
BMZ21	LA3939	5	100	78	4.15	4.14	8.260	2.155
BMZ24	LA3943	5	108	75	4.05	4.36	8.180	2.145
BMZ27	LA3948	7	98	80	3.70	3.61	7.490	1.995
BMZ29	LA3951	7	98	78	3.65	3.53	6.395	1.945
BMZ3	LA3915	1	95	77	4.25	4.07	6.760	1.945
BMZ37	LA3962	10~12	106	60	4.15	4.40	4.870	1.760
BMZ38	LA3964	10	80	62	4.40	3.53	8.045	2.110
BMZ39	LA3965	2~11	95	64	4.35	4.14	6.530	1.930
BMZ4	LA3916	1	81	69	5.25	4.21	7.405	1.990
BMZ41	LA3969	12	65	80	4.15	2.69	6.985	2.010
BMZ42	LA3970	1	95	69	4.20	3.99	8.330	2.180
BMZ45	LA3976	4	104	78	4.60	4.78	7.130	2.020
BMZ50	LA3983	5	101	80	4.40	4.48	7.580	2.135
BMZ57	LA3996	3~11	92	80	3.65	3.36	7.310	2.145
BMZ7	LA3921	2	91	78	3.85	3.49	6.985	2.080
BMZ65 (check)	E6203		82	68	4.38	3.62	7.755	2.188
CLN2498E (check)			97	77	3.70	3.64	6.063	1.798
E6203 (check)			37	83	5.35	1.96	7.110	1.985
LSD (5%)			22	ns	0.56	1.11	0.966	ns
Grand mean			89	78	4.12	3.65	7.140	2.036

ns = nonsignificant. The entry mean square from the analysis of variance was not significant.

[a] Female parents are introgression lines developed by Cornell University. Female parents were crossed to AVRDC line CLN2498E.

[b] Tomato chromosome number where introgression in the female introgression lines was mapped. See Genome 43: 803-813.

[c] Solids yield is the product of marketable yield by solids content.

[d] 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.

Marketable yields of BMZ-24 and BMZ-37 were significantly greater than the check hybrid BMZ-65 (CLN2498E x E6203) but not that of CLN2498E. All three hybrids with introgressions on chromosome 5 (BMZ-21, BMZ-24, and BMZ-50) yielded 100 t/ha. E6203 produced the highest solids content of all entries but the yield of solids was very low. The yield of solids of BMZ-2 with an introgression on chromosome 1 was significantly greater than the check BMZ65 and E6203 but not CLN2498E; while BMZ-45 with an introgression on chromosome 4 were significantly greater than all checks. None of IL hybrids produced lycopene contents significantly greater than the check BMZ65, although several hybrids with introgressions on chromosomes 4 or 5 such as BMZ-18, BMZ-20, and BMZ-21 produced higher than the average lycopene content. The selected IL hybrids in Table A will be tested again in the 2005–2006 cool season using larger plots and three replications to detect differences with more precision. Molecular markers linked to introgressions have been designed and marker-assisted selection will be applied to incorporate international distribution based on yield and fruit qualities.

Preliminary evaluation of LA1777 introgression lines for early blight resistance

Early blight (EB) caused by *Alternaria solani*, is a serious disease of tomato in the tropics, particularly the mid-altitude areas of South Asia and southern and eastern sub-Saharan Africa. Defoliation and fruit lesions due to EB often lead to severe yield reductions, and fungicide costs for disease control can be prohibitive for small-scale farmers. High levels of EB resistance have been found in some accessions of *Lycopersicon hirsutum (Solanum habrochaites)*.[1, 2] Using a growth room seedling screening technique, high levels of EB resistance were identified in *L. hirsutum* accession LA1777. LA1777 was also the donor parent of the *L. hirsutum* introgression line (IL) population developed by Monforte and Tanksley[3] and made available through the Tomato Genetics Cooperative Report (TGRC). The objective of this study was to evaluate LA1777 ILs for EB resistance.

Two growth room EB experiments were conducted at AVRDC in 2004. Entries in the first experiment included 90 *L. hirsutum* IL,[4] and parents of the IL population: LA1777 and E6203 (LA4024). Twenty ILs demonstrating relatively higher resistance in the first experiment were tested in the second experiment. In both experiments, 10–12 plants per entry were evaluated. Foliar inoculation with a 2.5×10^4 conidia/ml suspension of pathogen isolate *Alt. solani*-1 from Taiwan was carried out on 30-day-old plants. Plants were maintained at 23 ± 1°C and scored for disease severity rating (DSR) seven days after inoculation on the following scale: 0 = no symptoms; 1 = very few lesions per plant; 2 = about 5 lesions per plant; 3 = numerous lesions per leaf; 4 = numerous lesions per leaf, coalescing lesions, and leaf collapse.

LA1777 introgressions are defined by restriction fragment length polymorphism (RFLP) markers. Many PCR-based tomato markers have been developed and mapped, and are publicly available from a variety of sources (e.g., http://www.sgn.cornell.edu/, http://hornbill.cspp.latrobe.edu.au/ssrdiscovery.html). These resources enabled screening a set of genome-wide markers to identify polymorphic markers distinguishing LA1777 and LA4024. If the markers were informative, these were then screened on the ILs to delineate introgressed regions.

All entries in both experiments developed lesions although differences in DSR were evident. Mean DSR of most IL in experiment 1 exceeded 3.7 and were dropped from experiment 2. None of the IL demonstrated resistance comparable to LA1777 with a DSR of 1.0 (Table 31). Among ILs, LA3913, LA3914, LA3916 and LA3970, all with *L. hirsutum*

[1] Nash, A.F. and Gardner, R.G. 1988. Heritability of tomato early blight resistance derived from *Lycopersicon hirsutum* P.I. 126445. *Journal of the American Society for Horticultural Science* 113:264-268.

[2] Foolad, M.R., Zhang, L.P., Khan, A.A., Niño-Liu and Lin, G.Y. 2004. Identification of QTLs for early blight (*Alternaria solani*) resistance in tomato using backcross populations of a *Lycopersicon esculentum* x *L. hirsutum* cross. *Theoretical and Applied Genetics* 104:945-958.

[3] Monforte, A.J. and Tanksley, S.D. 2000. Development of a near isogenic and backcross recombinant inbred lines containing most of the *Lycopersicon hirsutum* genome in a *L. esculentum* background: a tool for gene mapping and gene discovery. *Genome* 43:803-813.

[4] Tomato Genetics Cooperative. 2000. *L. hirsutum* introgression lines. Tomato Genetics Cooperative Report. 50:75-77.

Table 31. Reactions of *L. hirsutum* introgression lines and parents to *Alternaria solani*, sorted by overall disease severity rating (DSR), AVRDC, 2004

		Experiment I DSR[b]						Experiment II DSR						Overall	
Entry	Chrom[a]	0	1	2	3	4	Mean	0	1	2	3	4	Mean	Mean	LSD[c]
LA1777			10				1.0		10				1.0	1.0	a
LA3922	2				6	5	3.5			9	3		2.3	2.9	b
LA3913	1				10	2	3.2			4	7	1	2.8	3.0	bc
LA3914	1				7	4	3.4			5	5	2	2.8	3.1	bcd
LA3941	5				10	2	3.2			1	9	1	3.0	3.1	bcd
LA3923	2				10	2	3.2			2	7	3	3.1	3.1	bcd
LA3929	3,8				5	7	3.6			6	4	2	2.7	3.1	bcd
LA3970	1				7	5	3.4			1	7	4	3.3	3.3	b-e
LA3916	1				5	7	3.6			1	8	3	3.2	3.4	b-e
LA3924	2				5	7	3.6			2	5	5	3.3	3.4	b-e
LA3971	1				5	7	3.6			1	6	5	3.3	3.5	cde
LA3972	2				6	6	3.5				3	9	3.8	3.6	de
LA3915	1				4	8	3.7				4	8	3.7	3.7	e
LA4024 (E6203)					3	9	3.8				5	7	3.6	3.7	e

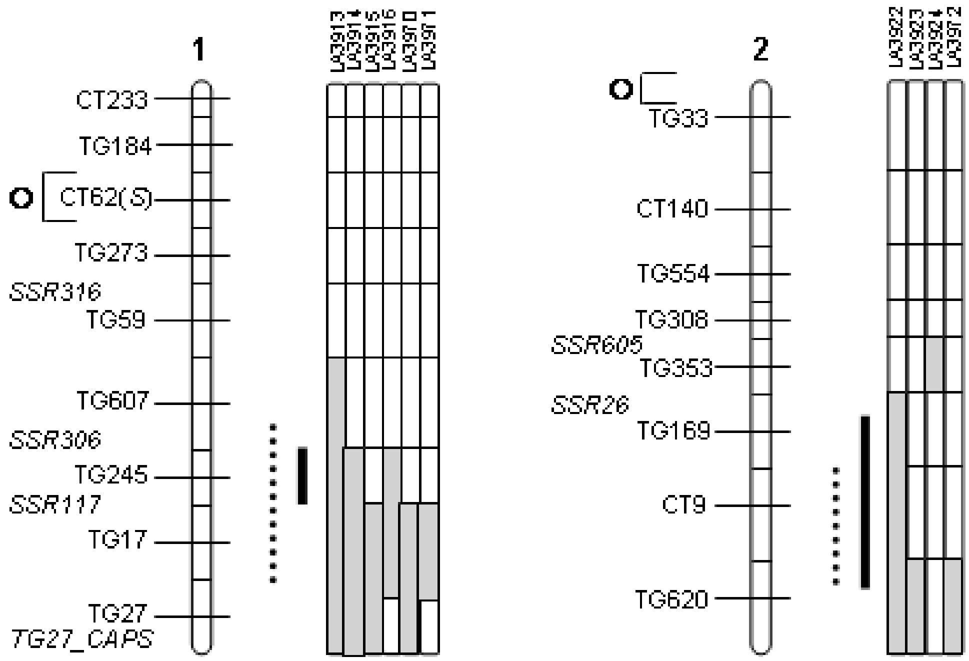
[a] Chrom is the chromosome containing the region introgressed from *L. hirsutum* LA1777.

[b] DSR: 0 = no symptoms; 1 = very few lesions per plant; 2 = about 5 lesions per plant; 3 = numerous lesions per leaf; 4 = numerous lesions per leaf, coalescing lesions and leaf collapse.

[c] Mean separation by least significant difference at 5% level.

introgressions on chromosome 1; and LA3922, LA3923, LA3924, and LA3971, with *L. hirsutum* introgressions on chromosome 2 displayed partial EB resistance; however, variability in DSR scores within each of the above IL was apparent.

EB resistance in LA1777 is multigenic like that of *L. hirsutum* PI126445.[2] It is likely that EB QTL from LA1777 are located on chromosome 1 between TG607 and TG17, and chromosome 2 between TG353 and TG620 (Figure 13). Foolad et al. (2004) also mapped EB QTL on chromosomes 1 and 2 in the same region. However, IL with introgressions on chromosome 9 in our experiment showed no resistance while Foolad (2004) found a large EB QTL on chromosome 9 and additional QTLs on chromosomes 3, 5, 10, 11, and 12. Several colleagues in India have agreed to evaluate resistant ILs and checks for reaction to local pathogen isolates. At AVRDC, it is intended to rescreen the resistant IL chromosome 1 and 2 introgressions and determine if combining QTL improves resistance, using marker-assisted selection.



RFLP markers next to the chromosomes delineate introgressions, single sequence repeat (SSR) and cleaved amplified polymorphic sequences (CAPS) markers offset in italics are PCR-based markers that can be used to differentiate ILs. Putative EB QTL are indicated to the right of the chromosomes by dashed line (Foolad et al.)[2] and solid line (AVRDC). The shaded bars to the far right of the chromosomes show individual introgressions.

Figure 13. Chromosomes 1 and 2 depicting *L. hirsutum* introgressions and putative EB QTL.

Contact: Peter Hanson

Entomology

Nucleopolyhedrovirus for the control of legume pod borer, *Maruca vitrata* (F.) (syn. *M. testulalis*) (Lepidoptera: Pyralidae)

Legume pod borer (LPB), *Maruca vitrata* (F.) (syn. *M. testulalis*) (Lepidoptera: Pyralidae), is the most serious pest that attacks vegetable legumes, an important food crop in the tropics and subtropics of Asia, Africa, Latin America, and Oceania. The larvae attack floral buds, flowers, young pods, and seeds. Twenty to eighty percent yield losses have been reported. As the farmers rely exclusively on the application of chemical insecticides, at times with mixtures of different chemicals applied at intervals of a few days to combat the pest, an integrated pest management strategy needs to be urgently established. Insect pathogenic viruses have been recognized as potential alternatives to chemical insecticides. In spring 2004, diseased LPB larvae were observed in *Sesbania cannabina*, a leguminous green manure crop. Preliminary researches indicated that this is a nucleopolyhedrovirus (NPV). Hence, the virus infecting *M. vitrata* has been characterized using the polymerase chain reaction, restriction enzyme analysis, and electron microscopic observations. Its effectiveness against various larval stages of LPB has also been tested.

Transmission electron microscopy and molecular characterization of NPV. Occlusion bodies (OBs) of the *M.vitrata* multiple nucleopolyhedrovirus (*Mavi*MNPV) were obtained from the diseased LPB larvae collected from the sesbania fields in and around AVRDC. This isolate was propagated in the laboratory reared LPB larvae by feeding the insects with sesbania leaves treated with suspension of the purified OBs. The diseased cadavers were collected and the OBs were purified. OBs were counted using the hemocytometer under a phase contrast microscope. The structural analysis was done at the Department of Entomology, National Taiwan University, Taipei, Taiwan. The structure of viral OBs was studied by transmission electron microscopic (TEM) studies. The viral DNA was extracted from OBs for further molecular studies. Molecular characterization was done at the Southern Taiwan University of Technology, Tainan, Taiwan. The coding region of the polyhedrin gene, which is highly conserved among NPVs, was targeted as template DNA. One set of degenerate primers, primer 35 and primer 36, was selected for amplification of polyhedrin genes of NPVs by polymerase chain reaction (PCR). The PCR reaction was performed using the viral DNA. The genomic DNA of the NPV was digested with restriction enzymes viz., *Hind*III, *Eco*RI, *Bgl*II, and *Pst*I at 37ºC incubation. Restriction profiles were analyzed in a 1% agarose gel electrophoresis. After electrophoresis, the gels were stained with ethidium bromide and exposed to ultraviolet light. Molecular size was determined for all the fragments by using 1 kb plus DNA ladder and *Hind*III markers.

Electron microscopical studies of the ultrastructure of the *Mavi*MNPV OBs showed several virions with multiple nucleocapsids packaged within a single viral envelope (Figure 14). The diameter of OBs was 0.9 to 1.3 µm with a mean of 1.152 $\pm$ 0.116 µm. The PCR analysis revealed that the primer annealed to DNA sequences within the coding region of the polyhedrin gene and yielded an amplified product of approximately 680 bp in length (Figure 15). Restriction analysis of the PCR products with *Hind*III, *Eco*RI, *Bgl*II, and

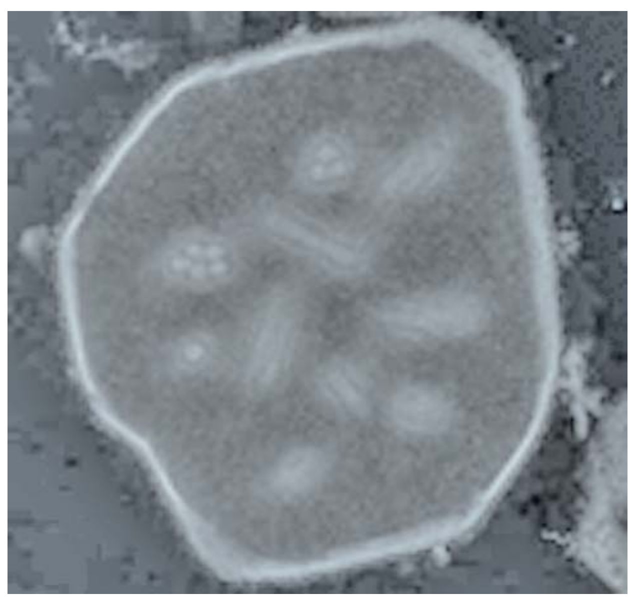


Figure 14. Transmission electron micrograph of the *Mavi*MNPVs occlusion body (OB).

*Pst*I resulted in distinct profiles and the genome size of *Mavi*NPV was estimated to be 113.41 ± 1.50 kbp from the sum of the fragment sizes (Figure 16). This is the first record of this virus from this region.

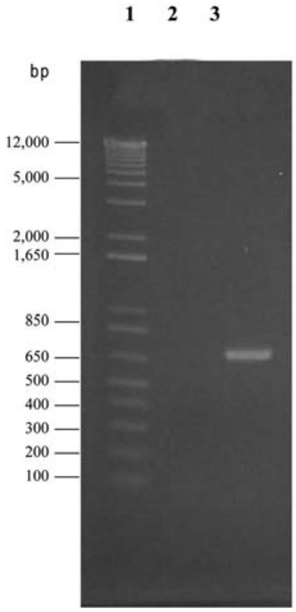


Figure 15. PCR amplification of the polyhedrin gene coding region of *Mavi*MNPV. Lane 1: molecular weight standard (1 kb plus DNA ladder); Lane 2: reagents control (all the PCR reagents included except viral DNA); Lane 3: PCR reaction mixture containing viral DNA.

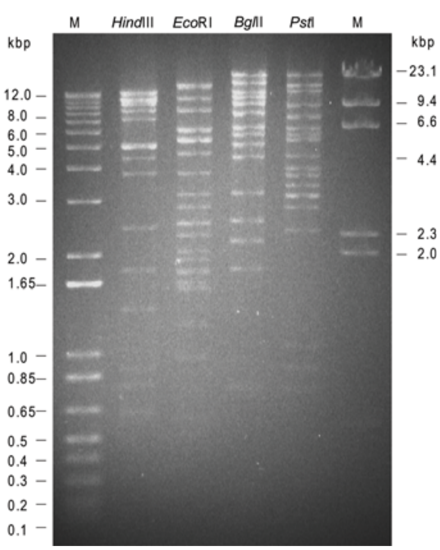


Figure 16. Restriction profile of *Mavi*MNPV genomic DNA digested with *Hind*III (lane 2), *Eco*RI (lane 3), *Bgl*II (lane 4) and *Pst*I (lane 5). The molecular weight standards used were the 1 kb plus DNA ladder (lane 1) and *Hind*III (lane 6).

Pathogenicity of MaviNPV. Biossays were carried out on the first-, second-, third-, and fourth-instar larvae of LPB, which have been starved overnight. A preliminary study was conducted to establish suitable concentrations for each treatment. Based on the larval stage, four to five different concentrations were selected based on the preliminary study. A leaf dip bioassay was conducted. Serial dilutions were made from the purified OBs that have known numbers of OBs/ml. For the control treatment, sterile water was used. Tender sesbania leaflets of uniform size from plants grown in the greenhouse were dipped in the respective concentrations with continuous agitation. The treated leaves were then air-dried and placed in individual plastic cups, which were lined with moist tissue paper. Larvae were transferred to plastic cups and maintained at 27 ± 1°C until pupation or death. After the larvae fully consumed the leaves dosed with virus, they were transferred to fresh, clean leaves placed inside different plastic cups. Thirty larvae were used per treatment in three replications, using the completely randomized design (CRD). Larvae were checked every 24 hours to record the mortality due to virus until they became pupae.

The mean larval mortality was calculated for each dose and the data were subjected to probit analysis using the LdP Line (Ehab Bakr, Cairo, Egypt) and the Statistical Analysis System (SAS) programs. All data were transformed to probits and estimates of median lethal concentration (LC_{50}) of *Mavi*MNPV with 95% fiducial limits were obtained.

Early larval instars (first and second) were more highly susceptible to the *Mavi*MNPV compared to the late instars (third and fourth). First instar was the most susceptible stage (LC_{50} 2.053X10^2 OBs/ml) followed by the second, third, and fourth instars with the median lethal concentrations 1.410 x 10^3, 2.390 x $10^{3,}$ and 2.636 x 10^3 OBs/ml, respectively (Table 32). The efficiency of the *Mavi*MNPV against the late larval instars needs to be improved. Further studies, therefore, are underway to improve the efficacy of *MaviM*NPV, which could reduce the subsequent population build-up of the late larval instars of *M. vitrata.*

Optimizing the viral dose for mass multiplication. To determine the optimum dose of the virus, insects were individually given sesbania leaves, inoculated with five different doses, viz., 10^3, 10^5, 10^7, 10^9, and 10^{11} OBs/ml. They were allowed to feed and develop, and 50 insects were inoculated successfully at each dose. The insects that are still alive after four days were

Table 32. Relative pathogenicity of *Mavi*MNPV to various stages of *Maruca vitrata* larvae

Larval stage	LC_{50}(OBs/ml)	Slope (± SE)	95% Fiducial limits	
			Lower	Upper
First instar	2.053 x 10^2	1.048 ± 0.249	1.307 x 10^2	2.852 x 10^2
Second instar	1.410 x 10^3	0.995 ± 0.256	1.018 x 10^3	1.901 x 10^3
Third instar	2.390 x 10^3	1.558 ± 0.344	1.930 x 10^3	2.820 x 10^3
Fourth instar	2.636 x 10^3	1.095 ± 0.298	1.931 x 10^3	3.359 x 10^3

collected and the OBs were purified. The OB content was determined using a hemocytometer. This experiment was replicated four times, based on CRD.

Table 33 clearly shows that the highest productivity of 6.55 x 10^6 OBs occurs in insects dosed at 10^3 OBs/ml. This was at par with 6.36 x 10^6 OBs at the dose 10^5 OBs/ml ($F_{(4, 15)}$ = 4.601; P = 0.0127). At doses higher than 10^5 OBs, insect survival was lower, accompanied by poor OB production and an overall productivity of less than two million OBs per larva. Hence, the yield of NPV per larvae at higher doses, from 10^7 to 10^{11} OBs, was less than the lower doses. This may be related to the destruction of the midgut by a massive primary infection by NPV accompanied by the more rapid mortality of the larvae.

Table 33. Mean NPV production per larva against dose of NPV received

Dose (OBs/ml)	Mean NPV production per larva (x 10^6)
10^3	6.55 a
10^5	6.36 a
10^7	1.82 ab
10^9	0.82 b
10^{11}	1.19 ab
Tukey's HSD (5%)	5.48
ANOVA	$F_{(4, 15)}$ = 4.601; P = 0.0127

Susceptibility of legume pod borer, *M. vitrata* to the δ-endotoxins of *Bacillus thuringiensis* (Bt)

Yardlong bean (*Vigna unguiculata* ssp. *sesquipedalis*) is one of the most important vegetable crops in Southeast Asia. Yardlong bean (YLB) is infested by the LPB, which causes extensive damage to the reproductive parts and thus drastically decreases the yield. Chemical insecticides are widely used to control the insect, which could adversely affect human health and the environment due to frequent applications and short harvest intervals. Safe, efficient, and eco-friendly pest control strategies are warranted to reduce the pesticide misuse in YLB. Efforts are underway to develop genetically engineered cowpea with genes encoding insecticidal crystal proteins (ICPs) from *Bacillus thuringiensis* (Bt), a soil-borne, gram-positive bacteria against LPB. The ICPs or δ-endotoxins produced during the sporulation of *Bt* are highly species-specific and effective at low concentrations. Hence, screening of the different ICPs against LPB to assess its susceptibility was attempted.

Five Bt δ-endotoxins, viz., Cry1Aa, Cry1Ab, Cry1Ac, Cry1Ca, and Cry2Aa were obtained from Jeroen Van Rie (Bayer BioScience, Belgium). Insect bioassays were done by incorporating the δ-endotoxins in to the LPB artificial diet. A modified semi-synthetic diet was used for bioassays. The diet consisted of 7.0 g of beet armyworm (BAW), *Spodoptera exigua* (Hübner) diet dry mix (Bio-Serve, French Town, NJ, USA), 1.0 g of adzuki bean powder and 0.5 g of agar in 21.5 ml of distilled water. Four to five concentrations of each δ-endotoxin were prepared, based on the preliminary range-finding tests, and mixed with the diet. The diet was poured into five clear plastic cups (4.5 cm high and 4 cm wide) and allowed to solidify. Five second-instar larvae were released into each cup and covered with lids. The cups were incubated at 27 ± 1°C, and 70 ± 10% r.h., L12:D12. Larval mortality was recorded after four days and the toxicity was assessed using probit analysis.

Table 34 shows the relative efficacy of δ-endotoxins against second-instar larvae of LPB. The toxin Cry1Ab was the most potent toxin followed by Cry1Ca, Cry1Aa, Cry2Aa, and Cry1Ac in descending order. Hence, expression of Cry1Ab and Cry1Ca in transgenic YLB would possibly provide better protection against LPB. However, continuous and large-scale cultivation of transgenic YLB with a single Bt gene may pose as a problem later as insect resistance to the transgenic YLB could develop. Hence,

Table 34. Relative toxicity of Bt δ-endotoxins to *Maruca vitrata* larvae

Bt δ-endotoxin	LD_{50} (µg/g)
Cry1Aa	0.811
Cry1Ab	0.201
Cry1Ac	1.678
Cry1Ca	0.475
Cry2Aa	1.053

the transgenic YLB should be developed using two Bt genes, which would have different target sites in the midgut of LPB. Thus, it is imperative to characterize the Bt toxin receptors in the midgut of LPB. However, commercial Bt formulations containing Cry1Ab and Cry1Ca toxins may immediately be used to control LPB in YLB.

Studies on the parasitoids of legume pod borer, *M. vitrata*

Sesbania cannabina is a leguminous green manure crop, grown over a large area in Taiwan during summer months. LPB larvae feeds concealed inside leaf whorls of sesbania. As sesbania is not sprayed with any pesticides, a large number of natural enemies were found attacking LPB. A tachinid fly, which occurred in high numbers in 2004 was collected and sent for identification to the Natural History Museum, UK. It has been identified as *Nemorilla maculosa* (Meigen) (Diptera:Tachinidae), which is an ectoparasitoid. Though it has a wide host range, experiments at AVRDC–The World Vegetable Center showed that it preferred LPB larvae in vegetable legumes and cabbage head caterpillar (CHC), *Crocidolomia binotalis* larvae in crucifers. Hence, it could be conserved and/or augmented in vegetable legumes and crucifers to control the LPB and CHC larvae, respectively.

Preliminary experiments were carried out to determine the suitable host's larval stage for mass producing the parasitoid, *N. maculosa*. Fresh larvae of CHC were collected from AVRDC's insect rearing facilities. Fifty larvae were selected from each larval instar and placed on cabbage leaves. Each group was exposed to five pairs of *N. maculosa* adults. Insects were kept together for six hours after which the parasitized CHC larvae were removed from the cages. These were maintained at 27 ± 1°C, and 70 ± 10% r.h., until parasitoids or CHC adults emerged from them. A total of four such tests were conducted.

The percent parasitism of CHC by *N. maculosa* and percent parasitoid adult emergence are given in Table 35. *N. maculosa* is a larval-pupal parasitoid. It usually lays eggs on the host larva, with the parasitoid larva growing inside the host larva until the host larva

Table 35. Parasitism of cabbage head caterpillar (CHC), *Crocidolomia binotalis* by *Nemorilla maculosa*

Larval stage (instar)	Host larval mortality (%)	Host adult emergence (%)	Parasitoid adult emergence (%)
First	0.50 b	99.50 a	0.00 b
Second	0.00 b	100.00 a	0.00 b
Third	19.00 a	81.00 b	0.00 b
Fourth	21.00 a	78.00 b	1.00 b
Fifth	28.00 a	18.00 c	54.00 a
Tukey's HSD (5%)	14.50	8.60	12.42
ANOVA	$F_{(4, 15)} = 13.01$, $P < 0.0001$	$F_{(4, 15)} = 257.7$, $P < 0.0001$	$F_{(4, 15)} = 63.28$, $P < 0.0001$

becomes a pupa. Nearing its pupation, parasitoid larva comes out of the host pupa and becomes a pupa, thus, killing the host insect (Figure 17). In general, the parasitoid prefers the late host larval stages for egg laying to ensure proper growth of its progeny. About 19 to 28 percent larval mortality was recorded in the third to fifth host larval instars ($F_{(4, 15)} = 13.01$; $P < 0.0001$). The parasitoid sometimes lays more eggs on a single host larva, thus, inflicting larval mortalities (Figure 18). As the parasitoid did not prefer to attack the first and second host larval instars, these were relatively safer as adult emergence was almost 100%, which was significantly different from other larval stages ($F_{(4, 15)} = 257.7$; $P < 0.0001$). Although 19–21% mortality was recorded in third and fourth larval instars, the majority of the population managed to avoid the parasitization, with host adult emergence at 78–81%, as the larvae could shed the parasitoid eggs before hatching during host larval molting (Figure 19). The fifth instar larva, however, was highly vulnerable to the parasitoids as these could not shed the eggs. Hence, most of the larvae died during immature stages and the host adult emergence was only 18%. The parasitoid adult emergence was 54% in the fifth host larval instar, which was significantly different from other larval stages ($F_{(4, 15)} = 63.28$; $P < 0.0001$), indicating that the fifth larval instar is most suitable for mass producing this parasitoid for augmentation.

Two unidentified hymenopteran parasitoids, which occurred in high numbers in 2005, were also collected and sent for identification to the Natural History Museum, UK. These have been identified as *Trathala* sp. (Figure 20) and *Triclistus* sp. (Figure 21).

Figure 17–21. From left to right: a) Pupae of *N. maculosa* with LPB (host) pupae; b) Super parasitism of CHC larvae by *N. maculosa*; c) Exuvia (moulted skin) of CHC larvae with *N. maculosa* eggs; d) *Trathala* sp. attacking LPB larvae; e) *Triclistus* sp. attacking LPB larvae.

Integrated crop management system for safer tomato production

Tomato production in the tropics and subtropics is challenged by several biotic constraints like tomato fruit worm, *Helicoverpa armigera*, whitefly, *Bemisia tabaci*; Tomato leaf curl virus; bacterial wilt diseases; and abiotic constraints like blossom end rot. Tomato farmers rely on large quantities of fertilizer, pesticide, and fungicide to obtain high yields and good-quality fruits. The indiscriminate use of fertilizers induces excessive nutrients without necessarily improving the productivity of fruits; the heavy pesticide applications pollute the environment, increase the resistance in insects, induce resurgence, and cause pesticide residue problems. Hence, an attempt was made to produce safer tomato in spring, autumn, and summer seasons with optimum chemical inputs. Techniques such as growing healthy seedlings, using balanced and optimum organic and chemical fertilizers, encouraging nonpesticide methods of pest management, and using minimum and efficient pesticides were integrated to reduce the use of chemical inputs (fertilizers and pesticides) in tomato production. The aim was to develop a standard operating procedure to grow safer tomato and maintain a safer environment.

The varieties used were: FMTT 904 (fresh tomato), which is resistant to bacterial wilt, ToLCV, and ToMV; and CHT 1358 (cherry tomato), which is resistant to ToLCV and ToMV. Adoption of disease-resistant varieties could reduce pesticide applications in tomato production. The disease-resistant seedlings were raised in 32-mesh nethouse. Optimum irrigation was followed to prevent soil-borne diseases and yellowing of leaves. Foliar fertilization was done at the end of the seedling stage. Yellow sticky traps were hung in the seedling nursery to trap small insect pests, thereby reducing pesticide use.

About 0.1 ha land was rototilled. Composite soil samples were collected before transplanting, and basic soil properties, such as EC, pH, inorganic N, total N, organic matter, and available P and K were analyzed. Optimum doses of fertilizers were adjusted based on the analytical results of soil. Balanced fertilization technology was adopted for both fresh and cherry tomatoes. Organic and inorganic fertilizers were applied as basal fertilizers before transplanting. The land was then divided into 1.5-m-wide and 40-m-long beds. Four-week-old seedlings of each entry were transplanted on 21 February 2005. Small amounts of concentrated liquid solution were then applied near the root zone immediately after transplanting, followed by furrow irrigation. The level of water was not too high and allowed the surface soils on the bed to become moist by capillary force.

Similar amounts of liquid fertilizers were also applied during the first and third side dressings. Solid inorganic fertilizers were supplemented as second, fourth, and fifth side-dressings. Total fertilization amounts for fresh tomato and cherry tomato were equivalent to 300-250-270, 296-247-267 ($N-P_2O_5-K_2O$) kg/ha, respectively. After harvest, soil analysis was carried out to monitor the nutrient residues in soil under field conditions. The branches were pruned into two or four branches, according to the varietal character. Hand weeding was done. Yellow sticky traps were used to monitor pest populations, and to schedule pesticide spraying by following the Plant Protection Manual.

The yield was recorded during different harvests. The marketable yields of fresh market tomato and cherry tomato were 40.31 and 66.11 t/ha, respectively (Table 36), which were significantly different ($F_{(4, 15)}$ = 1009; $P < 0.0001$ and $F_{(4, 15)}$ = 5104; $P < 0.0001$) from the unmarketable yield losses due to physiological disorders like blossom end rot (BER), cracking, deformation, among others, and insect pests like tomato fruit worm, *Helicoverpa armigera*, and common armyworm, *Spodoptera litura*. The unmarketable fruit percentage in fresh tomatoes were 24.21%, mostly caused by BER. Only 1.4% (fresh market) and 0.6% (cherry) of the total yield losses were caused by insect pests. The success of safer tomato production with optimum pesticide and fertilizer application was demonstrated to farmers during the field day conducted in May 2005.

Table 36. Yield of tomato under safer tomato production systems

Marketable/Unmarketable tomato	Yield (t/ha) ± SD	
	FMTT 904	CHT 1358
Marketable	40.31 ± 2.53 a	66.11 ± 2.48 a
Damaged (physiological disorders)	13.12 ± 1.81 b	3.45 ± 0.54 b
Damaged (insect pests)	0.76 ± 0.25 c	0.45 ± 0.10 c
Tukey's HSD (5%)	1.88	1.53
ANOVA	$F_{(4, 15)}$ = 1009 $P < 0.0001$	$F_{(4, 15)}$ = 5104 $P < 0.0001$

Contact: Srinivasan Ramasamy

Phylotype identification and phylogenic relationships of *Ralstonia solanacearum* strains isolated from different hosts in Taiwan

Bacterial wilt (BW) caused by the soil-borne plant pathogenic bacterium *Ralstonia solanacearum* is a destructive disease to many economically important crops like tomato, eggplant, groundnut, pepper, and potato. *R. solanacearum* is a heterogeneous species with significant phenotypic and genetic diversity. A stable and meaningful classification system to group *R. solanacearum* strains into clusters of strains that relate to epidemiology, pathogenicity, host range, and geographic origin is an essential tool for plant breeders, plant pathologists, and quarantine officials. Traditionally *R. solanacearum* has been classified into five races and five biovars on the basis of host range and carbon utilization, respectively. Recent studies on the genetic relatedness and phylogeny of *R. solanacearum* strains have revealed that the species complex is comprised of four broad genetic groups corresponding to its geographic origin (Asia, America, Africa, and Indonesia). Under a new classification system proposed by Fegan and Prior, *R. solanacearum* species complex can be divided into four phylotypes consistent with four genetic groups based on sequence analysis of the non-coding but internal transcribed spacer (ITS) region between the 16S and 23S rRNA genes, the *hrpB* gene, and the endoglucanase gene. Phylotype I is composed of strains belonging to biovar 3, 4, and 5 isolated primarily from Asia.[5] Phylotype II is composed of strains belonging to biovar 1, 2, and 2T isolated primarily from America. The potato strains of race 3 and banana strains of race 2 were included in Phylotype II. Phylotype III is composed of strains belonging to biovar 1 and 2T isolated primarily from Africa and its surrounding islands. Phylotype IV is composed of strains belonging to biovar 1, 2, and 2T isolated primarily from Indonesia. *Pseudomonas syzygii* and the blood disease bacterium genetically close with *R. solanacearum* were included in Phylotype IV. In Taiwan, bacterial wilt has been reported on common hosts like tomato and many uncommon hosts like Perilla (*Perilla crispa* Tanaka), among others. Although all Taiwanese strains of *R. solanacearum* tested are race 1 and biovar 3 or 4, it is not clear whether the diverse strains all evolved from a single origin. Therefore, the objectives of this study include: 1) to determine the phylotype of Taiwan strain; and 2) to determine the phylogenetic relationships of strains in Taiwan using endoglucanase partial gene sequences.

A total of 157 strains of *Ralstonia solanacearum* isolated from different host plants, soil, and water were selected from the collection maintained at AVRDC. Bacterial cells of each strain were harvested from overnight cultures and genomic DNA from each strain was extracted using the method of Chen and Kuo. Phylotype identification was conducted following the protocol described by Fegan and Prior (2005). It is a multiplex PCR using primers designed from the transcribed ITS region and species-specific primer pairs. The primer sequences are Nmult21:1F (5"-CGT TGA TGA GGC GCG CAA TTT-3'), Nmult21:2F (5'-AAG TTA TGG ACG GTG GAA GTC-3'), Nmult22:InF (5'- ATT GCC AAG ACG AGA GAA GTA-3'), Nmult23:AF (5'-ATT ACG AGA GCA ATC GAA AGA-3'), AU759f (5'- GTC GCC GTC AAC TCA CTT TCC-3'), and AU760r (5'- GTC GCC GTC AGC AAT GCG GAA TCG-3'). PCR amplification was performed in the MJ Research PTC100 thermocycler (MJ Research, Waltham, MA, USA). The initial denaturation at 96°C for 5 min was followed by 35 cycles of 94°C for 15 seconds, 59°C for 30 seconds, and 72°C for 30 seconds. The final extension was at 72°C for 10 min. The PCR products were separated by 2% agarose gel electrophoresis in 1x Tris-acetate-EDTA (TAE) buffer at 5 V/cm and visualized with UV light after ethidium bromide staining. An 850-bp fragment of the endoglucanase gene was amplified using the primer pair Endo-F (5'-ATG CAT GCC GCT GGT CGC CGC-3') and Endo-R (5'-GCG TTG CCC GGC ACG AAC ACC-3') according to the method of

[5] Fegan, M. and Prior, P. 2005. How complex is the *Ralstonia solanacearum* species complex? In: Allen, C., Prior P., and Hayward A.C., eds. *Bacterial wilt disease and the Ralstonia solanacearum species complex.* St. Paul, MN: APS Press. p. 449–461.

Fegan et al. (1998).[6] PCR products were purified and sequenced. The DNA sequences of the endoglucanase gene were analysed using the ARB Software Environment. Sequences were aligned using the ARB sequence editor. Evolutionary distances between sequences were computed by using the algorithm of Jukes and Cantor of the DNADIST program of the PHYLIP package. Phylogenetic trees were constructed from genetic distance values using the neighbor-joining method of the NEIGHBOR program of the PHYLIP package.

In this study, we have included strains of *R. solanacearum* isolated from 32 different hosts, soils, and water around Taiwan. Using the multiplex PCR protocol with primers designed from ITS region, the 144 bp fragment specific to Phylotype I was observed from all tested strains except two potato strains (Pss525 and Pss526), while Phylotype II-specific 372 bp fragment was observed from Pss525 and Pss526. These two strains were isolated in 1999 in central Taiwan where outbreaks of potato brown rot occurred. Studies have indicated that the pathogen causing this outbreak was race 3 (biovar 2) of *R. solanacearum*. Partial endoglucanase gene sequences of 154 Taiwanese strains of *R. solanacearum* were determined and aligned. The phylogenetic relationships according to endoglucanase gene sequences analysis was analyzed together with other strains in the global database maintained by P. Prior at the French National Institute for Agricultural Research (INRA)/Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), France. Results indicated that Taiwanese strains all fell within phylotype I except for two potato strains which fell within phylotype II (Figure 22). A significant finding was the separation of phylotype I strains into two groups. Group 1 consisted of 27 Taiwanese strains which include Pss190 and six strains from other Asian countries. These six strains are from Indonesia (T41 from tomato), Australia (ACH007, ACH092, JS834 from ginger), and Japan (CFBP765 from tobacco; and MAFF211266 from tomato). Group 2 consisted of 127 Taiwanese strains and 32 strains from Asia/Pacific, Indian Ocean, and Caribbeans/Central America. GMI1000, the strain with its genome sequence available, is grouped here. Before the inclusion of the additional 154 Taiwanese strains, Pss190 has been separated from the other Phylotype I strains (Prior, personal communication). Here, existence of a group of strains similar with Pss190 within Phylotype I was confirmed. Due to the large number of strains used in this study, only one strand of the endogluconase gene was sequenced. Thus, strains located in major branching positions will be selected and grouped to confirm their sequence by sequencing both strands.

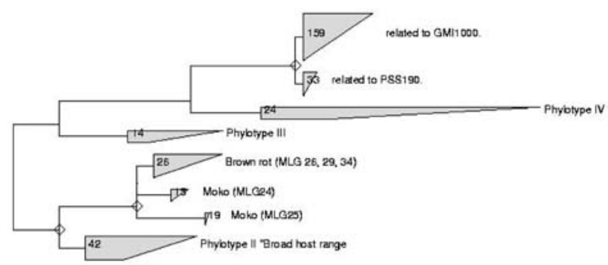


Figure 22. Phylogenetic relationships of *Ralstonia solanacearum* Taiwanese strains together with global representative strains based on endoglucanase gene sequence analysis (prepared by P. Prior).

In conclusion, the multiplex PCR protocol using primers designed from ITS region is capable of differentiating the two biovar 2 potato strains. This result agree with Fegan and Prior's phylotype concept and, hence, would be a useful tool for epidemiology, quarantine, and other research.[5] The division of Phylotype I strains based on the endogluconase gene sequence is a major finding. The result needs to be confirmed and more strains from different Asian countries should be studied to trace the origins.

[6] Fegan, M., Taghavi, M., Sly, L. I., and Hayward, A. C. 1998. Phylogeny, diversity, and molecular diagnostics of *Ralstonia solanacearum*. Pages 19-33 In: Bacterial wilt disease: molecular and ecological aspects. P. Prior, C. Allen, and J. Elphinstone, eds. Springer, Berlin.

Managing tomato bacterial wilt with resistant rootstocks in combination with urea and slacked lime mixture in the field

Bacterial wilt caused by *Ralstonia solanacearum* is a major constraint of 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 disease control a formidable task. Planting resistant material has been the main strategy for disease control. Resistant tomato or eggplant varieties have been used as rootstocks particularly when commercial cultivars with high resistance are not available. However, resistance to bacterial wilt in tomato can be location- or strain-specific. Resistance to bacterial wilt in eggplant could have similar properties. Reducing initial pathogen density is a common strategy in controlling soil-borne diseases. A mixture of urea and lime has been reported to have significant control on tomato bacterial wilt. However, the efficacy can be soil-dependent. To address the strain-specific problem of host resistance, strains of *R. solanacearum* were collected from targeted regions in Taiwan, i.e., Chunglin of Hsinchu (CL), Hsinshe of Taichung, Kuantien of Tainan (KT), and characterized for their aggressiveness. Predominant strains were selected to evaluate a set of resistant rootstock varieties. Eggplant variety, EG203, was found to have stable and high resistance against all tested strains. Tomato variety Hawaii 7996 was found to be the most resistant tomato variety among the tested strains but its resistance level is lower than EG203. Thus, these two varieties were used as rootstock in this study. To address the soil-dependent nature of urea and slacked lime mixture, soils from the field trial sites in CL, KT, Taiwan Seed Multiplication and Propagation Station (TSS) in Hsinshe, Taichung, and AVRDC were used to determine its biocidal effect at 30ºC. The soil amendment (SA) was found to have significant biocidal effect in AVRDC, CL, and TSS soils, but not in KT soil. The effect was particularly large in AVRDC and CL soils, where the pathogen was suppressed to an undetectable level. The objectives of this study were to evaluate the control efficacy of resistant rootstock and urea/slacked lime mixture, individually or jointly, in targeted areas and to relate the results with pre-evaluated results.

A total of four field trials were conducted. Information on the trial site are listed in Table 37. Strains presented in the trial sites all belong to race 1 and biovar 3 or 4 of *R. solanacearum*. The CL and KT fields have similar cropping systems, on which paddy rice is grown in spring or summer or both before tomato. Both sites had a history of tomato bacterial wilt, with a severe outbreak in fall 2002. In order to maintain pathogen density in the trial site, cherry tomato and yardlong bean, instead of paddy rice, were cultivated from winter 2002 to spring 2003 in CL and KT sites, respectively. At AVRDC, the trial was conducted in an artificial disease nursery, which has been infested regularly for bacterial wilt experiments. At TSS, soil was naturally infested and routinely used for screening of resistant materials to bacterial wilt. Total of six treatments, with all possible combinations between application and none application of SA, and three planting materials were conducted. The soil amendment was a mixture of urea (825 kg/ha) and $Ca(OH)_2$ (3993 kg/ha). The planting materials included Taichung-AVRDC No.10 (ASVEG10), ASVEG10 grafted on EG203, or ASVEG10 grafted on Hawaii 7996. The experiment was arranged in RCBD with three replications. The plot size was 22 m × 1.5 m and there were 100 plants per plot with spacing of 45 cm between plants. On-farm trials started by applying SA on 14

Table 37. Information of field trial sites

Trial code[a]	Soil texture (sand/silt/clay%)	pH[b]	Transplanting date (dd/mm/yr)	Mean max/min T (°C)[c]	Mean RH (%)[c]	Rainfall (mm)[c]
CL	19/58/23	5.4	18/08/03	30/23	75	67
KT	18/62/20	6.0	12/09/03	30/20	71	84
AVRDC	56/32/12	7.1	05/07/04	32/24	69	972
TSS	30/38/32	5.2	01/09/04	24/15	68	259

[a] Trial codes: CL trial was located at Chunglin, Hsinchu; KT trial located at Kuantien, Tainan; AVRDC trial located in the research farm of AVRDC at Shanhua, Tainan; TSS trial located at mid-elevation (470 masl) at the research farm of Taiwan Seed Improvement and Propagation Service, Hsinshe, Taichung.
[b] pH was determined with 0.01M $CaCl_2$ in the ratio of 1:2 (w/v).
[c] Mean maximum and minimum temperature (T), relative humidity (RH), and total rainfall during trial period.

July 2003, 15 August 2003, 4 June 2004, and 27 July 2004, at CL, KT, AVRDC, and TSS site, respectively. Seedling transplanting was conducted about one month after SA application, and all trials ended at 105 days after transplanting. Disease incidence was recorded every three weeks until the end of each trial. Relative area under disease progress curve (RAUDPC) was calculated by dividing AUDPC by the trial duration. Yield was calculated based on harvests during a 42-day period at two months after transplanting. For fruit quality measurements, ten mature fruits per treatment per replication were picked from 10 plants (one fruit per plant) at the second harvest.

Disease development of all treatments in the field trials followed a sigmoidal pattern and maximum incidence was observed at 63 or 84 days after transplanting. However, disease pressure varied among trials, judging from the final disease incidence of the control treatment. The lower temperature at TSS site, due to its higher elevation and use of pipe irrigation, could result to its low disease pressure. In KT site, on the other hand, initial pathogen density was low and the field has been kept under low soil moisture as compared with other trials. Despite the difference in disease pressure, the ranking of control efficacy over treatments was similar over trials (Table 38). Analysis of variance, using either transformed data of final disease incidence or RAUPDC data, indicated significant plant material effect in all trials. The SA effect was only significant for non-grafted plants in AVRDC trial using transformed final disease incidence and in CL, AVRDC, and TSS trials using RAUDPC. Significant interaction between the two factors was detected only in the AVRDC trial using either parameter. Eggplant rootstock EG203 provided the best control effect in reducing final incidence as well as suppressing disease development (Table 38). At seedling screening, EG203 showed high and stable resistance against all tested local strains. Control efficacy of Hawaii 7996 rootstock was similar or significantly lower than EG203, but could still provide significant control efficacy under both high and low disease pressure conditions. Performance of the planting materials in the field correlated well with seedling screening results against local pathogen strains. The effect of soil amendment is more on suppressing the disease development than on reducing the final incidence (Table 38). This soil amendment displayed significant biocidal effect in AVRDC, CL, and TSS soil when incubated at 30ºC and similar results were observed in field trials. This suggested that a pre-evaluation at 30ºC can be useful in predicting the field control efficacy of biocidal soil amendments. Under high or low disease pressure, application of SA had no effect on yield or fruit quality. Grafting onto resistant rootstock could drastically increase yield compared with the non-grafted control (Table 39). Although eggplant rootstock provided better disease control than tomato rootstock, it did not have significantly higher yield than that of tomato rootstock. Effect of rootstock on fruit quality was not consistent. This suggests that environment as well as cultural practices could affect fruit quality. Synergistic effect of these two factors on disease control and yield increase was only observed in the case of integrating Hawaii 7996 rootstock and SA in the CL trial. This implies that the use of SA is most beneficial when moderate resistant plant materials and high disease pressure condition coexist.

Table 38. Effect of resistant rootstock and soil amendment (SA) on the suppression of tomato bacterial wilt in four field trials

Plant materials[a]	Final % wilted plant			RAUDPC		
	SA[b]	No SA	No SA – SA	SA	No SA	No SA – SA
CL						
EG203	0.9 b[c]	2.8 c	1.9[ns]	0.4b	1.5 c	1.1[ns]
Hawaii 7996	18.4 b	47.4b	29.0[ns]	8.3b	24.2b	15.9[*]
Non-grafted	88.4 a	92.9a	4.5[ns]	54.5a	64.5a	10.0[ns]
Mean	35.9	47.7	11.8[ns]	21.1	30.1	9.0[*]
KT						
EG203	0.7b	2.3 b	1.6[ns]	0.4 a	1.0 a	0.6[ns]
Hawaii 7996	16.5 ab	9.9 b	-6.6[ns]	7.4a	5.0 a	-2.4[ns]
Non-grafted	34.8 a	40.8 a	6.0[ns]	17.7 a	22.7 a	5.0[ns]
Mean	17.3	17.7	0.4[ns]	8.5	9.6	1.1[ns]
AVRDC						
EG203	0.0 c	0.7 c	0.7[ns]	0.0 b	0.4 b	0.4[ns]
Hawaii 7996	15.0 b	17.5 b	2.5[ns]	7.6 b	8.3 b	0.7[ns]
Non-grafted	54.7 a	88.1 a	33.4[**]	31.5 a	51.6a	20.1[**]
Mean	23.2	35.4	12.2	13.0	20.1	7.1
TSS						
EG203	0.0 b	0.0 c	0.0[ns]	0.0 b	0.0 b	0.0[ns]
Hawaii 7996	2.2 b	7.0 b	4.8[*]	0.6 b	2.6 b	2.0[ns]
Non-grafted	19.1 a	24.4 a	5.3[ns]	8.3 a	11.3 a	3.0[ns]
Mean	7.1	10.5	3.4[ns]	3.0	4.6	1.6[*]

[a] Plant materials were non-grafted or grafted seedlings (on EG203 or Hawaii 7996) of ASVEG 10.

[b] SA means application of mixture of urea (825 kg/ha) and $Ca(OH)_2$ (3993 kg/ha); No SA means none application; No SA – SA means difference between the two treatments by planting materials and by trials.

[c] Data of final % wilted plant were transformed with arcsine square root before statistical analyses. Mean separation in a column by location by LSD (5%); **, *, ns mean significant at $P < 0.01$ and 0.05, and not significant, respectively.

Table 39. Effect of resistant rootstock and soil amendment on yield and quality of tomato cultivar ASVEG 10 in two field trials

Plant	Yield (mt/ha)		Fruit weight (g)		Soluble solid (Brix°)		Acidity (% citric acid)	
materials[a]	SA[b]	No SA	SA	No SA	SA	No SA	SA	No SA
CL								
EG203	35.7 a[c]	35.8 a	166 a	160 a	5.2 a	5.4 a	0.44 a	0.44 a
Hawaii 7996	37.2 a	23.3 a	177 a	161 a	4.9 b	4.8 b	0.38 b	0.40 b
Non-grafted	1.8 b	2.0 b	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
KT								
EG203	41.0 a	46.6 a	132 b	127 b	4.3 a	4.5 a	0.36 a	0.38 a
Hawaii 7996	50.0 a	51.6 a	140 a	150 a	4.4 a	4.4 a	0.34 a	0.38 a
Non-grafted	35.9 a	30.1 a	137 ab	125 ab	4.9 a	4.4 a	0.38 a	0.38 a

[a] Same as in Table 38.
[b] Same as in Table 38.
[c] Means with the same letter are not significantly different at 5% level according to Fisher's least significant difference *t*-test by location. Comparison between SA and no SA is not significant. n.a. means that data is not available due to insufficient fruit samples.

Mapping quantitative trait loci associated with resistance to bacterial wilt in tomato line Hawaii 7996

Bacterial wilt caused by race 1 strains of *Ralstonia solanacearum* is a devastating disease of tomato production in warm and humid regions worldwide. Symptom development is highly affected by environment, including pathogen strain, temperature, and soil properties. DNA markers, therefore, linked to resistance alleles will be very valuable in breeding resistant varieties. A tomato variety, Hawaii 7996 (H7996), has been identified as the most stable resistance source after its field testing in 10 countries, challenging diverse strains under different environments. The F_2 cutting or F_3 families of the cross between Hawaii 7996 and West Virginia 700 (WVa700) have been used to map quantitative trait loci (QTL) associated with resistance. Mapping results were different when different strains and inoculation methods were used. A major constraint is the limited polymorphism between the two parents. Hence, the objectives of this study were: 1) to evaluate the recombinant inbred population (F_8 generations) of H7996 x WVa 700 for resistance to bacterial wilt with different strains and under different environments; 2) to identify polymorphic molecular markers using SSR markers and diversity arrays technology (DArT) markers; 3) to map QTL associated with stable resistance in Hawaii 7996. This study is collaboratively undertaken by AVRDC–The World Vegetable Center; Diversity Arrays Technology Pty Ltd., Australia; Institute of Plant Breeding, University of the Philippines at Los Baños, Philippines; Université de La Réunion, La Réunion, France; PT. East–West Seed, Indonesia; Marco Polo Seed Ltd., Thailand; East–West Seed Company Ltd., Thailand; and the Indian Institute of Horticultural Research, India.

The cross between H7996 and WVa700 was originally made in INRA, France and advanced to F_3 generation. UPLB and AVRDC continued to advance the population to F_8 lines and a population consisting of 188 recombinant inbred lines was used for this study. The mapping population, two parents and a susceptible check, L390 were evaluated for disease reaction against local pathogen strains in a total of 11 field or greenhouse trials conducted in India, Indonesia, Philippines, Taiwan, Thailand, and Réunion. All strains used or present in the trials were race 1, biovars 3 or 4, except in Réunion where a strain of race 3, biovar 2 isolated from potato was used.

Disease incidence, measured as percentage of wilted plants, of the resistant and susceptible parents ranged from 0–20% and 60–100%, respectively, while mean incidence for the mapping population was 10–83% (Table 40). Final disease incidence data after arcsine square root transformation were employed for mapping resistance to BW. A total of 338 polymorphic DArT and SSR molecular markers were identified and mapped. A linkage map of 132 evenly distributed markers was generated and used for QTL analysis. Results of composite interval mapping identified 10 QTLs significantly associated with variation in resistance in nine trials. The number of QTLs and

Table 40. Mean percentage of wilted plants observed on two parental lines and the mapping population

Trial code	Country	Race[a]	H 7996	WVa 700	RIL
IIHR	India	1 (F)	0.0	59.6	9.6
JT519	Reunion	1 (S)	0.0	79.7	20.6
ThaiEW	Thailand	1 (F)	0.0	100.0	41.3
ThaiMP	Thailand	1 (S)	0.0	95.8	36.7
TSS	Taiwan	1 (F)	15.0	100.0	44.4
Pss186	Taiwan	1 (S)	4.2	86.5	56.7
Pss4	Taiwan	1 (S)	19.8	96.9	70.4
JT516	Reunion	3 (S)	19.9	89.2	76.4
TM22	Philippines	1 (S)	0.0	100.0	76.7
TM151	Philippines	1 (S)	18.8	100.0	83.3

[a] Races of the strains used in seedling screening or present in the field trial site. Trials were conducted at seedling stage (S) or in the field (F).

amount of total variation contributed by each QTL vary over trials (Table 41). Among them, four QTLs were identified from more than one trial and could contribute to durable resistance. A major QTL mapped on chromosome 3 between TG564 and K4a showed a significant effect in six trials and accounted for 10.6 to 43.6% of the phenotypic variation. A second QTL mapped on chromosome 4 between markers af37g and D1249B11 was important in five trials and accounted for 6.9–14.5% of the phenotypic variation. Two QTLs were found on chromosome 6 confirming results from previous studies. The QTL located within the TG325 and TG178 interval was important for resistance to both race 1 and race 3.

In conclusion, four significant QTLs that are associated with stable resistance to BW in Hawaii 7996 were mapped. Fine-mapping of the selected QTLs is ongoing and interactions among QTL will be evaluated.

Table 41. Variation of major QTL controlled that was detected using composite interval mapping method

Trial code	Total QTL[a] number (%)	Chromosome 3 TG564 – K4a 10.5cM (%)	Chromosome 4 af37g – D1249B11 3.7cM (%)	Chromosome 6 TG325 – TG178 7.4cM (%)	Chromosome 6 TG153 – D1304O23 22.3cM (%)
IndoEW	3 (70.2)	43.6	10.5	-	-
Pss186	4 (50.7)	18.0	10.0	13.0	-
TSS	4 (47.4)	10.6	6.9	-	17.7
JT519	2 (45.4)	22.7	-	-	22.7
ThaiMP	3 (41.7)	-	14.0	15.2	-
Pss4	3 (35.5)	-	14.5	11.2	-
IIHR	1 (20.4)	20.4	-	-	-
JT516	1 (12.2)	-	-	12.1	-
TM22	1 (11.2)	-	-	-	-
ThaiEW	0	-	-	-	-
TM151	0	-	-	-	-

[a]Total number of QTLs detected and the total variation they explained (shown in the parentheses) in each trial.

Contact: Jaw-fen Wang

Mycology

Summary of tomato late blight studies at AVRDC from 1991 to 2005

Late blight (LB), caused by *Phytophthora infestans*, is one of the most destructive diseases affecting both tomato and potato in cool and rainy environments. The pathogen has caused numerous epidemics on tomato and potato since it was first identified. The disease has increased in severity around the world in recent years and is believed to be associated with the migration of new and more aggressive populations of the pathogen. Since 1991, AVRDC has characterized the phenotype and genetic characters of *P. infestans* isolates collected in Taiwan. Damaging late blight epidemics have busted tomato and potato crops in Taiwan since 1998. It is obvious that the epidemic outbreak is due to the migration of a new genotype, US-11, which appears to be more aggressive and carries resistance to metalaxyl. The US-11 genotype became the predominant population by replacing the original US-1 genotype in Taiwan after 1998. Only a few tomato varieties in the world are reported to have resistance to late blight and these are not effective against races of the pathogen found in most regions. For this reason, AVRDC initiated a program in 1991 to identify additional resistant sources in *Lycopersicon* spp., and subsequently introgress resistance from identified sources into advanced tomato lines. In this report, the population shift of *P. infestans*, identification of resistant sources, and the durability of the AVRDC advanced resistant tomato lines to late blight from 1991 to 2005, are summarized.

A total of 556 isolates of *P. infestans*, mostly from tomato, have been collected in Taiwan since 1991, including 104 isolates collected in 2005. The population shift of *P. infestans* was analyzed by phenotype and genotype characterization. The phenotypes of these isolates were characterized for host specific pathogenicity, mating type, in vitro assessment of metalaxyl sensitivity, and putative physiological race at AVRDC. The molecular genotypes of the isolates were identified following the protocols developed by the USDA-ARS Vegetable Laboratory in Beltsville, Maryland, USA.

The isolates collected after 1999 do not only have higher virulence but also non-host specific pathogenicity. Introduction of A2 mating type isolates of *P. infestans* is a major concern in disease management due to the potential of the pathogen genetic recombination via sexual reproduction. All isolates of this study were A1 mating type, indicating that A2 mating type was not yet introduced into Taiwan. Metalaxyl is a fungicide most commonly used for the effective control of *Phytophthora* late blight. All isolates collected before 1997 were very sensitive to metalaxyl; however, only seven isolates obtained from 1998 to 2005 were sensitive to the fungicide (Table 42). Apparently, metalaxyl will not be effective for managing the disease. It is suggested that metalaxyl be replaced with Famoxadone+Cymoxanil or Azoxystrobin based on the field evaluation at AVRDC in 2004 (Table 43).

A significant shift on pathogen populations in Taiwan was observed from 1997 to 2005. Most isolates (520/556) had dilocus allozyme genotypes 100/111 and 100/100, except for three isolates which had 100/122 and 100/100 for the loci coding the glucose-6-phosphate isozyme (*Gpi*) and peptidase (*Pep*), respectively. Mitochondrial haplotype analyses of polymorphic regions of the mitochondrial genome (mtDNA) were IIb. These characters, together with RG57 fingerprinting, indicated that these isolates belonged to the US-11 clonal lineage, containing 25.6% variant. There were only 36 isolates analyzed as 86/100 and 100/100 allozyme genotype for *Gpi* and *Pep*, Ib mtDNA haplotype. These isolates belong to the US-1 clonal lineage with RG57 fingerprinting. The data indicated that the new genotype, US-11, disseminated very rapidly and displaced the old one as the predominant population (Table 42).

Several germplasms in *L. pimpinellifolium* (L3707, L3708, and others) and *L. hirsutum* (L3683, L3684, LA1033, and others) resistant to *P. infestans* were identified at AVRDC in 1993. Resistant germplasms L3708 (*L. pimp.*), LA1033 (*L. hirs.*), and advanced tomato lines with resistance derived from L3708 have been evaluated for their durability of resistance to late

Table 42. The phenotype and genotype characteristics of *Phytophthora infestans* isolates collected in Taiwan from 1991 to 2004

Year	Number of isolates collected	Metalaxyl (100 ppm)		Mating type		*Gpi/Pep*[a]				mtDNA Haplotype[b]		RG57[c]	
		Sensitive	Resistant	A1	A2	86/100 92/100	86/100 100/100	100/111 100/100	100/122 100/100	Ib	IIb	US-1	US-11
1997	28	28	0	28	0	19	9	0	0	28	0	28	0
1998	33	5	28	33	0	3	2	28	0	5	28	5	28
1999	24	1	23	24	0	1	0	23	0	1	23	1	23
2000	37	0	37	37	0	0	0	37	0	0	37	0	37
2001	58	0	58	58	0	0	0	58	0	0	58	0	58
2002	58	0	58	58	0	1	0	57	0	1	57	1	57
2003	101	1	100	101	0	1	0	100	0	1	100	1	100
2004	113	0	113	113	0	0	0	110	3	0	113	0	113
2005	104	0	104	104	0	0	0	104	0	0	104	0	104
Total	556	35	521	556	0	25	11	517	3	36	520	36	520

[a] Allozyme genotype analysis.
[b] Mitochondrial haplotyping through PCR and RFLP analysis.
[c] DNA fingerprint analysis using RG57 probe.

Table 43. Evaluation of integrated control for tomato late blight with host resistance and fungicides in the field[a]

Tomato lines[b]	Treatment	Diluted concentration	Area under disease progress curve[c] (AUDPC)
FMTT795 (resistant)	50% (Famoxadone+Cymoxanil) WG	2,500x	40.83 b[d]
	Supa Stand Phos	500x	71.17 ab
	23% Azoxystrobin SC	1,000x	40.83 b
	50% Dimethomorph WP	4,000x	51.33 b
	Phosphoric acid	600x	60.67 b
	Control	-	98.00 a
Tauyuan ASVEG No. 9 (susceptible)	50% (Famoxadone+Cymoxanil) WG	2,500x	47.83 e
	Supa Stand Phos	500x	162.17 bc
	23% Azoxystrobin SC	1,000x	79.33 de
	50% Dimethomorph WP	4,000x	134.17 cd
	Phosphoric acid	600x	211.50 b
	Control	-	410.33 a

[a] The trial was conducted from October 2003 to April 2004.
[b] FMTT795 is one of the resistant F_1 hybrids derived from L3708 to *P. infestans*; and Tauyuan ASVEG No.9 is the susceptible control.
[c] Area under the disease progress curve was calculated from the average of 10 evaluations.
[d] Mean separation in columns by Duncan's multiple range test at $P < 0.05$.

blight in outfield trials in Hualien, Hsinshe, and Puli areas in Taiwan since 1995. Resistance in L3708, its derivatives, and LA1033 held up throughout the 1995 crop season and through most of the seasons in 1996. The resistance of L3708 and lines developed from it was broken down by a new race T1,2,3, but not LA1033 toward the end of the 1996 season. In 1997, this pattern was repeated. All tested resistant lines and hybrid F_1s held up in trials conducted from 1998 to 2001. This suggested that resistant materials selected against US-1 genotype were also effective against US-11 genotype. However, since the new race T1,3 appeared in the late spring season of 2002 trial in Hualien, the advanced lines with resistance derived from L3708 showed severe symptoms, but not L3708 or LA1033. In 2003, similar results also occurred in Puli and Hsinshe but not in Hualien. However, the resistance of advanced lines was broken down again in Hualien in 2004 (Table 44). This implies that L3708 may possess more than one resistant gene for late blight resistance, but only one of them was introgressed into the advanced lines.

Table 44. Disease reaction of resistant germplasms and resistant lines to *Phytophthora infestans* in Hualien, Hsinshe, and Puli from 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[a]	S	R	R	R	S	S	S	R	R
Hybrids[b]	S	R	R	R	S	S	S	R	R

[a] CLN2037A-I, nine BC_3F_6 advanced lines derived from L3078 were evaluated.
[b] FMTT791-795, five hybrid F_1 lines derived from CLN2037 series were evaluated.

AVRDC started characterizing physiological races of *P. infestans* isolates collected in Taiwan in 1994 while only race T1,2 was identified, which overcomes the *Ph1* and *Ph2* resistant genes in some commercial varieties. Based on the reactions to *P. infestans*, AVRDC developed a set of differential hosts for putative race identification of *P. infestans*, including TS19 (*Ph*+), TS33 (*Ph*-1), W. Va. 700 (*Ph*-1,2), CLN2037B (*Ph*-1,2,3), L3708 (*Ph*-1,2,3,4), and LA1033 (*Ph*-1,2,3,4,5). A total of nine races including race T1; T1,2; T1,3; T1,2,3; T1,3,5; T1,2,3,4; T1,2,3,5; T1,3,4,5; and T1,2,3,4,5 were identified from 184 isolates from 2004 to 2005 through the reaction to these differential hosts. New races seem to appear continuously in Taiwan during the past years (Table 45). Race T1,2,3 was the predominant race. Breeding for resistance to *P. infestans* should be continued.

Data from this study indicated that migration and asexual reproduction were the predominant mechanisms influencing *P. infestans* population structure in Taiwan from 1991 to 2005. The introduction of the A2 mating type and new genotype *P. infestans* isolates will increase the risk of genetic recombination. Therefore, the design of a stringent local quarantine regulation to prevent these from migrating into Taiwan is the most important strategy on disease management. In addition, the genetic characters and virulent factors of *P. infestans* were seen to be changing rapidly; therefore, further studies on pathogen population shifts and genetics are necessary.

Table 45. Designation of putative physiological races of *Phytophthora infestans* isolates collected from tomato and potato in Taiwan from 2004 to 2005

Putative race	TS19 (*Ph*+)	TS33 (*Ph*-1)	W. Va. 700 (*Ph*-1,2)	CLN2037B (*Ph*-1,2,3)	L3708 (*Ph*-1,2,3,4)[a]	L1033 (*Ph*-1,2,3,4,5)[b]	Number of isolates
T1	S	S	R	R	R	R	18
T1,2	S	S	S	R	R	R	24
T1,3	S	S	R	S	R	R	18
T1,2,3	S	S	S	S	R	R	76
T1,3,5	S	S	R	S	R	S	3
T1,2,3,4	S	S	S	S	S	R	17
T1,2,3,5	S	S	S	S	R	S	18
T1,3,4,5	S	S	R	S	S	S	2
T1,2,3,4,5	S	S	S	S	S	S	8
Total							184

[a, b] Gene(s) conditioning late blight resistance in this accession is not yet characterized.

Characterization of Taiwan isolates of *Fusarium oxysporum* f.sp. *lycopersici* and evaluation of commercial tomato cultivars for resistance to Fusarium wilt

Tomato Fusarium wilt (FW) caused by *Fusarium oxysporum* f. sp. *lycopersici* (FOL) is a disease devastating many tomato production areas worldwide. Recent study at AVRDC indicated that FOL overcomes numerous commercial cultivars planted in Taiwan. This disease caused severe damage and has become an important constraint of tomato production in Taiwan. Unfortunately, very little information were documented on host resistance and pathogen variation of FOL in Taiwan since this disease has been reported in 1981. For this reason, a program was initiated to investigate the variation and population structure of FOL isolates in Taiwan; and to identify commercial tomato cultivars with resistance to FW. These objectives are to identify the predominant physiological race existing in Taiwan and the durable resistant cultivars for the control of the disease.

A total of 108 FOL isolates were recovered from diseased plants around Taiwan during 2002 to 2005. These fungal isolates were preserved in silica gel at 4°C after single-spore isolation. After making the subculture from silica gel stock, the isolates were then transferred into PDA and MMC plate kept at 28°C. All isolates were subsequently characterized based on race determination, vegetative compatibility (VC) and rDNA IGS-RFLP haplotyping. Two reference isolates, Fol 11A (race 1) and Fol 34-1 (race 2) were used as checks.

Pathogenicity test and race determination of each isolate were conducted using the root-dip inoculation on two-week-old seedlings of three host differentials: Bonny Best (no resistance), UC82-L (resistance to race 1), and Florida MH-1 (resistance to races 1 and 2). Thirty-six seedlings of each cultivar were arranged into three replications and inoculated with each isolate, then incubated at ≥ 25°C in the greenhouse. Disease reaction was evaluated three weeks after inoculation. The DSR was evaluated on individual plant following the scales: 0 = plant health without external symptom; 1 = slight vascular discoloration with or without stunted growth; 2 = severe vascular discoloration usually with stunted growth; and 3 = plant wilted beyond recovery or dead. Mean DSR on each cultivar that is more than 1 was classified as susceptible reaction. The race of each isolate was determined according to the disease reaction on differential hosts.

The nitrate non-utilizing (*nit*) mutants of each isolate were selected from minimal agar medium with chlorate and characterized by phenotype identification outlined by Correll et al. 1987. The VC of each isolate was evaluated according to the complementation between *nit1* and NitM mutant on minimal medium agar plate. The appearance of white fuzzy mycelium resulted from successful heterokaryon formation indicated the recovery of wild type. Otherwise, VC test without wild type recovery was regarded as incompatible reaction.

Fungal DNA was extracted from 4-day-old PDA culture following the extraction procedure described by Liu et al. 1997. The IGS region of the ribosomal DNA was amplified with the primer CNL12 (5'-CTGAACGCCTCTAAGTCAG-3') and CNS1 (5'-GAGACAAGCATATGACTACTG-3'). PCR amplification was performed in total volume of 50 µl reaction mixture containing 5 µl of 10x PCR buffer (500 mM KCl, 100 mM Tris HCl [pH 9.0], 1% Triton X-100, 2 mM MgCl2), 20 ng of template DNA, 50 µM of dNTPs, 1 unit Yea Taq polymerase and 10 µM of both primers, CNL12, and CNS1. The PCR programs are: 1 cycle of denaturation (94°C, 5 min); 35 cycle of amplification (94°C, 5 min; 58°C, 30 sec; 72°C, 1.5 min); and 1 cycle of final extension (72°C, 10 min). Approximately 2.6 kb size of amplification products were individually digested with the restriction enzymes *Eco*RI, *Rsa*I, and *Hae*III. The *Eco*RI-, *Rsa*I-, and *Hae*III-digested DNA were subjected to electrophoresis at 3 V/cm in 1.5, 3, and 4% NuSieve GTG agarose gel, respectively. Gels were stained with ethidium bromide and photographed under a UV transilluminator. The IGS-RFLP haplotype of each isolate was identified based on the banding patterns described by Cai et al. 2003.

Using a resistant cultivar is the best strategy for disease control. However, the durability of resistant cultivars is usually related to the occurrence of physiological race in the field. So far, FOL race 1 and race 2 have been reported in Taiwan. Identification of a cultivar with resistance to both race 1 and race 2 for the farmers is important and urgent.

A total of 32 commercial cultivars usually planted in Taiwan were evaluated for their resistance to race 1 and race 2. These were collected from private seed company including Evergrow Seed Co., Know-you Seed Co., Syngenta Seed Co., Longtai Seed Co., and AVRDC. The resistance of each cultivar was evaluated by inoculating with Fol 11A (race 1) and Fol 34-1 (race 2). The inoculation, incubation, and disease severity rating followed the abovementioned procedures but only 18 seedlings of each cultivar were tested for one race due to the limitation of seed quantity. The resistance was classified into three categories: Resistant (R) = mean DSR < 1; Moderately susceptible (MS) = mean DSR > 1 but < 2; Highly susceptible (HS) = mean DSR > 2.

The results of characterizations were summarized in Table 46. Pathogenicity test indicated that all isolates were race 2 except three avirulent isolates. Over 70% isolates showed high virulence, which caused severe symptoms on cultivars Bonny Best and UC-82L (DSR ≥ 2). Ninety isolates produced *nit1* or NitM, which were capable of determining their vegetative compatibility, and 18 isolates did not produce mutants. The problem in mutant selection is probably due to the high chlorate tolerance in some isolates. However, two clonal lineages were identified from 90 isolates. Although only one isolate showed vegetative incompatibility and displayed a unique banding patterns from others, this study demonstrated the predominance of race 2 and high genotypic similarity of current Taiwan FOL population. The intergenic spacer (IGS)-RFLP haplotyping may serve as a basis for studying population dynamics since it correlates with VCG and the population structure is simple in Taiwan. Also, it could be used as a possible marker to differentiate distinct FOL populations such as VCG0033 pathogen (race 3).

Table 46. Characterization of Taiwan isolates of *F. oxysporum* f. sp. *lycopersici* based on physiological race, VCG, and rDNA IGS-RFLP haplotype identification

Race[a]	VCG[b]	rDNA IGS-RFLP[c] *Eco*RI	*Rsa*I	*Hae*III	No. of isolates identified
2	TW1	A	B	A	87
2	TW2	B	B	C	1
2	ND	A	B	A	17
Av	TW1	A	B	A	2
Av	ND	A	B	A	1
1	TW1	A	B	A	check (Fol 11A)
2	TW1	A	B	A	check (Fol 34-1)

[a] Race determination based on pathogenicity test on differential hosts: Bonny Best (no resistance), UC82-L (resistant to race 1), and Florida MH-1 (resistant to races 1 and 2). Isolates that did not cause any symptom was regarded as avirulent (Av).

[b] Vegetative compatibility grouping based on VC test. Isolate was classified as TW1 if compatible with Fol34-1. Isolate was classified as TW2 if compatible with Fol 137. ND means not detected due to lack of *nit* mutant.

[c] IGS-RFLP haplotyping based on banding patterns resulted from *Eco*RI-, *Rsa*I-, and *Hae*III digestion of rDNA IGS region (Cai et al. 2003).

The results of evaluation for host resistance in commercial cultivars showed all tested cultivars are resistant to race 1 but only seven of them, three of which are from AVRDC, hold resistance to both race 1 and race 2 (Table 47). Since race 2 predominates around Taiwan now, these seven cultivars might be useful for effective disease management. If these cultivars proved to be good yielders as well, it may be valuable to recommend these to farmers for the control of Fusarium wilt. In addition, continuous breeding for resistance to race 2 is urgent and necessary in Taiwan.

Table 47. Evaluation of commercial tomato cultivars for reaction to *F. oxysporum* f. sp. *lycopersici* race 1 and race 2 under controlled greenhouse condition

Entry No.	Variety name	Seed source	Race1 (Fol 11A)		Race 2 (Fol 34-1)	
			DSR	Reaction[a]	DSR	Reaction[a]
1	BENITA	Evergrow Seed Co., Ltd.	0.00	R	0.00	R
2	GOLD EMPEROR	Evergrow Seed Co., Ltd.	0.00	R	0.06	R
3	SHIP SAINT	Evergrow Seed Co., Ltd.	0.00	R	2.44	HS
4	HONG LING	Evergrow Seed Co., Ltd.	0.00	R	2.44	HS
5	RED CROWN	Evergrow Seed Co., Ltd.	0.11	R	1.89	MS
6	APY	Evergrow Seed Co., Ltd.	0.06	R	1.67	MS
7	Gold Star	Long-tai Seed Co., Ltd.	0.00	R	1.41	MS
8	Golden Gem	Knowyou Seed Co., Ltd.	0.41	R	2.28	HS
9	Sugary	Knowyou Seed Co., Ltd.	0.71	R	1.78	MS
10	Farmers 133	Knowyou Seed Co., Ltd.	0.00	R	1.28	MS
11	Sugar Pearl	Knowyou Seed Co., Ltd.	0.63	R	1.67	MS
12	Chiquita	Knowyou Seed Co., Ltd.	0.28	R	2.78	HS
13	Tropical Ruby	Knowyou Seed Co., Ltd.	0.11	R	1.28	MS
14	Farmer 252	Knowyou Seed Co., Ltd.	0.29	R	2.11	HS
15	Jolly	Knowyou Seed Co., Ltd.	0.00	R	2.72	HS
16	Farmers 301	Knowyou Seed Co., Ltd.	0.00	R	2.33	HS
17	Ladyship	Knowyou Seed Co., Ltd.	0.00	R	2.89	HS
18	Grace	Knowyou Seed Co., Ltd.	0.00	R	2.28	HS
19	Golden Shine	Knowyou Seed Co., Ltd.	0.00	R	0.00	R
20	Precious	Knowyou Seed Co., Ltd.	0.00	R	1.72	MS
21	Santa	Knowyou Seed Co., Ltd.	0.06	R	1.50	MS
22	Mituo Black	Farmers selection	0.47	R	2.33	HS
23	Double Harvest	Syngenta Co., Ltd.	0.00	R	0.31	R
24	ASVEG no.4	Tomato unit, AVRDC	0.61	R	2.41	HS
25	ASVEG no.5	Tomato unit, AVRDC	0.00	R	1.83	MS
26	ASVEG no.6	Tomato unit, AVRDC	0.00	R	1.72	MS
27	ASVEG no.9	Tomato unit, AVRDC	0.44	R	2.89	HS
28	ASVEG no.10	Tomato unit, AVRDC	0.00	R	2.89	HS
29	ASVEG no.11	Tomato unit, AVRDC	0.00	R	0.33	R
30	Tainan no.12	Sing-flow Seed Co., Ltd.	0.00	R	1.00	MS
31	ASVEG no.13	Tomato unit, AVRDC	0.00	R	0.16	R
32	ASVEG no.14	Tomato unit, AVRDC	0.00	R	0.16	R
33	Bonny Best (control)	Mycology unit, AVRDC	2.39	HS	2.56	HS
34	UC-82L (control)	Mycology unit, AVRDC	0.00	R	2.28	HS
35	Fla. MH-1 (control)	Mycology unit, AVRDC	0.00	R	0.0	R

[a] R (resistant): Mean DSR < 1; MS (moderately susceptible): Mean DSR ≥ 1 but < 2; HS (highly susceptible): Mean DSR ≥ 2.

Contact: Tien-chen Wang

Virology

The role of weeds in the epidemiology of tomato begomoviruses

Weeds, known to be hosts of whiteflies and often showing symptoms typical of those caused by begomoviruses such as leafcurling, yellowing, vein-clearing, and stunting of the whole plant, have often been implied as hosts or reservoirs of tomato begomoviruses. To assess the importance of weeds vis-à-vis tomato begomoviruses, surveys were conducted to determine whether weeds were infected with begomoviruses. Weeds especially those showing symptoms were collected from within tomato and around tomato plantings and tested by PCR or nucleic acid hybridization (NAH) for presence of begomoviruses. Several begomoviruses from PCR-positive weeds from Taiwan and other countries were cloned and sequenced in order to determine whether these are identical or similar to the tomato-infecting begomoviruses.

Weed surveys in Asia

Leaf and stemtip samples of symptomatic weeds from within and around tomato plantings were collected by AVRDC and its collaborators in the National Agricultural Research Systems (NARSs). They were tested by NAH using a begomovirus-specific ~1.4 kb digoxigenin-labeled DNA probe derived from ToLCTWV (U88692), ToLCBV (L11746), and/or by PCR with the begomovirus-specific primer pair PAL1v1978/PAR1c715 using the methods previously described. Twenty-five percent of the total 299 weed samples collected from nine countries in Asia were found to contain begomoviruses (Table 48). Weed species infected with begomoviruses included *Ageratum, Acalypha, Croton, Clerodendron, Euphorbia, Malvastrum, Mimosa, and Parthenium*.

The possible role of weeds in the epidemiology of the Tomato leaf curl Taiwan virus

Survey on the presence of begomoviruses of weeds in Taiwan. Tomato fields of seven counties were surveyed using the same method as described above. Ninety-four symptomatic samples comprising 21 weed species were collected and tested. The results of this survey are shown in Table 49. Only *Ageratum* sp. was found to be infected with begomoviruses. Five isolates were cloned and sequenced. Only two distinct virus species, namely AYVV-TW (AYVV isolates Hualien 1 and Hualien 2) and AYVV-Singapore (AYVV isolates Taoyuan, Tainan 1, Tainan 2, Pingdong) were identified (Figure 23). None of the five fully sequenced *Ageratum*-infecting begomoviruses were the same or were strains of the local tomato-infecting begomoviruses (Figure 23).

Table 48. Survey for begomoviruses of weeds conducted in Asia by AVRDC in collaboration with local partners

Country	Number of samples tested	Number (%) positive	Species tested positive of begomovirus
Bangladesh	26	6 (23)	*Ageratum* sp, *Croton* sp., *Croton sparsiflorus*
Cambodia	3	2 (67)	*Ageratum* sp.
India	157	38 (24)	*Ageratum conyzoides, Clerodendron duranta, Croton bonplandianum, Croton* sp., *Euphorbia geniculata, Euphorbia* sp., *Malvastrum* sp., *Parthenium hysterophorus*
Indonesia	18	2 (11)	*Ageratum conyzoides, Ageratum* sp.
Lao PDR	9	7 (78)	*Ageratum houstonianum*
Malaysia	23	7 (30)	*Ageratum conyzoides, Ageratum* sp., *Mimosa invisa*
Myanmar	9	3 (33)	*Ageratum* sp., *Ageratum houstonianum*
Nepal	37	7 (19)	*Ageratum houstonianum, Ageratum* sp., *Croton* sp.
Sri Lanka	17	3 (18)	*Ageratum conyzoides, Ageratum* sp., *Acalypha indica*
Total	299	75 (25)	*Acalypha, Ageratum, Croton, Clerodendron, Euphorbia, Malvastrum, Mimosa, Parthenium*

Table 49. Survey for begomoviruses of weeds in Taiwan

Location (county)	Number of samples tested	Weed species (number) collected	NAH/PCR positive
Hualien	16	*Ageratum* sp.	4
	1	*Erigeron bonariensis* (1)	0
Hsinchu	7	*Erigeron bonariensis* (3), *Emilia sonchifolia* (1), *Ageratum houstonianum* (3)	0
Tainan	5	*Ageratum* sp.	3
(AVRDC)	34	*Ageratum* sp. (3)	2
		others[a]	0
Nantou	11	*Ageratum* sp.	8
Miaoli	1	*Ageratum* sp.	1
Changhua	12	*Solanum nigrum* (9), *Bidens pilosa* (1), *Euphorbia hirta* (2)	0
Taitung	3	*Solanum nigrum* (1), *Euphorbia hirta* (1), *Ageratum houstonianum* (1)	0
Taoyuan	4	*Ageratum* sp.	2
Seven counties	94	21 weed species	20 (only *Ageratum* sp.)

[a] *Ageratum conyzoides* (1), *Ageratum houstonianum* (2), *Amaranthus spinosus* (2), *Amelopsis brevipedunculata* (1), *Artemisia princes* (2), *Bidens pilosa* (2), *Cardiospermum halicababum* (3), *Chrysanthemum* sp. (1), *Cynodon dactylon* (2), *Digitaria henryi* (2), *Echinochloa colonum* (2), *Euphorbia hirta* (2), *Ipomoea gracilis* (2), *Oxalis corniculata* (2), *Passiflora foetida* (2), *Polygonum convolvulus* (2), *Portulaca oleracea* (2), *Solanum nigrum* (2), *Vinca* sp. (1).

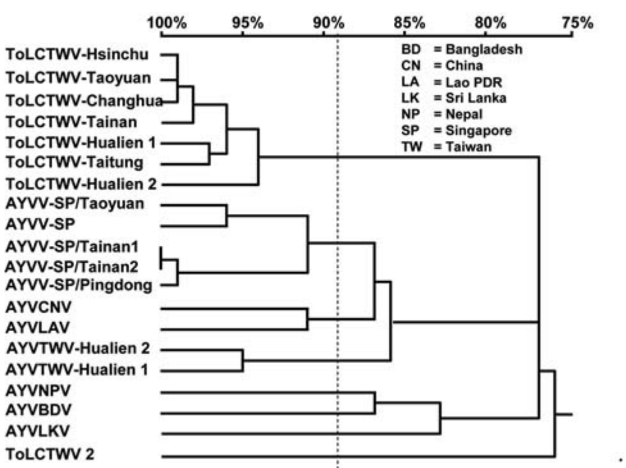


Figure 23. Homology tree of the DNA-A sequences *Ageratum*-and tomato-infecting begomoviruses of Taiwan (AYVV = Ageratum yellow vein virus, ToLCV = Tomato leaf curl virus).

Weeds as hosts of ToLCTWV. The epidemiology, especially the existence of alternate hosts of ToLCTWV, is poorly understood. Aside from *Datura stramoniun*, *Nicotiana benthamiana,* and *Nicotiana tabacum* cvs 'Samsun' and 'Xanthi,' no other hosts were previously found to be infected with ToLCTWV both by grafting and by infection with viruliferous whiteflies including *Capsicum annuum* (24 lines), *Cucumis* sp. (4 lines), *Cucurbita* sp. (2 lines), *Gossypium hirsutum* (2 lines), *Glycine max* (2 lines), *Vigna unguiculata* (2 lines), *Phaseolus vulgaris* (1 line), *Solanum melongena* (1 line), *Abelmoschus esculentus* (1 line), *Carica papaya* (1 line), and *Zinnia elegans* (1 line).

Eleven common weed species of Taiwan, such as *Ageratum houstonianum* (3 lines), *Amaranthus mangostanus*, *A. spinosus*, *A. virides*, *Bidens pilosa*, *Celosia argentea*, *Physalis angulata*, *P. floridana*, *Solanum indicum*, *S. incanum*, and *S. nigrum* were exposed to ToLCTWV-viruliferous whiteflies (*Bemisia tabaci* biotype B). Twenty-four seedlings of each line were exposed for 40 days to the whiteflies in an insect-proof screen house. Thereafter the plants were tested for the presence of ToLCTWV by NAH, using a digoxigenin-labeled probe described previously (AVRDC 1993 (1992 Progress Report)). None of these weeds were found to have become infected with ToLCTWV and it was suspected that they were not hosts of this virus.

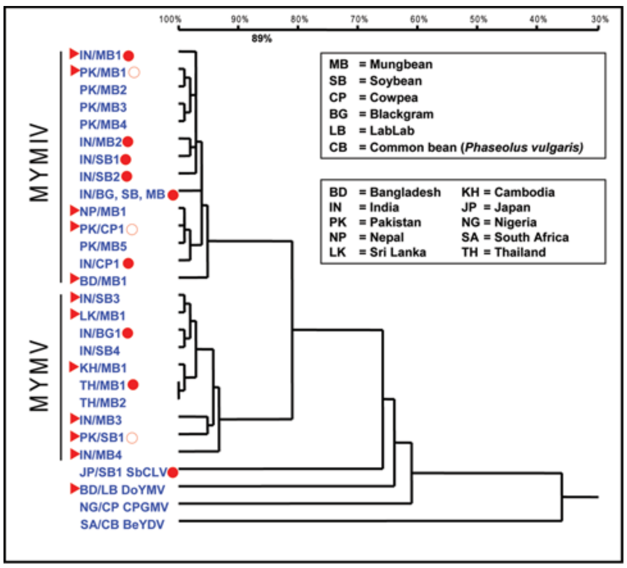
Infection of tomato with Ageratum yellow vein virus. Five DNA-A sequences of *Ageratum* sp.-infecting begomovirus isolates collected from Tainan, Hualien, and Taoyuan counties in Taiwan were previously characterized (AVRDC Report 2002). Their DNA-A sequences were found to have < 81% nucleotide sequence identities with the two Taiwan tomato-infecting begomoviruses ToLCV-TW1 and ToLCV-TW2, indicating that they are distinct from ToLCV-TW. Furthermore, these *Ageratum* sp.-infecting begomovirus isolates had only > 86% sequence identities with each other, and could be grouped into two virus species, i.e., AYVV-TW/Tainan and AYVV-TW/Hualien. In an attempt to determine whether AYVV is able to infect tomato, one of the AYVV isolates AYVV-TW/Tainan, belonging to the AYVV-Taiwan virus species, was selected for testing its infectivity on the tomato line *L. esculentum* TK70. In an insect-proof (50 mesh) cage, > 200 healthy whiteflies (*B. tabaci* biotype B) were placed on AYVV-TW/Tainan infected *Ageratum houstonianum* plants for acquisition feeding and to obtain viruliferous whiteflies. Ten healthy *L. esculentum* TK70 seedlings (set 1) were then placed into the same cage for exposure to the AYVV-TW/Tainan-viruliferous whiteflies. At the same time, in a separate cage, another 10 *L. esculentum* TK70 seedlings (set 2) were exposed to ToLCV-TW/Tainan-viruliferous whiteflies. Whitefly exposure symptoms appeared on both sets of tomato plants after one month. While AYVV-TW/Tainan-infected tomato plants showed leaf deformation and blistering symptoms, the ToLCV-TW/Tainan-infected plants showed curling and yellowing of leaves. The presence of ToLCV-TW/Tainan or AYVV-TW/Tainan in symptomatic tomato plants was confirmed by PCR with the ToLCV-TW/Tainan and AYVV-TW/Tainan-specific primers. Virus contamination or mixed infection was not detected. This is the first demonstration of tomatoes being infected with a weed begomovirus by whitefly inoculation, albeit with symptoms distinct from those caused by ToLCV-TW on tomatoes (leaf curling and yellowing) and from those caused by AYVV in *Ageratum* sp. (yellow vein). There is a possibility that a weed begomovirus may change its primary natural host either through the appearance of more aggressive whiteflies or by the absence of the primary natural host and acclimatization of the whiteflies to other hosts. These are some of the factors which must be seriously considered in the vector/virus epidemiology of the tomato leaf curl disease in Taiwan or elsewhere, where similar diseases occur and in developing sustainable control methods.

Diversity of begomoviruses of legumes in South and Southeast Asia

Leaf samples were collected in previous years from different legumes (including mungbean, soybean, blackgram, cowpea, and lablab) showing symptoms typical of begomovirus infection such as leaf yellowing, yellow mottle or mosaic, vein yellowing and/or leafcurling. They were tested for the presence of begomovirus by PCR using the primer pair PAL1v1978B/PAR1c715H which was designed based on alignments of sequences of known legume geminiviruses. DNA extraction was done as described in the 2000 AVRDC Report. A 1.4-kb band following electrophoresis was evidence that the sample contained a begomovirus. For molecular characterization, specific primers were designed based on the sequences of the 1.4-kb DNA products in order to obtain the bottom part of the DNA. For DNA-B detection, two degenerate primer pairs, previously designed by AVRDC virologists (Green et al. 2001)[7] were used, namely DNA BLC1/DNA BLV2 and DNA BLC2/DNABLV2. Presence of DNA-Beta was detected by the primer pair Beta 01/Beta 02. During 2004/2005, 12 begomoviruses infecting diverse legume crops were cloned and sequenced. Their genetic diversity and relationship with other known legume begomoviruses were determined by full length sequence analyses. Contrary to the high genetic diversity of tomato-infecting begomoviruses in Asia, the majority of the legume begomoviruses can be grouped into only two distinct species (Figure 24), even those begomoviruses from different host species. Recently, AVRDC virologists as well as researchers from Japan, have identified two new distinct legume begomoviruses on soybean in Japan and on lablab in Bangladesh. Interestingly, the legume begomovirus reported from Nigeria, Cowpea golden mosaic virus (CPGMV), shares only less than 60% sequence homology with legume begomoviruses so far reported from Asia.

[7] Green et al. 2001. *Plant Disease* 85:1286.

Knowledge of this should greatly facilitate the deployment of suitable resistance genes and reduce the necessity for many multilocation resistance screening sites. However, it remains to be confirmed whether members (= strains) of the two viral species produce similar reactions on the different MYMV-resistant mungbean and soybean lines developed so far by breeders in Pakistan, India, and AVRDC.



▶ Cloned and sequenced by AVRDC.
● Bipartite geminivirus, DNA-B presence confirmed.
○ Tested for DNA-B by PCR with DNA-B specific primers, but not detected.
For other viruses, information on DNA-B is not available.
Bean yellow dwarf virus (BeYDV) is included as an outgroup (Mastrevirus).

Figure 24. Homology tree of Asian legume-infecting begomoviruses.

Contact: Sylvia Green

Crop and Ecosystem Management

Management of cauliflower, lettuce, chili pepper, sweet pepper, and tomato

Separate studies were conducted on water use efficiency (WUE) and yield of selected vegetable crops (cauliflower, lettuce, chili pepper, sweet pepper, and tomato) under drip and furrow irrigation systems. The use of low-cost drip irrigation system developed by the International Development Enterprises (IDE) was evaluated in tomato and chili pepper production.

Cauliflower

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most important vegetables in Taiwan as well as in some countries of Southeast Asia. For example, in Cambodia, Lao PDR, and Vietnam cauliflower is cultivated along the Mekong River during the dry season. In these regions cauliflower is irrigated using traditional hand watering or by sprinkler hose. This method of irrigation is inefficient especially during the hot-dry season when water supply is limiting. Very few studies on irrigation water requirement on cauliflower production are available. This study was conducted to determine the effect of irrigation water use on yield of cauliflower during the hot-dry season.

The experiment was carried out in alkaline soils at AVRDC field #45. The average annual rainfall was 3660 mm. The amount of rainfall received during the growing period (December 2004 to March 2005) was 69 mm. The trial was laid out in RCBD with four replications. Cauliflower hybrid var. Chin-long (65-day maturity) was grown and drip irrigated at soil moisture tensions maintained at -20, -30, -50, and -70 kPa as monitored by soil tensiometer (Spectrum Co., USA). Basal fertilizer was applied at the rate of 60 kg N/ha, 60 kg P/ha, and 60 kg K/ha prior to bed preparation. Urea fertilizer was side-dressed at 60 kg/ha for each application at two and five weeks after transplanting (WAT). Seeds were sown in the nursery on 1 December 2004 transplanted in the field on 15 February 2005.

Data in Table 50 showed significant differences in marketable yield between irrigation regimes. Highest marketable yield (50.8 t/ha) was obtained from irrigation regime of -30 kPa and the lowest yield (44.4 t/ha) was obtained from irrigation regime of -70 kPa. There were no significant differences in marketable yield between irrigation regimes of -30, -50, and -70 kPa, but the yield of -20 kPa was significantly lower compared with the other three irrigation regimes. The effect of irrigation regime was also significant on the size of flower head. The average head size under treatments -30 and -70 kPa regimes was significantly larger than that under -20 kPa (Table 50). No significant differences were observed among treatments in terms of total gross weight (flower head + leaves). Leaf weights of the two lowest irrigation regimes (-70 and -50 kPa) were comparable and significantly higher than the two highest irrigation regimes (-30 and -20 kPa).

Highest total water use was recorded in irrigation regime of -20 kPa (157.4 mm) and lowest water use was with -70 kPa (100.8 mm) as shown in Table 50.

Table 50. Effect of irrigation regimes on marketable yield, leaf weight, total gross weight, head-size of cauliflower, water usage, and water use efficiency (WUE) during hot-dry season, AVRDC, 2005

Irrigation regime (kPa)	Marketable yield (t/ha)	Leaf weight (kg/ha)	Total (gross) plant weight (kg/ha)	Flower head-size (kg)	Water usage (mm)	WUE (kg/ha/mm)
-20	44.4 b	86.3 b	136.1	0.92 b	157.4	282
-30	50.8 a	88.5 b	138.0	1.02 a	146.7	346
-50	49.5 a	96.9 ab	147.7	0.99 ab	114.0	434
-70	49.9 a	109.5 a	153.9	1.03 a	100.8	495
Mean	48.6	95.3	143.9	0.99	130.0	389

This resulted in a range of WUEs from 282 kg yield per mm of water applied (-20 kPa) to 495 kg yield per mm (-70 kPa). During the dry season when irrigation water is limiting, the irrigation level should be maintained at the highest soil moisture tension (-70 kPa) to conserve water and cover a larger crop area with irrigation.

Head lettuce

A similar trial was conducted for head lettuce using the same irrigation regimes and experimental design. Head lettuce cultivar Georgia (55-day maturity) was sown in the nursery on 25 January 2005 and transplanted in the field on 15 February 2005. Fertilizer application was similar to that used for cauliflower. Data on marketable yield (total head weight), weight of outer leaves, total (gross) yield, head size, and bacterial soft rot infection (incidence) were recorded.

Data on Table 51 showed significant differences in all measured parameters except head size. Marketable head lettuce yields obtained from lower irrigation regimes of -50 and -70 kPa were significantly greater than those under higher regimes (-20 and -30 kPa) (Table 51). Even though there were significant differences in these parameters, the average head size from all treatments was comparable (1.3–1.4 kg). The incidence of bacterial soft rot disease was significantly highest in higher irrigation regimes of -20 and -30 kPa than in lower regimes (-50 and -70 kPa). With lower irrigation rates, better head quality was observed due to associated lower disease incidence. The lower yield under higher irrigation regimes may be attributed to higher incidence of bacterial soft rot disease.

As with cauliflower, water usage and efficiencies in lettuce varied with irrigation regimes. Similar trends were observed in terms of water use and WUE (Table 51). The higher the irrigation water application, the lower the WUE and vice versa. Thus, in lettuce production during the hot-dry season, lower irrigation (-50 to 70 kPa) results in higher yield, quality, and water use efficiency compared to higher irrigation regimes.

Chili pepper

During the hot-wet season of 2005, a field trial was conducted evaluating yield and water use efficiency of chili pepper under drip irrigation. The IDE low-cost, affordable drip irrigation system was modified using components similar or of better quality than those obtained from IDE India. The IDE low-cost drip kit consists of a 200-liter drum raised 1-2 m above ground, valve, filter, and main lateral, submain, and drip lines (tapes) with microtubing.

Chili cultivar ‘Delicacy 193’ (Known-You Seed Co.) was grown for this trial. Treatments consisted of grafted and nongrafted plants and drip irrigation regimes based on soil moisture tension of -20, -30, -50, and -70 kPa. Chili line 9852-54 was used as rootstock. The experiment was laid out using RCBD with four replications. Data on marketable fruit yield, number of fruits, fruit size, water use, and efficiency were collected and summarized.

Significant differences in marketable yield, fruit number, and fruit size were observed among irrigation regimes and plant types (grafted vs. non-grafted) as shown in Table 52. In general, marketable yield and number of fruits were significantly higher under higher

Table 51. Effect of irrigation regimes on yield and yield components, water usage, and water use efficiency (WUE) of head lettuce during the hot-dry season, AVRDC, 2005

Irrigation regime (kPa)	Weight of outer leaves (t/ha)	Marketable head yield (t/ha)	Total (gross) plant weight (t/ha)	Head size (kg)	Incidence of bacterial soft-rot (%)	Water usage (mm)	WUE (kg/ha/mm)
-20	16.8c	38.4 c	55.1 c	1.3	33.2 a	164.9	233
-30	20.4b	46.1 b	66.5 b	1.4	24.5 b	157.2	303
-50	24.3a	50.1 a	74.3 a	1.3	10.3 c	119.3	407
-70	22.7a	49.4 a	72.0 a	1.3	7.6 c	103.8	476
Mean	21.0	46.0	67.0	1.3	18.9	136.0	355

drip irrigation rates (-20 and -30 kPa) compared to lower rates (-50 and -70 kPa). Highest mean marketable yield (48.4 t/ha) was obtained from irrigation regime of -30 kPa, while the lowest mean yield (33.2 t/ha) was observed from irrigation regime of -70 kPa. Interaction between irrigation and plant type was not significant for marketable yield, but not so for other characters. For example, the effect of plant type on fruit size seemed to have been affected by irrigation. That is, fruits were significantly larger when non-grafted compared with grafted, but only under -50 kPa irrigation. Under other irrigation levels, the two plant types are comparable (Table 52).

As expected, water usage increased with increasing irrigation rates from 183 mm at -70 kPa to 292 mm at -20 kPa (Table 52). As water usage increased, WUE decreased. However in this trial, although WUE was higher at low drip irrigation rates, marketable yields were significantly lower, suggesting that it would be more profitable to use higher rates of irrigation during hot-wet season when market prices of chili pepper are high with favorable cost/benefit ratios.

This trial also demonstrated the feasibility of using low-cost drip irrigation system for chili pepper production. Its use has potential for developing countries where traditional practice of water application for vegetable production is not efficient.

During the hot-dry season of 2005, a field study was conducted to evaluate the effect of two methods of irrigation (drip vs. furrow) and irrigation rates on yield and water use efficiency of chili pepper. AVRDC Hybrid CCA 321 and Delicacy-193 were grown in two separate field experiments. Experiment 1 consisted of drip irrigated crop while Experiment 2 was under furrow irrigation. In both irrigation systems, irrigation water was applied at rates based on soil moisture tension: -20, -50, and -70 kPa as monitored by soil moisture meter (Spectrum Co., USA). For each irrigation regime, plot size on raised beds was 4 m x 1.5 m for drip and 6 m x 1.5 m for furrow irrigation. Each single-row bed was planted at 40 cm row spacing and a population equivalent to 16,666 plants/ha. The experiments were laid out using RCBD with four replications. However, irrigation system was not tested in a single experiment, therefore, interaction of irrigation system with irrigation regime and variety could not be statistically validated.

Data on Table 53 show that under furrow irrigation, only the fruit yield of Delicacy-193 was significantly affected by irrigation regimes, with the highest irrigation regime (-20 kPa) giving significantly lower yield. For CCA321, although the highest yield (81.7 t/ha) was obtained at the lowest regime (-70 kPa), this yield was not significantly different from yields under regimes -20 and -50 kPa. For both varieties, no significant differences among irrigation regimes were observed in fruit size and total plant biomass. Differences in top plant biomass were significant among irrigation regimes only under furrow irrigation (Table 53). The highest top biomass found in the lowest irrigation regime (-70 kPa) was not significantly different from other irrigation regimes, except that of -50 kPa of Delicacy-193. No significant differences were found under the drip irrigation system. WUE increased significantly as irrigation regime decreased in both varieties.

Table 52. Marketable yield, number of fruits, fruit size, water usage, and water use efficiency (WUE) of chili pepper under various drip irrigation regimes and grafting during the hot-wet season, AVRDC, 2005

Irrigation regime (kPa)	Plant type	Marketable yield (t/ha)	Number of fruits/ha (x 1000)	Fruit size (g)	Water usage (mm)	WUE (kg/ha/mm)
-20	Grafted	40.2 bcd	4,005	10.1 ab	292.4	137.5
	Non-grafted	41.0 bc	4,029	10.2 ab	292.4	140.2
-30	Grafted	49.9 ab	4,948	10.1 ab	280.7	177.8
	Non-grafted	46.8 ab	4,484	10.4 a	280.7	166.7
-50	Grafted	34.9 cd	4,007	8.7 e	210.5	165.8
	Non-grafted	35.3 bcd	3,659	9.6 bcd	210.5	167.7
-70	Grafted	32.8 d	3,608	9.1 de	182.5	179.7
	Non-grafted	33.5 d	3,619	9.3 cde	182.5	183.5
Grand Mean		39.3	4,045	9.7		

Table 53. Yield and water use of chili pepper grown under furrow (Experiment 2) and drip (Experiment 1) irrigation systems during the hot-dry season, AVRDC, 2005

Irrigation system	Regime (kPa)	Variety	Yield (t/ha)	Fruit number (1000/ha)	Fruit size (g)	Top-biomass (g/plant-dw)	Total-Biomass (g/plant-dw)	WUE (g/l water)
Experiment 1								
Drip	-20	CCA321	58.8 bc	6,392 b	9.2	318.4	350.6	0.76 d
	-50	CCA321	71.9 bc	7,226 b	10.0	516.7	558.2	13.56 c
	-70	CCA321	60.3 c	5,960 c	10.0	87.4	527.6	58.85 b
	-20	Delicacy-193	97.7 a	10,175 a	9.6	358.6	389.5	1.26 d
	-50	Delicacy-193	76.1 b	7,625 b	10.1	493.0	543.4	14.35 c
	-70	Delicacy-193	73.5b	7,627 b	9.6	463.2	496.0	71.69 a
	Mean		73.0	7,501	9.9	439.6	477.5	26.7
Experiment 2								
Furrow	-20	CCA321	73.4 ab	7,514	9.7	468.2 ab	509.9	0.75 c
	-50	CCA321	75.2 ab	7,092	10.7	504.2 ab	551.1	3.42 b
	-70	CCA321	81.7 a	8,132	10.1	557.7 a	606.7	8.76 a
	-20	Delicacy-193	63.2 b	6,180	10.3	418.7 ab	459.1	0.64 c
	-50	Delicacy-193	86.7 a	8,463	10.3	384.7 b	419.3	3.89 b
	-70	Delicacy-193	82.7 a	7,894	10.6	579.1 a	631.4	8.86 a
	Mean		77.2	7,546	10.5	485.4	529.6	4.40

WUE = water use efficiency; dw = dry weight.

Significant differences due to irrigation regimes were observed in fruit number and yield (Table 53). Highest yield (97.7 t/ha) and fruit number were obtained under irrigation regime of -20 kPa for Delicacy-193 and were significantly higher than all other treatments. As in furrow irrigation, no significant differences in fruit size and biomasses were found among irrigation regimes. In general, water use efficiency was higher with drip than furrow irrigation. Yield response to irrigation method varied with variety. CCA321 was favored using furrow irrigation. The yield of Delicacy-193 improved from 63.2 t/ha (furrow) to 97.7 t/ha (drip), only under the highest irrigation level, -20 kPa. For the lower irrigation levels, -50 and -70 kPa, yield of Delicacy-193 went down by 12% and 11%, respectively.

Tomato

Studies on drip irrigation were continued for tomato production during the hot-wet season in 2005. Using an AVRDC virus-resistant tomato cultivar ToLCV 15, the trial was conducted to determine the effect of irrigation regime and grafting on yield, water usage and efficiency of tomato. Non-grafted and grafted tomato using eggplant EG 203 rootstock were grown on raised beds at two rows per bed at plant spacing of 50 cm equivalent to 26,667 plants/ha. Basal fertilizer was applied at the rates of 60 kg N/ha, 60 kg P/ha, and 60 kg K/ha. Similar rates were applied for N and K as side-dressing at 3, 6, 9, 12, and 15 WAT. Treatments were arranged in RCBD with four replications. Data on fruit yield, number of fruits, fruit size, and incidence of blossom end rot, water use and efficiency were collected and summarized.

Table 54 presents the results of the trial showing marketable yield, fruit number and size, water usage, and water use efficiency. The effects of irrigation regime and grafting on fruit yield and size were significant. Non-grafted tomato in general has better yield and larger fruit size than grafted tomato at all irrigation regimes. Highest comparable yields of 150 and 139 t/ha were obtained from nongrafted tomato drip irrigated at -20 and -30 kPa, respectively. Yields of grafted tomato were below 100 t/ha for plots irrigated at -50 and -70 kPa, significantly lower than plots irrigated at -20 and -30 kPa. A similar trend was observed in fruit size. No significant differences in fruit size could be attributed to effect of irrigation regimes in both grafted and non-grafted tomato. Water use efficiency was higher at -30 kPa. Hence, it is recommended that soil moisture tension be maintained at -30 kPa.

Table 54. Marketable yield, number of fruits, fruit size, water usage, and water use efficiency (WUE) of tomato under various drip irrigation regimes and grafting during the hot-wet season, AVRDC, 2005

Irrigation regime (kPa)	Plant type	Marketable yield (t/ha)	Number of fruits/ha (x 1000)	Fruit size (g)	Water usage (mm)	WUE (kg/ha/mm)
-20	Grafted	112.2 d	2,858	39.3 c	265.7	422.2
	Non-grafted	149.9 a	3,106	48.5 a	265.7	564.1
-30	Grafted	111.0 d	2,827	39.2 c	256.7	432.5
	Non-grafted	138.9 ab	2,894	47.9 a	256.7	541.2
-50	Grafted	90.4 ef	2,302	39.5 bc	200.4	451.1
	Non-grafted	132.1 bc	2,662	49.4 a	200.4	659.2
-70	Grafted	84.1 f	2,294	37.1 c	177.7	473.2
	Non-grafted	122.7 cd	2,632	46.5 a	177.7	690.4
Grand Mean		117.7	2,697	43.0		

The incidence of blossom end rot on tomato fruits was more apparent in nongrafted than grafted plants (Table 55). Although yield of grafted tomato was lower than non-grafted tomato, fewer grafted fruits showed symptoms of BER. The data also indicate that incidence of BER tended to increase with decreasing irrigation rates. Differences in BER ratings were significant among treatments. Thus, grafting and increasing irrigation levels may reduce BER in tomato fruits during the hot-wet season. The incidence of Tomato leaf curl virus was not serious during the growing season since the variety used was known to have resistance.

Table 55. Incidence of blossom end rot (BER) on grafted and non-grafted tomato fruit grown under various drip irrigation regimes during the hot-wet season, AVRDC, 2005

Irrigation regime (kPa)	Plant type	BER incidence (%)	Weight of fruits with BER (kg)
-20	Grafted	0.27 c	0.36 c
	Non-grafted	0.56 bc	0.43 bc
-30	Grafted	0.39 c	0.50 bc
	Non-grafted	1.74 a	1.06 ab
-50	Grafted	0.21 c	0.32 c
	Non-grafted	1.57 ab	0.96 abc
-70	Grafted	0.74 bc	0.76 bc
	Non-grafted	2.24 a	1.46 a
Mean		0.97	0.73

Sweet pepper

A similar drip irrigation trial was also conducted to determine yield and water use efficiency of sweet pepper grown during the hot-wet season. Sweet pepper variety Andalus was used for this trial. Seedlings were grafted onto chili rootstock line 9852-54 known to have tolerance to bacterial wilt and Phytophthora blight. Irrigation regimes, experimental design, plot size, fertilizer rates, and plant population were similar with those used in the tomato and chili pepper trials. Data are shown in Table 56 for yield and Table 12 for water use and efficiency.

Marketable yield was not significantly affected by grafting under all irrigation regimes, while irrigation regime affected both grafted and non-grafted sweet pepper (Table 56). For grafted sweet pepper, 50 kPa gave comparable marketable yield with that given by -20 kP, but significantly higher yield than -30 kPa and -70 kPa. For non-grafted sweet pepper, the irrigation regimes -20, -50, and -70 kPa gave comparable yields which were all significantly higher than the yield under -30 kPa. The yield response to irrigation regimes varied but there was no increasing trend in yield as irrigation rates increased. Sweet pepper fruit yield from -20 and -50 kPa of both plant types exceeded 60 t/ha, whereas, those under -30 and -70 kPa regimes had mean yields of 52–55 t/ha. While the effect of grafting on marketable yield was not significant under all irrigation regimes, in fruit size, this effect was significant under -20 kPa and -50 kPa; in fruit number, the effect was significant under -50 kPa. Likewise, the yield response to irrigation regimes varied with plant type but was not similar to the response of fruit size and fruit number.

Table 56. Marketable yield, number of fruits, fruit size, water usage, and water use efficiency (WUE) of sweet pepper under various drip irrigation regimes and grafting during the hot-wet season, AVRDC, 2005

Irrigation regime (kPa)	Plant type	Marketable yield (t/ha)	Number of fruits/ha (x 1000)	Fruit size (g)	Water usage (mm)	WUE (kg/ha/mm)
-20	Grafted	61.8 ab	614 bc	101.9 a	291.9	211.7
	Non-grafted	60.6 abc	716 bc	84.7 cd	291.9	176.1
-30	Grafted	53.7 bc	617 bc	89.3 cd	280.1	191.7
	Non-grafted	51.4 c	545 c	93.8 abc	291.1	224.5
-50	Grafted	69.9 a	859 a	81.4 d	210.3	332.4
	Non-grafted	62.9 ab	631 bc	100.0 ab	210.3	265.4
-70	Grafted	54.2 bc	574 c	94.3 abc	182.5	296.9
	Non-grafted	55.8 bc	631 bc	90.2 bcd	182.5	332.0
Grand Mean		58.8	648	92.0		

Both grafting and irrigation regimes significantly influenced fruit number and size. Based on this trial, lower irrigation water requirement for higher yield is maintained at -50 kPa soil moisture level. Fruit yield from this treatment was comparable with yield at -20 kPa. WUE at irrigation regimes of -50 and -70 kPa was generally higher than those under -20 and -30 kPa.

Increasing off-season tomato production using grafting technology for peri-urban agriculture in Southeast Asia

Tomato grafting technology was developed by AVRDC to improve and increase tomato production during the hot-wet season (AVRDC 1995). It is currently being used to increase off-season production of small-scale vegetable farmers in peri-urban areas of Southeast Asia.

Grafting tomato onto resistant eggplant or tomato rootstocks provides protection against flooding and soil-borne diseases such as bacterial wilt common during hot-wet season. This technology was introduced in SUSPER project sites.

In Hanoi, Vietnam, trials were conducted on-station and on farms with farmers' participation. The trials at Research Institute of Fruits and Vegetables (RIFAV) in 2002–2004 consisted of tomato varieties (scions) TN001, TN005, TLCV15, VL2000, CHT501, and HS902 grafted onto eggplant EG203, tomato HW7996, and Doctor K rootstocks. In 2004–2005, the grafting technology was transferred to 16 farmers in Dong Anh district near Hanoi. Tomato scion varieties used were TN001, TN005, HS2922, VL2500, and BM136. All varieties were grafted onto eggplant EG203 rootstocks. Farmer cooperators attended a training workshop on grafting technology conducted by RIFAV before establishing their on-farm trials.

In Phnom Penh, Cambodia, on-station trials were conducted in 2003–2004 using the facility of the Research and Agricultural Development Center at Dey Eth. Tomato varieties used as scions were CLN1426A, TMTKK1, CHT501, and CLN2026D in 2003. These were grafted onto EG203 and HW7996 rootstocks. Similar varieties were used in 2004. In 2005, 15 farmers were trained in tomato grafting technology and the same farmers conducted on-farm trials on grafted tomato during the hot-wet season using four varieties (TLCV15, CHT501, TMTKK, and Mongial). All varieties were grafted onto eggplant EG203 rootstock. In Vientiane, Lao PDR, only one trial was conducted at the Crop Multiplication Center (CMC) in 2003. Four tomato varieties used as scions (SR382, CHT501, CLN2026D, and SIDA) were grafted onto eggplant EG203 rootstock and tomato HW7996 rootstock.

The on-station trials were conducted under shelters and open field for comparison while all farmer-managed trials were conducted in open field. Farmers followed the recommended cultural practices for tomato production including fertilizer application, furrow irrigation, insect and disease control, and staking as suggested by AVRDC.

Vietnam. On-station trial in Hanoi, Vietnam showed that all non-grafted plants did not survive as a result of flooding due to heavy rainfall from typhoon that came in 20–23 July 2004. Even all plants under shelter wilted and died after flooding. A high percentage of grafted plants survived the flooding under shelter and in the open field except for TLCV15 grafted onto tomato rootstock Doctor K, of which all plants died due to flooding. All varieties grafted onto eggplant rootstock have high tolerance and survival rate. Fruit yield was generally higher under shelter than in the open field (Table 57). Marketable fruit yield of TLCV15 under shelter was 13.04 t/ha when grafted onto eggplant rootstock and 12.07 t/ha with tomato rootstock, which were both significantly higher than the average yield of about 8.0–10.0 t/ha for TN001 and TN005 regardless of rootstock. Among the three scions, only TLCV15 was resistant to ToLCV. However, results from 16 farmer-managed trials showed that without grafting, even the resistant TLCV15 succumbed and was infected by BW disease. All varieties had 90–100% infection resulting in zero yields. In contrast, grafted plants showed high tolerance to BW disease and survived.

Table 57. Marketable yield of grafted tomato under shelter and in open field grown during hot-wet season, RIFAV, Hanoi, Vietnam, 2004

Scion	Rootstock	Marketable yield of grafted[a] plants (t/ha) Shelter	Open field
TN001	EG203	8.37 a	0.66 b
	Doctor K	7.37 b	0.49 a
TN005	EG203	9.96 b	0.41 a
	Doctor K	9.24 b	0.52 ab
TLCV15	EG203	13.04 d	1.23 c
	Doctor K	12.07 c	0.44 a
	Mean	10.00	0.83
	CV (%)	4.90	12.1

Mean separation in columns by Duncan's multiple range test, $P < 0.05$.
[a] Non-grafted tomato plants did not survive due to flooding.

Table 58 shows that TN005 produced the highest marketable yield both with hormone spray and without. All harvested fruits of TN005 and TN001 were counted as marketable, but some fruits of VL2500 and HS2922 were not marketable. Symptoms of ToLCV transmitted by whitefly were also observed in all varieties, but TN005 and TN001 had lesser infection than VL2500 and HS2992. The latter varieties were also susceptible to blossom end rot.

Results of on-farm trials conducted by farmers in 2005 indicated that most non-grafted plants regardless of the variety did not survive due to flooding and bacterial wilt disease. Four farmers that planted non-grafted tomato obtained low plant survival rate (30–40%) and very low yields averaging 3.3 t/ha (Table 59). Plant survival of grafted tomato ranged from 56–100% for TN005 and 61–100% for HS902. Of the eight farmers that planted TN005, the highest yield obtained was 19.8 t/ha. The lowest yield (1.5 t/ha) was obtained by one farmer who did not provide good management practice. The highest yield for HS902 was 34.2 t/ha. Two farmers obtained yields that were below 10 t/ha. Overall, the average yield of TN 005 was slightly lower (14.5 t/ha) than HS902 (17.3/ha). Only one farmer planted grafted BM136 with 94% plant survival and marketable yield of 30.8 t/ha. The most common disease observed on grafted tomato was the tomato leaf mold (*Fulvia fulva*) disease which seriously infected about 42% of the farms. Despite this disease incidence on grafted tomato, yield was higher than nongrafted tomato.

Table 58. Marketable yield of grafted tomato with and without hormone spray in on-farm trials, Hanoi, Vietnam, dry season, 2004

Variety	Hormone spray (yield, t/ha)	No hormone spray (yield, t/ha)
TN001	33.2	9.5
TN005	28.2	6.9
HS2922	32.1	7.3
VL2500	32.3	7.5
Mean	31.5	7.8

Data are means of 16 farms.

Table 59. Plant survival and marketable yield of grafted and non-grafted tomato in on-farm trials, Hanoi, Vietnam, 2005

Variety	Plant survival (%)		Marketable yield (t/ha)	
	Grafted	Non-grafted	Grafted	Non-grafted
TN005	85	-	14.5	-
HS902	87	33	17.3	3.4
BM136	95	40	30.8	3.3
Mean	89	37	20.9	3.4

Data are means of 16 farms.

Cambodia. In Phnom Penh, Cambodia, the benefits of grafting and rain shelter were not realized due to absence of stresses from heavy rainfall and flooding (Table 60). In the absence of such stress, differences in marketable yield between grafted and non-grafted tomato are expected to be small and not significant. In some cases non-grafted tomato even produced higher yield than grafted plants. In this study, the advantage of eggplant rootstock over tomato rootstock was likewise not exhibited. Yields under rain shelter without side netting were generally higher than under shelter with side netting and open field. Results from on-farm trials conducted by farmers in 2005 also indicated small differences in marketable yield between grafted and non-grafted tomato. Plant survival rates for both grafted and non-grafted tomatoes were high, which seems to indicate that in the absence of stress, non-grafted plants could perform at par as grafted plants. The results from both on-station and on-farm trials clearly indicate that the grafting technology has no agronomic and economic benefits when adverse climatic conditions (heavy rainfall and flooding) are absent, as what has been experienced in Cambodia.

Table 60. Effects of rootstocks, scions, and shelter on marketable yield of tomato grown in the hot-wet season, Phnom Penh, Cambodia, 2004

		Marketable yield (t/ha)		
Scion	Rootstock	Open field	Shelter	Shelter + net
CLN1462	EG203	16.7	28.4	6.0
	H7996	19.0	35.8	14.1
	Nongrafted	28.9	43.4	12.1
	F-test	**	**	**
CHT501	EG203	22.1	23.6	7.8
	H7996	26.5	38.8	7.3
	Nongrafted	24.8	36.0	23.9
	F-test	ns	ns	**
CLN1462A	EG203	19.7	22.0	13.9
	H7996	26.4	31.9	7.8
	Nongrafted	26.3	29.3	10.9
	F-test	ns	ns	ns
TMTKK1	EG203	26.4	28.1	41.6
	H7996	27.9	34.2	38.1
	Nongrafted	26.1	41.5	34.9
	F-test	ns	**	ns

F-test: **significant at $P < 0.01$; ns = not significant.

Lao PDR. All varieties of grafted tomatoes survived better than non-grafted plants both in shelter and open field. No plants survived among non-grafted plants of varieties CHT501 and SIDA. Plants grafted onto eggplant EG203 rootstock had a higher survival rating than those grafted onto tomato HW7996 rootstock. This also resulted in higher marketable yields of plants grafted onto eggplant rootstocks. Marketable yield varied among varieties under shelter and the open field. SR382 and SIDA produced higher marketable yield under shelter than the open field, whereas CHT501 and CLN2026D yielded higher in the open field than in shelter. Results of this on-station trial indicate that grafted tomato plants survived and yielded better than nongrafted plants.

The study has shown that in most locations of Southeast Asia where adverse environmental conditions prevailed during the wet season, grafted tomato plants performed better than non-grafted plants in terms of tolerance to flooding, bacterial wilt disease, and overall yield. Cambodia was the only site where the benefits of grafting technology were not demonstrated due to low rainfall and unusually dry weather. The combined effects of grafting and rain shelter in increasing tomato yield are significant only during season of heavy rainfall. However, the benefit from rain shelter may not be realized when seasonal rainfall is relatively low. Grafting technology has the potential of increasing tomato production during the off-season in Southeast Asia. Wider adoption through the development of infrastructure supporting the technology will increase market supply, provide high economic returns, and improve farmers' income in peri-urban agriculture.

Managing soil with Starter Solution Technology

Development of new starter fertilizer solution technology for vegetable production

When roots of plants are injured due to transplanting or heavy rain, it is crucial that affected plants receive without delay the available nutrients for fast recovery. Based on this principle, the Starter Solution Technology (SST) was developed to enhance early growth and overall yields of vegetable crops (cucumber, tomato, chili pepper, cabbage, lettuce, among others).

The principle of SST is tentatively raising the nutrient concentration in the soil solution by one application of very concentrated nutrient solution immediately after transplanting. According to many experimental results conducted at AVRDC, the optimal concentration of starter solution for many vegetables tested is 240 mg each of N-P_2O_5-K_2O in 50 ml for each plant. In terms of concentration, the starter solution is 4800 ppm (mg/l of N-P_2O_5-K_2O). Although the concentration of starter solution is extremely high, the concentration may decrease to 200–250 ppm N in extractable soil solution. This practice seems to be very contrary to the common fertilization application concept; however, it has proven its effectiveness for many transplanted vegetables. When starter solution prepared from a local compound fertilizer (liquid compound fertilizer #4, N-P_2O_5-K_2O=14-28-14%**)** is applied to tomato plants with a population of 29,600 plants/ha, for example, total application rate is only equivalent to 7.2–14.2–7.2 kg/ha of N-P_2O_5-K_2O.

Starter solution can be easily prepared by dissolving soluble fertilizers into water (Figure 25). Any type of locally available soluble fertilizer can be used, but the composition of the fertilizers should include N, P, and K, three essential macroelements. The form of N is of critical importance since some crops prefer NH_4^+-N but others prefer NO_3-N. It is suggested that the form best fitted to the crop being grown is chosen. Fertilizers containing urea as N fertilizer should be avoided. Although urea is soluble in water, it needs hydrolysis before the plant's root can take it up, hence, using urea as starter solution will be less effective.

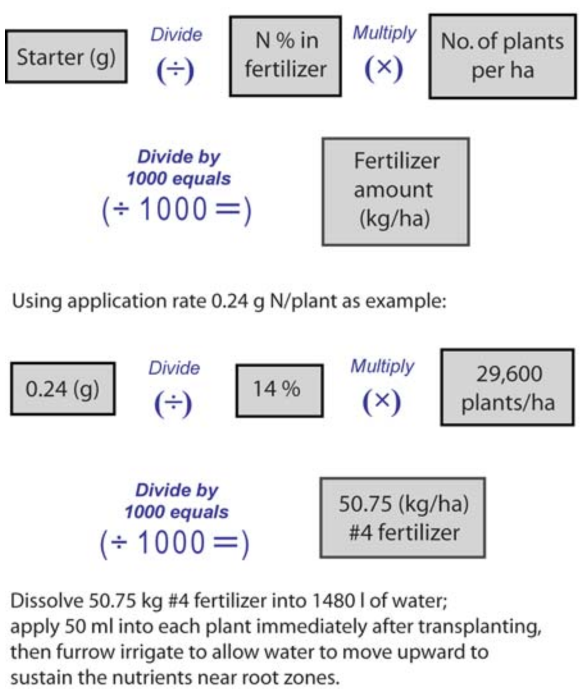


Figure 25. Preparation of starter solution set.

Starter solution can be applied manually to the rhizosphere soils of the plant. It can also be applied by injection, either by manual sprayer or by mechanized sprayer. The fastest speed tested for application is about 2.5 minutes per 100 plants.

Boost early growth of vegetables

Starter solution and fertilizer effects on heading cabbage, cherry tomato, fresh tomato, sweet, chili, and green peppers, and cucumber were evaluated in separate trials. Organic fertilizers were banded at 10–15 cm below the surface of raised beds before transplanting. Small amounts of concentrated liquid fertilizer as starter solution were then applied to rhizosphere soil immediately after transplanting and/or at critical times. The initial growth of all the tested vegetables was significantly enhanced by one or two starter solution applications compared to those crops grown using organic fertilization practices alone (Table 61).

Overall, the boosting effects of starter solution application on initial plant growth were very evident even within 12 days of application. The above-ground biomasses were enhanced by 31–160%, while the root growths were increased by 27–80%. Application of nutrients directly to soil-rhizosphere system may also stimulate activities of microorganisms.

Yield improvements and balanced fertilization

Application of SST with organic fertilizers improved yields of many vegetables tested. Table 62 shows the yield data of selected treatments for chili pepper in trials conducted for three years.

In 2003, marketable yields from the first three harvests, in treatment applied with starter solutions and chicken manure compost (CM+ST_0) was 22% higher than treatment with CM alone. Yield of CM treatment with starter solutions and two solid side-dressings was highest and 25% higher than standard inorganic (SI) fertilization check. The highest cumulative marketable yields from six harvests were achieved in the same treatment, the fruit yields were 26% higher than the SI check.

Table 61. The effects of starter solution applied with organic manures on the initial above-ground and root growth of selected vegetables

Fertilizer treatment	Vegetable crop	Survey time (DAT[b])	Top dry weight g/plant	Top dry weight Index[c]	Root dry weight g/plant	Root dry weight Index
CM*2[a]	Cabbage	12	2.4	100	0.21	100
CM+St_0[d]			3.9	163	0.29	138
CM	Cherry tomato	21	11.1	100	0.67	100
CM+St_0			17.1	154	0.85	127
CM	Fresh tomato	21	3.8	100	0.50	100
CM+St_0			9.9	260	0.90	180
CM	Sweet pepper	16	1.6	100	0.30	100
CM+St_0+St_{12D}[e]			3.2	200	0.38	127
CM	Chili pepper	25	7.2	100	0.73	100
CM+St_0			11.3	157	1.03	141
OF[f]	Green pepper	25	3.9	100	0.58	100
OF+St_0			6.2	159	0.87	150
OF	Cucumber	20	8.6	100	0.59	100
OF+St_0+St_{12D}			11.3	131	0.77	131

[a] Amounts of chicken manure (CM) applied equivalent to 2 x of inorganic solid fertilizer.
[b] DAT = days after transplanting.
[c] Percent increase of top and root dry weight after starter solution application
[d] Starter solution was applied after transplanting.
[e] Starter solution was applied after transplanting and 12 DAT.
[f] Local available organic fertilizer.

Table 62. Effects of starter solution and fertilizer treatment on the yield of chili pepper conducted in three years, 2003–2005

Fertilizer treatment of the trials	Year-Season	Marketable fruit yield (t/ha) Harvest 1-3	Index	Harvest 4-6	Index	Harvest 1-6	Index
CM[a]	2003-August	6.0	94	7.8	112	13.8	103
CM+ST_0[b]	2003-August	7.4	116	7.6	108	15.0	112
CM+ST_0+$Side_1$+$Side_3$	2003-August	7.9	125	8.9	127	16.8	126
Standard inorganic (SI)[c]	2003-August	6.4	100	7.0	100	13.4	100
PM[b]	2004-September	13.6	100	10.1	109	25.1	109
PM+ST_0	2004-September	15.0	110	9.7	105	24.8	108
ST_0+ST_1+ST_2+$Side_3$	2004-September	16.2	118	11.2	120	27.4	119
Standard inorganic (SI)[c]	2004-September	13.7	100	9.3	100	23.0	100
OF[f]	2005-August	10.0	103	14.4	91	24.3	95
OF+ST_0+ST_1+ST_2+$Side_3$	2005-August	11.4	117	15.9	101	27.3	107
OF+ST_0 +$Side_1$+$Side_3$	2005-August	12.7	131	17.2	108	29.9	117
Standard inorganic (SI)[c]	2005-August	9.7	100	15.9	100	25.5	100

[a] Composted chicken manure (CM, 10.4 t/ha); Composted pig manure (PM,17.3 t/ha) and local organic fertilizer (OF, 16.4 t/ha).
[b] Starter solution (ST) was soluble compound fertilizer # 4 (N-P_2O_5-K_2O=14%-28%-14%), diluted and applied at a rate of 240-480-240 mg of N-P_2O_5-K_2O in 50 ml water per plant (equivalent to 7.1-14.2-7.1 kg/ha N-P_2O_5-K_2O) for one application after transplanting (ST_0) and at 12 and 26 days after transplanting (ST_1 and ST_2)
[c] Standard inorganic fertilizer (SI) comprised a basal and six times side-dressing at 12, 25, 36, 50, 75 DAT and after 2nd harvest. Total applications were 300-150-200, 300-195-250 and 300-200-300 kg/ha of N-P_2O_5-K_2O for 2003-August, 2004-September, and 2005-August trials, respectively. Chili pepper variety *Jin's Joy selex* was used for all three trials.

In 2004, yield in treatment applied with starter solutions and solid side-dressing were higher than applied pig manure composts (PM) alone or SI check. Marketable yields from 4th to 6th harvests, in treatments applied with solid side-dressing at later growth stages were higher than yields from those treatments without solid side-dressing at later stages. This implies that application of solid side-dressing was essential for sustaining the booster effects of the liquid supplements in later production stages of chili pepper. For cumulative marketable yields from six harvests, the highest yield was achieved in the same treatment, i.e., when PM was supplemented with starter solution at transplanting, two additional liquid solutions at 12 and 26 days after transplanting (DAT) and side-dressed with solid inorganic fertilizers at 37 DAT. The marketable yield was 19% higher than the SI check. Application of starter solution in the SI check did not improve overall yield in this study.

In 2005, the highest yield of first three harvests was achieved when organic fertilizer (OF) was combined with the starter at transplanting and side-dressed with two solid inorganic fertilizers at 12 and 38 DAT. The marketable yield was 28% higher than the application of OF alone. Among the organically fertilized plots, those with starter solutions applied at early stages and solid fertilizers side-dressed at critical times of plant growth (12 and 38 DAT) yielded 7 and 17%, respectively, higher than SI check in accumulative yields of the six harvests.

Results of this study showed the feasibility and economic potential of applying starter solution technology in improving chili pepper production. Applications of starter solution enhanced the initial growth of plants, and better initial growths of plants led to higher fruit yields during early harvests. However, the application of solid side-dressing is crucial in order to sustain the booster effects of the liquid supplements into later production stages.

Results obtained from chili trials were consistent with the previous findings from other vegetables and explored new possibilities in enhancing the starter effects. Maximum yields in cabbage were obtained using organic fertilizers supplemented with starter solution at transplanting and one application after 12 days. The highest yields for cherry tomato were in plots fertilized with CM and either supplemented with one starter and two later applications of concentrated liquid inorganic fertilizer or one starter solution supplemented with one solid inorganic side-dressing at nine WAT. For sweet pepper, the yield was highest in the standard inorganic fertilizer treatment supplemented with one starter application after transplanting.

Based on these results, a balanced fertilization strategy was developed. Organic fertilizers are applied as basal, followed by starter solution applied after transplanting and at early growth stages, then side-dressed with solid inorganic fertilizers at later growth stages. By this approach, starter solution could substitute for 30–50% of inorganic fertilizer (basal) and more than 50% of organic fertilizer used during the cropping season. The proper amount and timing of side-dressings used in combination with starter solutions shall be developed according to the crop and local conditions.

In conclusion, the positive effects of starter solution application on initial plant growth were evident. Later in the cropping season, the effects of starter solution technology used as a side-dressing on yield varied depending on the vegetable, timing of the side-dressing, and other supplemental fertilizers. Balanced fertilization practices based on starter solution technology in combination with organic and inorganic nutrient sources can become a technology leading to increase fertilizer efficiency, profits of farmers, and reduce risks of environmental pollution. This technology is very easy to apply and modify for different vegetables. The technology is a low-input, soil-based approach, which may also be applicable to situations wherever excessive fertilizer use prevails or where fertilizers are rather costly for farmers. Moreover, with SST, leaching can be reduced.

Caution for application of Starter Solution Technology

The concentration of starter solution must be adjusted based on soil fertility, soil buffering capacity, plant species, and varieties. The soil at the AVRDC field has a texture of silty loam with about 1.5% organic matter and 8–10 meq/100g soil cation exchange capacity (CEC). In general, the lower the soil fertility, the better the effects of starter solution. For the first application of SST, it is necessary to have a preliminary test by transplanting several plants in the field and applying different concentrations of starter solution into each plant followed by irrigation. If the plants do not wilt or die after 1–2 days, this indicates that the concentration of starter solution is suitable for the plants.

The booster effect of SST is highest when it is applied immediately after transplanting, followed by furrow irrigation from the bottom to top of the beds. SST can also be applied at later critical stages, i.e., head initiation or fruit setting stages, to replace some of the used-up inorganic or organic solid fertilizers. Since the starter solution is expected to already supply some portions of the plant nutrient requirements, solid fertilizer application could now be reduced.

Organic vegetable production

AVRDC–The World Vegetable Center has recently initiated research on organic vegetable production, which is considered to be safe for consumers, farmers, and the environment. So far three donors are supporting AVRDC's Organic Vegetable Program including: 1) Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) under the Federal Ministry for Economic Cooperation and Development (BMZ), Germany; 2) The Organic Center for Education and Promotion, USA.; and since 2006, 3) COA the Council of Agriculture, Taiwan, ROC.

Funding for the AVRDC Organic Vegetable Program since 2005 are: 1) 'Development and implementation of AVRDC's Organic Vegetable Program' (GTZ/BMZ, Germany, three years duration); 2) 'Comparison of Lycopene and other Phytochemicals in Tomatoes grown under Conventional vs. Organic Management System' (The Organic Center, USA, two years duration); 3) 'Development of AVRDC's Organic Research Fields' (The Organic Center, USA, two years duration).

With this grant, several activities were supported in organic farming at AVRDC such as: variety evaluation of pak-choi, sweet corn, and rice; evaluation of green manure species; establishment of a fruit tree/banana/ elephant grass boundary and an agroforestry plot.

In this report, only key results of the above-mentioned projects and field studies are presented with one exception (Table 66), where results have been evaluated using the analysis of variance and comparisons of means ($P < 0.05$).

A 6-ha area of fields has been in transition from conventional to organic farming since the summer of 2004. In December 2005, planting of a boundary around the fields to protect the crops from pesticide drift was completed. In addition to vegetables, rice, sweet potato, sweet corn, green manure species, catch crops and tropical fruit trees were grown to increase the biodiversity and stability within the system. An agro-forestry plot of about 1 ha was established for research on intercropping of tropical fruit trees and vegetables. In 2005, variety evaluation trials in rice, sweet corn, green manure species, vegetable soybean, and pak-choi were undertaken.

In 2005, a short-term field study within the AVRDC Organic Vegetable Program revealed significant differences among 10 pak-choi varieties in terms of mortality, leaf development, and fresh biomass production. The field trial was laid out in RCBD with four replications. On 12 April 2005, the seeds were sown in two rows (spacing 15 cm between rows x 10 cm within row). Variety V1 was superior in all growth parameters assessed. For example, V1 significantly developed more true leaves compared with other varieties except V4 (Table 63).

Table 63. Mean true leaf number of pak-choi varieties

Pak-choi varieties	23 DAS	30 DAS	36 DAS
V1	5.6 a	8.9 a	11.1 a
V2	4.8 a	6.6 bc	8.1 bcd
V3	5.2 a	6.7 bc	8.4 bcd
V4	5.5 a	7.4 ab	9.5 ab
V5	5.0 a	7.3 bc	8.8 bc
V6	5.1 a	6.8 bc	7.4 bcd
V7	4.8 a	5.9 bc	7.0 cd
V8	5.3 a	7.0 bc	7.9 bcd
V9	5.3 a	6.8 bc	7.9 bcd
V10	4.4 a	5.8 c	6.4 d

DAS = days after sowing.
Results within each column followed by different letters are significant (Tukey's-test, $P < 0.05$).

The significant differences between varieties were achieved under severe biotic (tap root damage of seedlings caused by flea beetle larvae) and abiotic stresses (very high temperatures, low nitrogen availability). The results suggest that some pak-choi varieties were able to cope better with these stressful conditions than others. Observations in the field suggest that these varieties might have had a better regrowth capacity of secondary roots after severe damage of the tap root. Thus, the superior variety V1 might be a potential entry in breeding programs aimed at developing new pak-choi varieties better adapted to low nitrogen inputs and environmental stress.

In 2005, the performance of green manure species during the hot-wet season when there is frequent flooding was evaluated. Cultivation of green manure species improves soil fertility and structure. However, the choice of green manure species can be considerably limited if the species adaptability to specific conditions (flooding, drought, heat, cold, poor soil fertility, among others) is considered. In Taiwan, farmers are growing mainly sesbania (*Sesbania cannabina*, *S. roxburghii*, and *S. aculeaeta*) during the hot-wet season. However, if only sesbania is mainly grown, the biodiversity is expected to be small, which could sometimes result in insect pest problems as what happened in 2005 when the tobacco cutworm (*Spodoptera litura*) epidemic has severely damaged sesbania as well as other crops throughout southwest Taiwan.

The overall objective of this study was to provide farmers a wider choice in selecting appropriate green manure species adapted to the hot-wet season. In particular, this study aimed to evaluate the performance and flood tolerance of two green manure soybean cultivars namely cv. Tainan#4 and cv. Tainan#7 released by Tainan District Agriculture Improvement Station (Tainan DAIS), and to compare their performance with sesbania, the most common cultivated green manure species during the hot-wet season. The field trial was laid out in RCBD with four replications. On 18 May 2005, the seeds were sown (for technical reasons 20 x 20 cm spacing).

Among other crop growth parameters, the fresh biomass of the green manure species was assessed in two subplots per plot, each of 1 m^2 area. At 84 and 95 DAS the fresh matter of sesbania was significantly higher compared to both green manure soybean cultivars (Table 64). The fresh matter production of cv. Tainan#7 and cv. Tainan#4 was not significantly different (Table 64).

Table 64. Mean above-ground fresh matter (FM) of green manures

Green manure	84 DAS FM (kg/m^2)	97 DAS FM (kg/m^2)
Sesbania	3.16 a	4.42 a
cv. Tainan#4	2.13 b	2.32 b
cv. Tainan#7	2.35 b	2.52 b

Results within columns followed by different letters are significantly different (Tukey's-test, $P < 0.05$)

Sesbania and the green manure soybean cultivars cv. Tainan#4 and cv. Tainan#7 sown on 18 May 2005 survived severe flooding at AVRDC in the middle of June. The crops were able to cover the soil surface completely, although spacing of single plants was very wide (20 x 20 cm). Sesbania produced about 32 and 44 t/ha fresh above-ground biomass within 84 and 97 DAS, respectively. Both cv. Tainan#4 and cv. Tainan#7 also produced considerable amounts of fresh biomass of about 23 and 25 t/ha respectively at 97 DAS, within the range of biomass production levels reported in official Tainan DAIS reports. However, maximum biomass production of about 45 t/ha FM was not realized, either because of the adverse growing conditions in summer 2005 or because of the wide spacing of 20 x 20 cm not common in green manure soybean production. Cultivar cv. Tainan #7 is well adapted to rainfed cropping conditions, and is superior in drought and cold resistance. However, even the crop of cv. Tainan #4 survived the extended flooding period in 2005. Thus, under these experimental conditions, all three green manures tested in this study can be recommended for cultivation during the hot-wet season. While both cv. Tainan #4 and cv. Tainan#7 provided significantly lower yields than sesbania, recommending these two Tainan varieties as well could enrich the green manure diversity.

In 2005, the yield and disease susceptibility of two Taiwanese rice cultivars, namely cv. Taigon#8 and cv. Tainan#11, recommended for use in organic farming, were evaluated. The field study was a joint project of AVRDC–The World Vegetable Center and the Chiayi Branch Station of Tainan DAIS. Organic rice was cultivated for the first time at AVRDC within the newly established AVRDC Organic Vegetable Program to enhance crop diversity. The major objective was to identify the cultivar or cultivars that will give higher grain yields and would be least affected by disease and pests.

A total area of about 1 ha (AVRDC organic field #84) was divided into eight plots (RCBD with four replications). The plot size was about 25 x 50 m. The previous crop was sweet potato. Production technology of organic paddy rice used in this study such as cultivar choice, spacing (30 x 18 cm), fertilizer type (rape seed cake and soybean meal) and amount (120 kg/ha N basal before transplanting, and 40 kg/ha N top-dressing on 11 May 2005 during flowering stage) was chosen according to recommendations of Tainan DAIS rice experts at Chiayi Branch Station. Rice seedlings were transplanted on 1 March 2005 (1st rice crop, irrigated lowland rice). The rice crop was frequently irrigated. Weeding was done by hand. During the first 40 days after transplanting, it is especially important to manage weed competition in organic rice. Therefore, the first weeding operation started one week after transplanting. Two more major weeding operations were carried out eight (from 12 to 19 March) and 10 DAT (from 27 March to 5 April). Twice during the growing season (20 April and 10 June), a *Bacillus thuringiensis* (Bt)-product was sprayed to control rice stem borer (*Scirpophaga incertulas*), a major insect pest in rice. While rice grain yield was assessed in four subplots per plot (each of about 2.9 m^2 comprising 50 hills), other crop parameters such as plant height, disease impact, rice stem borer damage, panicle number, grain/straw relation, 1000-seed weight (TSW), among others, were assessed on 12-hill areas, about 2.3 m long (that is, from a total of six subplots per plot). All the abovementioned subplots were harvested by hand on 30 June 2005. During mid-June, about two weeks before rice harvest, about 1200 mm of rainfall was recorded over six days. Mean grain yield, TSW, and other yield components of both cultivars did not differ much from each other (Table 65). However, the cultivars were affected by different diseases. Cultivar Taigon#8 was affected by the brown spot disease (*Cochliobolus miyabeanus*), whereas cv. Tainan#11 was affected by rhizoctonia (*Rhizoctonia solani*).

Table 65. Mean grain yield and yield components (86% DM) of rice cultivars cv. Taigon#8 and cv. Tainan#11

	Grain yield (t/ha)	Panicles (per m^2)	TSW (g)	Straw (t/ha)	Grain/ straw relation
cv. Taigon#8	5.66	310	27.3	6.35	0.91
cv. Tainan#11	5.92	361	26.7	6.12	0.97

TSW = 1000-seed weight.

Both cultivars reached almost six t/ha grain yield, only about 1 t/ha less than the average yield of conventionally grown paddy rice in Tainan County (1st paddy rice crop: 6958 t/ha in 2004 according to the Taiwanese Statistical Yearbook). Under high rhizoctonia disease pressure, it would be profitable to grow cv. Taigon #8, whereas under brown spot disease pressure, cv. Tainan #11 should be chosen since the disease susceptibility of cultivars turned out to be different in this study. Two weeks before harvest in June 2005, both cultivars withstood more than 1200 mm rainfall over six days without any lodging, whereas all neighboring conventionally managed fields suffered severe lodging. This observation suggests that organic rice cultivation might be more likely to maintain yield stability in times of disasters compared to conventionally cultivated rice, although the maximum yield level of rice in favorable agronomic environments (high natural soil fertility, high-yielding variety, high input) usually cannot be realized in organic farming.

The performance of two different processing tomato varieties in commercial organic and conventional farms in central and southwest Taiwan was evaluated. One major objective of the study was to compare plant vigor and yields of tomato crops grown on-farm under organic versus conventional management systems. In October 2005, replicated field trials were established at three organic and three conventional farms (three matched farm pairs in Shinhua, Madou, and Sihu); two out of three farm pairs (Madou, Sihu), mean marketable fruit yields across varieties were significantly higher at conventional farms than organic farms (Table 66).

The ranking across all farm types and locations for marketable fruit yield was SI-C > SH-C > SH-O > MA-C > MA-O > SI-O. The mean marketable fruit yield was similar at Shinhua in both farming systems. Among organic farmers, the management of the organic farmer in Shinhua appeared to be superior. His practice was to irrigate and fertilize his tomato crop moderately, and spray a Bt-product immediately after detection of tomato fruitworm (*Helicoverpa armigera*) and tobacco cutworm (*Spodoptera litura*), thus preventing severe damage of the crop. A combination of proper crop management and the right application time of an effective biopesticide was most likely the reason for his success. In general, the crop yield and quality was independent of the farming system, but rather dependent on individual farmer's good management skills that are especially required in organic farming.

Table 66. Mean marketable tomato fruit yield (t/ha) across two tomato processing varieties

Farm pair/type	Marketable yield (t/ha)[a]
Shinhua organic (SH-O)	55.1
Shinhua conventional (SH-C)	57.1
Difference (SH-O) - (SH-C)	-2.0
Madou organic (MA-O)	34.7
Madou conventional (MA-C)	52.4
Difference (MA-O) - (MA-C)	-17.7 **
Sihu organic (SI-O)	22.2
Sihu conventional (SI-C)	59.3
Difference (SI-O) - (SI-C)	-37.1 **

[a] Combined data across farms were statistically analyzed by combined analysis of variance using the PROC MIXED procedure of the SAS. The mean differences between the organic and conventional farms within each farm pair were compared using the Tukey's-test (* significant at $P < 0.05$ and ** significant at $P < 0.01$, respectively).

Integrated pest management

In 2005, the activities in integrated pest management (IPM) became part of the Crop and Ecosystem Management (CEM) Unit. The IPM Specialist joined the CEM Unit in April 2005 and managed two subgrant projects under the United States Agency for International Development (USAID)-IPM Collaborative Research Support Project (CRSP). These projects were: 1) 'Regional IPM Program in East Africa: Kenya, Tanzania, and Uganda' led by the Ohio State University; and 2) 'Ecologically-based Participatory IPM in Southeast Asia' with Clemson University as the lead institution. These projects were initiated in late 2005 and research activities are in progress.

Contact: Manuel Palada

Nutrition

Screening of edible plants for antimicrobial activities against food-borne pathogens

Protein, iron, vitamin A, iodine deficiencies, and diarrhea are among the most significant issues for global health. Diarrheal diseases are major causes of malnutrition and morbidity in infants and young children in the developing world. Contamination of food and drinking water contribute to most diarrhea incidence. Food-borne illness is also a great concern for industrial countries. Natural antimicrobial agents are of increasing interest for both consumers and food industries.

Plants produce a huge variety of secondary compounds that act as natural protection against microbial and insect attacks. Some of these compounds may be toxic to animals and some are not. Many of these have been used in the form of whole plants or extracts for food or medicinal applications in humans. Flavonoids are ubiquitous in photosynthetic cells and occur widely in the plant kingdom, including fruits and vegetables. Many groups of these natural products, particularly in medicinal plants, have been isolated and proven to possess antiviral, antibacterial, and antifungal activities. Edible plants and vegetables that originated or are adapted in subtropical and tropical areas may also possess antimicrobial properties. The selection of potential plant materials with antimicrobial properties could be further applied for: 1) food to inhibit food-borne pathogen growth in food matrix or pathogenic microflora in the gut; 2) chemotherapy for incorporation into oral dehydration solution for diarrhea in resource-poor areas; or 3) feed to reduce antibiotic use in livestock. The objective of this work was to screen indigenous vegetables for antibacterial activities against common food-borne pathogens.

A total of 34 indigenous vegetables were used for antimicrobial tests. These were selected based on previous work to present high total phenolic content of plant species. Water and methanolic extractions (plant/solvent: 1/5, w/v) were prepared right after harvests and kept at -70°C until analyses. Antimicrobial properties were measured using a hole-plate agar diffusion method and tested against three common food-borne pathogens including *Escherichia coli* (ATCC11775), *Salmonella typhimurium* (ATCC 14028), and *Staphylococcus aureus* (ATC9144).

Table 67 shows the methanol extracts of eight species possessing anti-*S. aureus* activity including *Bidens bipinnata*, *Corchorus capsularis*, *Houttuynia cordata*, *Moringa oleifera*, *Polygonum odoratum*, *Ruta graveolens*, *Cedrela sinensis*, and *Isatis indigotica*. Inhibition of *S. aureus* did not correspond with total phenolic density. Only *Cedrela sinensis* exhibited anti-*S. typhimurium* activity. None of samples were found to exert anti-*E. coli* activity. Except for *M. oleifera* and *I. indigotica*, none of the water extracts showed anti-*S. aureus* activity.

Antimicrobial activities were further assessed and compared among four *Moringa* species grown in AVRDC fields and between two *Cedrela sinensis* varieties obtained from home gardens near AVRDC. One more strain, *S. typhimurium* I50, originally from chicken gut, was included. Results shown in Table 68 indicated that methanol extracts of red and green *Cedrela sinensis* demonstrated similar antibacterial activity against *S. aureus* and two strains of *S. typhimurium*. Water extracts did not show antimicrobial activity. Results in Table 69 indicated that all four frozen dried *Moringa* species exhibited anti-*S aureus* activities for both water and methanol extracts. However, the activities were maintained only for the two species, *M. drouhardii* and *M. peregrina* after the leaves were 50°C hot-air dried instead of frozen-dried.

Eight edible plants showed antimicrobial activities in this work. Among these, moringa (*Moringa sp.*) and Chinese cedar (*Cedrela sinensis*) are potential sources for both nutrients and alternative antimicrobial agents. Antimicrobial activity against other pathogenic bacteria, fungi, and viruses, the minimal inhibitory concentrations (MIC), and modes of actions for moringa and Chinese cedar need further studies. More indigenous vegetables lower in phenolic content should be included for antimicrobial tests since there is no evident association of phenolic density to the positive antimicrobial activity.

Table 67. Antimicrobial activities[a] and total phenolics (TP)[b] content of methanol extracts of 34 edible plants[c]

Common name	Scientific name	TP	*E. c.*	*S. t.*	*S. a.*
Baobab tree	*Adansonia digitata*	1946	-	-	-
Ashitaba	*Angelica keiskei*	376	-	-	-
Mugwort	*Artemisia indica*	747	-	-	-
Pilose beggarticks or Spanish needles	*Bidens bipinnata*	571	-	-	+
Hairy baggarticks	*Bidens pilosa*	391	-	-	-
Rocket-salad	*Brassica eruca*	460	-	-	-
Mizuna or field mustard	*Brassica campestris*	448	-	-	-
Cassod tree or iron wood	*Cassia siamea*	3,272	-	-	-
	Cassia sophera	589	-	-	-
Coffee senna	*Cassia occidentalis*	709	-	-	-
Feathery amaranth or cockscomb	*Celosia argentea*	735	-	-	-
Chinese cedar	*Cedrela sinensis*	12,070	-	+	+
Butterfly pea	*Clitoria ternatea*	447	-	-	-
Jute mallow	*Corchorus capsularis*	496	-	-	++
Chinese foldwing	*Dicliptera chinensis*	367	-	-	-
Sesame	*Eurca sp.*	490	-	-	-
Roselle	*Hibiscus sabdariffa*	958	-	-	-
Saururus	*Houttuynia cordata*	934	-	-	+
Folium isatidis	*Isatis indigotica*	611	-	-	++
Sweet potato leaf	*Ipomoea batatas*	1,682	-	-	-
Honeysuckle	*Lonicera japonica*	492	-	-	-
Indian mulberry	*Morinda citrifolia*	1,000	-	-	-
Drumstick tree	*Moringa oleifera*	453	-	-	++
Watercress	*Nasturtium officinale*	2,189	-	-	-
Stinking passion flower	*Passiflora foetida*	489	-	-	-
Frog fruit	*Phyla nodiflora*	1,122	-	-	-
Vietnamese coriander or cilantro	*Polygonum odoratum*	6,496	-	-	++
Rue	*Ruta graveolens*	1,668	-	-	+
Star gooseberry	*Sauropus androgynus*	576	-	-	-
African nightshade	*Solanum scabrum*	394	-	-	-
Indian cress	*Tropaeolum majus*	405	-	-	-
Chinese wedelia	*Wedelia chinensis*	607	-	-	-
Wedelia	*Wedelia trilobata*	367	-	-	-
Ailanthus prickly-ash	*Zanthoxylum ailanthoides*	738	-	-	-

[a] Antimicrobial activities against: *E. c., Escherichia coli; S. t., Samonella typhimurum; and S. a., Staphylococcus aureus;* ++, clear zone > 0.5 cm; +, < 0.5 cm; and -, no clear zone. Results were based on two determinations.
[b] TP, mg chlorogenic acid /100 g fresh weight.
[c] Leaves or young shoots were used.

Table 68. Antimicrobial activities[a] of methanol and water extracts[b] of green- and red-stem Chinese cedar (*Cedrela sinensis*) leaves

	TP[c]	*E. coli*	*S. typhimurium*	*S. typhimurium* I50	*S. aureus*
Green stem	4,586	-	++	+	+
Red stem	2,489	-	++	+	+

[a] Results were based on two determinations.
[b] Results from water and methanol extracts were the same.
[c] TP: total phenolics, chlorogenic acid equivalent, mg/100 g fresh weight.

Table 69. Antimicrobial activities[a] of frozen- and oven-dried leaves of four *Moringa* species

	TP	*E. coli*	*S. typhimurium*	*S. typhimurium* I50	*S. aureus*
	Frozen dried				
M. oleifera	817	-	-	-	++
M. stenopetala	915	-	-	-	++
M. peregrina	1,791	-	-	-	++
M. drouhardii	719	-	-	-	++
	Oven-dried				
M. oleifera	734	-	-	-	-
M. stenopetala	860	-	-	-	-
M. peregrina	1,705	-	-	-	+
M. drouhardii	824	-	-	-	++

TP: total phenolics, chlorogenic acid equivalent, mg/100 g fresh weight.
[a] Results were based on two determinations.

Phenolic profiles of leafy sweet potato varieties for two harvests

Sweet potato leaves (SPL) have been consumed as a fresh vegetable by people in many parts of the world, particularly in Asia and Africa. Varieties of various leaf colors, including dark green, yellow green, purple, mixed purple, and green are grown. Sweet potato is a perennial crop and can be continuously harvested for tips and leaves. It is adapted in the tropics and tolerant to environmental stress and resistant to diseases.

Based on previous studies of antioxidant capacity, nutrient values, and crop traits (e.g., resistance to disease and pests), leafy sweet potato (*Ipomoea batatas*) has been identified as a nutrient-dense and flavonoid-rich food that may contribute to micronutrient and antioxidant intake and health promotion. The total amount of phenolic constituents in the SPL powder is about 6 g gallic acid equivalents (GAE)/100 g. According to published reports, more than 15 anthocyanins have been identified in SPL, principally cyanindin and peonidin glucosides conjugated with caffeic or ferulic acid. Health benefits of simple phenolics and anthocyanidins from various crops have been demonstrated in numerous studies.

The phenolics compounds in leaves may protect against antimicrobial and insect attacks and act in response to environmental stress. This work was to compare phenolic profiles and contents of six leafy sweet potato varieties for two harvests.

Six leafy sweet potato varieties (Table 70) were used in this study. Each variety was grown in 2 x 10 m^2 at the AVRDC IV Display Garden in April 2003 by the International Cooperation Office (ICO) and harvested twice in April 2004 and October 2004. About 2 kg of sweet potato tips including leaves and 10-cm-long petioles were cut from the vines and collected from east and west sides of the block, respectively, for each variety. Fresh materials were washed, cut

Table 70. Leafy sweet potato varieties for functional component analyses

No.	Leaf description	Root description	Source
SPL 1	Purple, round wide	Light copper root periderm, white flesh	I-Lan Red; collected from I-Lan, Taiwan
SPL 2	Pink and green, deep lobe	White root periderm, light yellow flesh	Collected from Hualien, Taiwan
SPL 3	Green, deep lobe	White root periderm, white flesh	Local variety in Taiwan; collected from Southern Taiwan
SPL 4	Dark green, round wide	Purple red root periderm, purple flesh	Hybrid with taro; collected from Hualien, Taiwan
SPL 5	Yellow green, round wide	Pink root periderm, white flesh	Delo, collected from Philippines; Acc. no: I 426, GRSU, AVRDC
SPL 6	Yellow green, deep lobe	Red root periderm, white-purple flesh	Acc no: CN1367-2, GRSU, AVRDC, collected from Tai-tung

Plant materials and information source were from Kuo and colleagues, ICO, AVRDC.

into 1 x 1 cm^2 and mixed thoroughly. Exactly 20 g were weighed, sealed in plastic bags and stored at -70 until analyses. Anthocyanins, phenolic acids, and flavonoids in purple SPL were identified according to reported data using LC-MS-MS. This work was done in collaboration with J. Blumberg and his colleagues, Antioxidant Research Laboratory, Human Nutrition Research Center for Aging, Tufts University. Quantification of phenolic compounds for SPL varieties was performed using high performance liquid chromatography (HPLC) and conducted in the Nutrition Unit of AVRDC.

Phenolic profiles of purple sweet potato leaf

Three major phenolic groups in the purple SPL1 (Table 71) included: 1) anthocyanins (13 compounds identified); 2) chlorogenic acids and derivatives (5 compounds); and 3) flavonoids of quercetin derivatives (5 compounds). The molar ratio of the three groups was anthocyanin : phenolic acids : flavonoids = 7.3 : 70.0 : 22.7. Chlorogenic acid derivatives included chlorogenic acid (P1), neo-chlorogenic acid (P2), and dicaffeoyl quinic acid isomers (P8"P10), which were 77% of the total chlorogenic acid derivatives in purple SPL1 (Figure 26a). Dicaffeoyl quinic acids were the major soluble phenolic compounds (> 50% of the three groups of compounds) in SPL and have been reported to possess anti-human immunodeficiency virus (HIV) properties through inhibition of the HIV integrase.

Thirteen anthocyanin peaks, with absorbance at OD_{530} in purple SPL, were detected and nine compounds were identified (Figure 26b and Table 72). SPL anthocyanins have two aglycones, cyanidin, and peonidin, as reported. Peak A10, A12, and A14 are the major cyanidin derivatives, which consisted of more than 75% of total SPL anthocyanins.

Table 71. Phenolic compounds of purple sweet potato leaf powder

Peak	Chemical name	Aglycone
Chlorogenic acid and derivatives		
P1	Chlorogenic acid	
P2	Neochlorogenic acid	
P8	4,5-Dicaffeoyl quinic acid	
P9	3,5-Dicaffeoyl quinic acid	
P10	3,4-Dicaffeoyl quinic acid	
Quercetin derivatives		
P3	unidentified	Quercetin
P4	unidentified	Quercetin
P5	unidentified	Quercetin
P6	unidentified	Quercetin
P7	unidentified	Quercetin

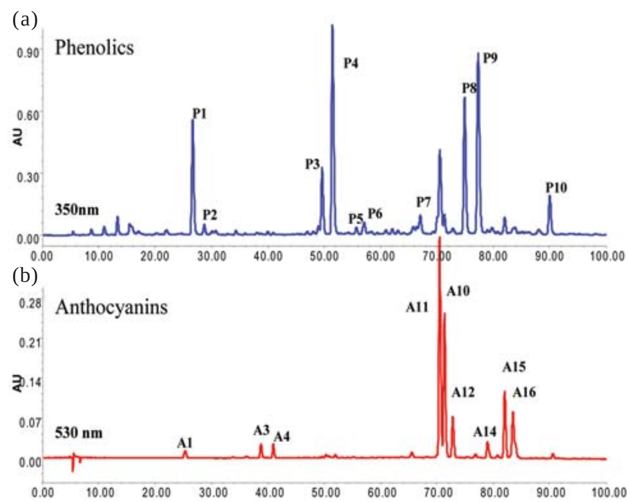


Figure 26. (a) Phenolic and (b) anthocyanin profiles of purple sweet potato leaves.

Table 72. Anthocyanin profiles of purple sweet potato leaf powder

Peak	Chemical name	Aglycone
A1	Cyanidin 3-sophoroside-5-glucoside	Cyanidin
A3	P-hydroxybenzoate(cyanidin 3-sophoroside-5-glucoside)	Cyanidin
A4	Caffeoylated(cyanidin 3-sophoroside-5-glucoside)	Cyanidin
A10	Cyanidin 3-(6,6'-caffeoyl-p-hydroxybenzoylsophoroside)-5- glucoside	Cyanidin
A11	Cyanidin 3-(6,6'-dicaffeoylsophoroside)-5-glucoside	Cyanidin
A12	Cyanidin 3-(6-caffeoylsophoroside)-5-glucoside	Cyanidin
A14	Cyanidin 3-(6,6'-caffeoylferuloylsophoroside)-5-glucoside	Cyanidin
A15	Peonidin 3-(6,6'-dicaffeoylsophoroside)-5-glucoside	Peonidin
A16	Peonidin 3-(6,6'-caffeoyl-p-hydroxybenzoylsophoroside)-5-glucoside	Peonidin

Comparison of six sweet potato leaf varieties for phenolic profile and content

The phenolic profiles of the six SPL varieties are illustrated in Figure 27. All SPL varieties contained chlorogenic acids (P1, P2) and dicaffeoyl quinic acids (P8"P10). Only purple SPL showed exceptionally high flavonoids of P3 and P4. It is known that quercetin is one of the precursors for anthocyanin synthesis, and thus it is not surprising that the anthocyanin-rich SPL were also high in quercetin. In Table 73, phenolic acids and flavonoid content among six SPL varieties were compared by *t*-test. While higher values of total phenolic acids and flavonoids (sum of P1–P10) were found in SPL4 (taro), SPL6 (yellow), and SPL1 (purple), differences were not statistically different. Only SPL6 (yellow) showed significantly higher value of total content of P1–P10 than that of SPL5 (yellow). This implies that leaf color did not necessarily correspond to phenolic density. The highest contents of dicaffeoyl quinic acids were found in taro SPL4 and yellow SPL6, with mean values about 1.6- to 1.8-fold higher than the lowest one of yellow SPL5. On the other hand, yellow SPL5 had the highest mean values of chlorogenic acids (P1, P2) with an 1.8-fold difference compared to the lowest in pink SPL2.

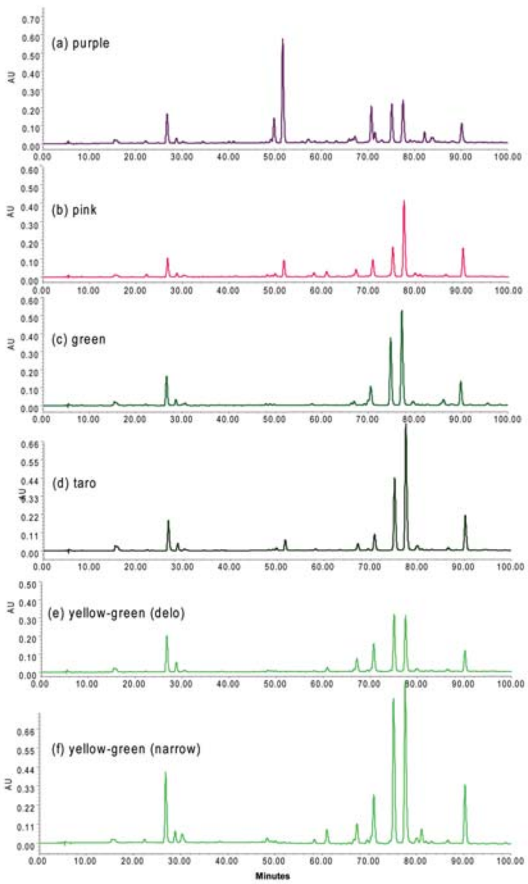


Figure 27. HPLC profiles at OD $_{350\ nm}$ of sweet potato leaves for SPL1 to SPL6, (a) to (f), respectively.

Anthocyanins were detected in purple SPL1, pink SPL2, and taro SPL4 (Table 74). Purple SPL1 contained 391 µmol/100 g dry weight anthocyanins, which was ninefold higher than pink SPL2 and 60-fold higher than taro SPL4.

In conclusion, all the tested SPL varieties were rich in chlorogenic acids and dicaffeoyl quinic acids. Contents of these compounds did not correspond to leaf color. Additionally, SPL with red color were detected to have both anthocyanins and quercetin derivatives, which were particularly high in purple SPL. Regarding the phenolic profile and concentration, purple SPL is the best source of functional components among the tested varieties.

Diets rich in micronutrients and antioxidants are strongly recommended as a supplement in medicinal therapy for HIV-acquired immune deficiency syndrome (AIDS). Leafy sweet potato is easy to grow, nutritious, and provides an affordable source of micronutrients, antioxidants, and potential anti-HIV agents for the poor. Purple SPL can provide additional antioxidants including anthocyanins and quercetin. Bioavailability and bioactivity of SPL-derived compounds as antioxidants and anti-HIV agents need to be further studied.

Table 73. Phenolic acid and flavonoid contents[a] of six leafy sweet potato varieties

	SPL1 Purple	SPL2 Pink	SPL3 Green	SPL4 Taro	SPL5 Yellow (delo)	SPL6 Yellow (narrow)
DM	11.7 ± 2.6 a	10.0 ± 1.3 c	8.5 ± 0.6 d	9.9 ± 1.7 c	10.6 ± 2.1 b	8.8 ± 0.6 d
P1[b]	736 ± 329 a	477 ± 179 a	537 ± 182 a	581 ± 496 a	845 ± 330 a	725 ± 307 a
P2	116 ± 53 b	92 ± 37 b	98 ± 38 b	160 ± 60 a	171 ± 30 a	122 ± 43 b
P3	231 ± 84 a	11 ± 12 b	0 ± 0 b	0 ± 0 b	0 ± 0 b	0 ± 0 b
P4	1,066 ± 399 a	143 ± 18 b	4 ± 3 c	103 ± 73 b	3 ± 1 c	8 ± 3 c
P5	13 ± 11 a	0 ± 0 b	0 ± 0 b	0 ± 0 b	0 ± 0 b	0 ± 0 b
P6	46 ± 15 a	0 ± 0 b	0 ± 0 b	0 ± 0 b	0 ± 0 b	0 ± 0 b
P7	76 ± 32 ab	57 ± 11 bc	22 ± 8 d	41 ± 18 cd	104 ± 13 a	95 ± 60 a
P8	1,438 ± 929 b	633 ± 101 c	1,179 ± 311 b	2,001 ± 1,036 a	1,309 ± 464 b	1,956 ± 483 a
P9	1,255 ± 667 c	1,839 ± 523 b	1,721 ± 472 b	2,360 ± 490 a	1,082 ± 246 c	1,957 ± 620 ab
P10	472 ± 203 c	568 ± 145 ab	486 ± 155 c	519 ± 112 bc	382 ± 97 d	634 ± 208 a
Total	5,450 ± 2,718 ab	3,819 ± 976 ab	4,047 ± 1,138 ab	5,766 ± 2,025 ab	3,896 ± 1,157 b	5,497 ± 1,704 a

[a] Values are mean ± SD in µmole/100 g dry weight, n = 4 including two field replications for two harvests. Means with the same letter in row are not significantly different, $P > 0.05$, according to *t* test.

[b] P = phenolic peak, P1“P2 are indicated in Figure 26a.

Table 74. Anthocyanin contents[a] of three leafy sweet potato varieties

	Purple SPL1	Pink SPL2	Taro SPL4
DM	11.7 ± 2.6 a	10.0 ± 1.3 c	9.9 ± 1.7 c
A1[b]	5.6 ± 0.9 a	1.6 ± 0.7 b	0.2 ± 0.2 c
A3	14.7 ± 4.7 a	0.5 ± 0.4 b	0.4 ± 0.4 b
A4	10.6 ± 3.3 a	2.6 ± 1.5 b	0.4 ± 0.5 c
A11	122.3 ± 13.1 a	19.6 ± 8.1 b	1.9 ± 1.0 b
A10	111.5 ± 15.3 a	3.8 ± 2.0 b	1.6 ± 1.4 b
A12	21.2 ± 1.9 a	3.1 ± 1.4 b	0.3 ± 0.1 b
A14	18.0 ± 6.0 a	6.0 ± 2.6 b	0.6 ± 0.5 b
A15	41.6 ± 10.6 a	5.3 ± 2.0 b	0.6 ± 0.2 b
A16	45.2 ± 6.1 a	1.6 ± 0.5 b	0.4 ± 0.4 b
Total	390.6 ± 28.9 a	44.1 ± 19.0 b	6.5 ± 4.5 c

[a] Values are mean ± SD in µmol/100 g dry weight , n = 4. Means with the same letters in a row are not significantly different.

[b] A = anthocyanin peak, A1"A16 are indicated in Figure 26b.

Contact: Ray-yu Yang

Socioeconomics

Urbanization and demand for food quality in Hanoi

The objective of this study was to quantify the changes in demand for food quality due to urbanization and enhanced income. Six criteria of good quality food were considered: 1) supply of major nutrients and micronutrients; 2) food diversity; 3) stage of processing; 4) prices; 5) food sources; and 6) proportion of food eaten outside the house. The difference in these parameters of food quality across various income and regional groups in Hanoi were observed. The data for this study were collected through a household consumption survey using the 24-hour recall method. The survey was conducted in the urban and peri-urban areas of Hanoi, and rural provinces of Hatay and Hungyen around Hanoi. To cover seasonality in fruits and vegetable consumption, the survey was repeated three times in a year, representing three distinct seasons of the city.[8] Appropriate representation was given to different income[9] and farm-related[10] groups in the survey.

Seven food groups were defined as cereals, vegetables, fruits, meats, aquatic products, eggs and milk, and others. The data of each food item consumed in each household were converted into available nutrients using the Food Composition Table from Vietnam published by the National Nutritional Institute in Hanoi.

Nine nutrients considered important in this study were: calories, protein, calcium, iron, vitamin A, vitamin B_1, vitamin B_2, vitamin C, and niacin. The calories were separately estimated for fat and nonfat sources. Food prices were estimated as cost on each item divided by its quantity consumed. In case the food is home produced, the average price for all households in the same commune who bought that food assumed a shadow price. The food diversity index (DTF) was estimated as follows:

$$DTF = \sum_{i-1}^{m} (S_i^{\alpha})^{1/(1-\alpha)}$$

where S_i is the share of the *i*th food item, and α is the diversity parameter ($\alpha \geq 0$ but $\alpha \neq 1$).

Nutrient supply

Results suggest no serious deficiency in major nutrients and micronutrients at the mean level, except for calcium, B_1, B_2, and niacin. But when nutrient availability of individual families is compared on a daily basis, a significant population falls below the 80% requirement of almost all nutrients, reflecting an imbalance on the food quality consumed by this segment of the population. For example, 67%, 81%, 95%, and 75% population is below 80% of the requirements for calcium, vitamin B_1, B_2, and niacin, respectively. A smaller percentage of the population is deficient in calories, iron, vitamin A, and vitamin C (Table 75).

Despite the increasing trend in food diversity in the diet of Hanoi and its surrounding communities, cereals are the main sources of calories, protein, vitamin B_1, and niacin. About one-fifth of the calories consumed are fat-based, and the remaining four-fifth comes from non-fat sources. Vegetables provide more than three-fourths of vitamin A and vitamin C, and are the major sources of calcium. Similarly, iron comes from cereals which have low bioavailability. Most of the nonfat based calories come from cereals, and fat-based calories from meats. In supplying vitamin A, vegetables play a higher role among low-income groups, while fruits are more important among high and upper-income groups; similarly, iron from cereals is more important among low-income groups, and iron from meat is a more important source among high-income groups.

[8] These seasons are cold-wet (October–November), cold-dry (February–March) and hot-wet (June–July).

[9] Three income groups as Low, Middle, and Upper were formed based on the income classification in the Vietnam Household Survey for 2002. The ranges of monthly per capita income for each income group were separately defined for each surveyed province.

[10] Five types of farms classified in this study were vegetable farmers, non-vegetable farmers, non-farmers in urban, non-farmers in peri-urban, and non-farmers in the rural areas.

Table 75. Deficiency level of major nutrients and micronutrients by income groups and by region

Nutrient	Overall	Deficiency level (> 20%)			Deficiency level (> 20%)		
		Low	Middle	Upper	Urban	Peri-urban	Rural
Calories	17.0	20.3	14.6	14.5	15.7	13.8	20.7
Nonfat	-	-	-	-	-	-	-
Fat	-	-	-	-	-	-	-
Protein	6.9	10.2	5.2	3.0	3.5	5.1	11.2
Calcium	67.3	68.3	66.2	67.3	62.1	65.2	73.3
Iron	14.5	18.0	12.8	9.6	11.0	13.2	18.3
Vitamin A	30.4	33.3	28.3	28.5	24.5	34.9	31.7
Vitamin B_1	80.6	84.4	79.1	74.9	73.4	81.2	86.1
Vitamin B_2	94.9	96.6	94.7	90.9	91.1	96.4	96.7
Niacin	75.3	79.6	74.5	66.8	70.2	76.5	78.7
Vitamin C	24.2	30.9	21.2	15.2	12.6	27.8	30.9

Generally, the population that is unable to meet at least 80% of the nutrient requirements increases from upper-income to low-income groups. However, a significant proportion of the population remains deficient even in the upper-income group, suggesting that income is not the only factor in improving the quality of food in terms of nutrient supply. Similarly, although the deficient populations are highest in rural areas, a high portion of the population is deficient even in urban areas to meet the 80% requirements of calcium, vitamin B1, vitamin B2, and niacin.

Food diversity

Diversity in food is universally recognized as a key component of a healthy, quality diet. In Hanoi, the level of micronutrient consumption improves at a higher food diversity level, although the consumption of major nutrients such as carbohydrates and protein also increases to a certain extent. Food diversity increases as one moves from rural to urban areas. The diversity also increases with improved income. The farmer group has lower food diversity than the non-farmer group, which has more access to diversified food from the market. The vegetable-farmer households have higher food diversity than non-vegetable farmers, although the difference was not significant (Table 76).

Table 76. Food diversity by location, and respondent group

Location/group	Diversity index
Location	
Urban	5.86 a
Peri-urban	4.69 b
Rural	4.15 c
Income group	
Low	4.45 a
Middle	5.09 b
Upper	5.26 c
Farming-based group	
Farmer	4.22 a
Vegetable farmer	4.29 a
Non-vegetable farmer	4.19 a
Non-farmer	5.64 b

Difference in prices

Difference in food prices is a composite measure of food quality. It includes the perceived difference of consumers in terms of nutrient, taste, hygiene, and safety conditions, and convenience in purchase and preparation, among others. Some of the price difference of a given food across regions may also be attributed to different marketing costs, especially that of transportation and retailing, but such differences will be small if the regions are closer to each other; such as in this study.

The prices of a large number of food commodities increase as one moves from rural to urban areas, reflecting consumers' willingness to pay for an improvement in the perceived quality of these items. For example, out of 71 commodities where price difference was tested statistically, 54 had significantly higher prices in urban as compared to rural areas, and the similar number of food items had higher prices in peri-urban compared to rural areas. Similarly, a large number of commodities had significantly higher prices in urban as compared to peri-urban areas. More fruit and vegetable commodities showed higher prices near the urban center than other food commodities.

To quantify the extent of price difference across regions and income groups, a regression of logarithm of price of each food item (where number of observations was 100 or more) on region and income dummies was run. Again the price difference of urban-rural, urban-peri-urban, and peri-urban-rural was positive and significant in almost all cases. The positive price difference across urban and rural areas is highest as compared to other regions, and is as high as 92.4% for fish sauce. The difference between urban and peri-urban regions is as high as 60.4% again for fish sauce. Similarly, the difference between peri-urban and rural areas is as high as 33.5% for fresh fish. Such a large difference in food prices across regions can be attributed to food quality.

Processed food

Processed food involves value addition. It may reflect better quality not in terms of improved nutrient composition or health, but in terms of convenience of the consumers. Overall, about 7% of the food is bought as readymade; eight percent, mainly fruits, is consumed fresh, while the remaining passes through the cooking process in the house. The highest proportion of readymade food (29.5%) is in the category of 'others.' About one-fifth of the total quantity of eggs and milk group and 9% of meats are consumed as readymade in Hanoi. Surprisingly, about 6% rice and 7% meats are also purchased readymade.

The proportion of readymade or processed food generally increases as one moves from rural to urban areas. However, urbanization will decrease the demand for processed fruits and increase the share of fresh fruits, while vegetables will continuously be demanded as fresh. Urbanization will dramatically increase the demand for readymade (or processed) cereals and eggs and milk, while it has slight impact on the readymade aquatic products.

As expected, the shares of readymade (or processed) and fresh foods increase as one moves from low-income to upper-income groups, while the opposite is true for the share of food cooked at home. This may partly reflect the reduced priority of the housewives for cooking time, and partly increased preferences for processed food at higher income level.

Farmers consume a noticeably higher share of food that is cooked at home and less proportion of readymade and fresh food compared to their counterpart non-farmer group. The main difference comes in cereals, fruits, and egg and milk where they consume a significantly higher amount of home cooked food.

Sources of food

Foods come from various sources; but temporary markets,[11] retail markets, and owned farms are the major sources for Hanoi consumers. Street vendors, home gardens, and gifts also supplied 2–6% of the total food requirements, while night markets, supper markets, and vegetable shops contribute an insignificant share of the food supply (less than 1%).

The relative importance of various food sources varies across three regions. The quantity of foods bought from temporary markets, retail markets, and vegetable shops tends to increase from rural to urban areas while an opposite trend was observed for owned farm, home garden, and gifts. In rural areas, the importance of a home garden is higher than that of farm production in supplying vegetables, fruits, meats, and eggs and milk; however, the farm is a more important source in supplying cereals, aquatic products, and 'others.' Even in peri-urban areas, the importance of a home garden is greater than that of farm production in supplying fruits, meats, eggs and milk, and 'others,' while both make a similar contribution to the vegetable supply. Home gardens and farms are insignificant sources of food supply in urban areas. Surprisingly, street vendors are generally a more important food source in rural areas than in urban and peri-urban areas.

Overall, temporary markets and retail markets are the two major sources of food supply among all the three income groups. The percentage of food obtained from temporary markets, retail markets, street vendors,

[11] The temporary market in this study was defined as a market place not recognized by the authorities as a market place nor is it permanent. Most of the goods sold here are foods and it is usually located at a convenient place (for example, road side). The prices of foods in these markets are usually lower than in other markets because the shop-owners do not have to pay market fees, and hygienic conditions are usually poor.

and vegetable shops generally increases as one moves from low- to upper-income groups, but that of owned farm, home garden, and gift had an opposite trend. This is true for overall as well as for individual food items. Own-farm was the most important source of cereal supply in all the three income groups, and temporary and retail markets are respectively second and third major sources in the order of priority for all income groups. The importance of the own-farm supply for other food items, however, varies across the income groups. For example, for the low-income group, it was the third most important source of vegetables and aquatic products supplies after temporary markets and retail markets. For the middle-income group, own-farm supplies for aquatic products ranked third, while for vegetables, it ranked fifth after temporary markets, retail markets, home gardens, and street vendors in the same order. The importance of own-farm supplies decreases even further for the upper-income group in supplying aquatic products. Although the share of vegetable shop is insignificant for all groups, it increases as one moves from low- to upper-income groups.

About 38% of the food consumed among farm families comes from their own-farm production, and an additional 5% comes from home gardens. About 76% cereals, 18% aquatic food, and 11% vegetables comes from own farm production, while 21% of eggs and milk, 15% fruits, and 12% vegetables consumed by farm families come from home gardens. The temporary and retail markets are the next two major important sources of food purchase. A significant percentage of aquatic products, other food, and meats are also purchased from street vendors. Surprisingly, more than one-tenth of the fruits are shared as gifts among farm families. Among non-farm families, the temporary market is the single major source of food purchases, followed by retail markets. About 6% of the food purchases of this group come from street vendors, and 1% from home gardens.

Food eaten outside home

Food eaten outside the house was estimated to be about 9% based on the survey for the whole sample. This proportion was directly related to income; it increase as one moves from rural to urban areas; vegetable farmers consumed a lower proportion of food outside, but the difference was not significant; among non-farmers, the group in the urban area consumes the highest proportion of food outside while the group in rural area takes the lowest proportion.

Policy implications

The analysis suggests that urbanization and enhanced incomes will bring qualitative changes in food consumption patterns, as consumers have the capacity and willingness to pay higher prices for food. However, all these changes will not be positive in terms of food quality. While consumers will demand more diversified and micronutrient-dense foods, the sources supplying fresh food will shrink in relative importance, and demand for readymade and restaurant foods and fat-based calories will increase dramatically in the near future. These trends create a space for public policies to maintain the hygienic conditions of food and public health. The planners have to provide the necessary policy and regulatory environment and infrastructure to avoid the negative implications of these food marketing changes on food quality.

Farms and home gardens are among the major sources of food supply in peri-urban and rural areas of Hanoi. The contribution of home gardens for farm families is even higher than that of farm production in supplying vegetables, fruits, meats, and eggs and milk. The low-income group of the city especially relies more on these sources. The freshness of farm and home garden produce is of great importance for farmers, which constitute about 28% of the population of the city. Therefore, strengthening food supplies from urban and peri-urban agriculture production and home gardens will not only contribute to food security but also food quality, especially for low-income groups.

The temporary, unrecognized or informal markets, which turned out to be the major source of food supply in urban and peri-urban areas, usually do not have means and resources to keep the food in appropriate hygienic conditions. However, because these markets are an important source of food and employment, the government should integrate the sector into formal markets by providing appropriate space and licensing and equipping them with appropriate tools and skills to keep the food hygienic for public health.

Analysis of the vegetable sector in Central Asia and the Caucasus Region

The Central Asia and the Caucasus (CAC) region comprise eight countries of the former Soviet Union: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan from Central Asia; and Armenia, Azerbaijan, and Georgia in the Caucasus. The CAC region is located at 39–48º N to 43–75º E covering more than 4 million km^2 of land. The region has 33.2 million ha of arable land with a population of more than 74 million people. The area under all crops in one year is 25.1 million ha, about half of which is irrigated.

Kazakhstan is the largest country in the region, while Armenia is the smallest. Uzbekistan is the most populated country, while Armenia is the least populated. The population growth in the region stands at 0.72% per annum. In 2003, the per capita gross domestic product (GDP) was US$816, ranging from US$210 in Tajikistan to US$1780 in Kazakhstan. Average per capita availability of arable land in the regions ranges from 0.15 ha in Georgia to 1.39 ha in Kazakhstan with an average of 0.45 ha. The contribution of agriculture in GDP ranges between 8% in Kazakhstan to 39% in Kyrgystan; and the population that depends upon agriculture ranges from 12% in Armenia to 32% in Turkmenistan. The industrial and services sectors show similar variations.

The region has several unique characteristics: 1) Climatic patterns limit crop cultivation to only the cool–wet spring and hot–dry summer; 2) Population density as well as the proportion of the labor force engaged in agriculture is relatively low, implying a labor shortage for labor-intensive agriculture in general, and vegetable cultivation in particular; 3) Per capita arable land is small, suggesting a great pressure on land to meet the population's food and fiber requirements; 4) The farm size is relatively large, which in combination with labor shortage, underlies the importance of machinery in the agriculture sector; 5) A small proportion of arable land is allocated to permanent crops and a large proportion goes to pastures and fruit crops; 6) The majority of crop area, except in Kazakhstan, is irrigated, which provides a great opportunity for the cultivation of vegetables. The purpose of this analysis was to review the past achievements and present status of vegetable production vis-à-vis other crops using data from the Food and Agriculture Organization of the United Nations (FAO) and the Central Intelligence Agency (CIA) websites, and others.

A variety of climatic conditions, from arid desert to polar mountains, occurs in CAC (Table 77). Generally, there are three seasons: winter, spring, and summer. The winter temperature goes as low as 0^{o}C, and heavy snowfall dominates in the season, especially on the mountains. The summer temperatures in some regions can reach above 40^{o}C. Most of the rainfall, less than 40 mm per month, occurs in spring.

Table 77. Climatic conditions in the CAC region

Countries	Climatic conditions
Armenia	Highland continental, hot summers, cold winter
Azerbaijan	Dry, semi-arid steppe
Georgia	Warm; Mediterranean-like on Black Sea coast
Kazakhstan	Cold winter and hot summer, arid and semi-arid
Kyrgystan	Dry continental to polar in high Tien Shan; Subtropical in southwest (Fergana Valley); temperate in northern foothill zone continental
Tajikistan	Mild-latitude continental, hot summer, mild winter; Semi-arid to polar in Pamir Mountains
Turkmenistan	Subtropical desert
Uzbekistan	Mostly mid-latitude desert, long, hot summer, mild winter; Semi-arid grassland in the east

Source: CIA 2004

Trends in production

In 2004, more than 10 million t of vegetables were produced in the CAC region, from 0.64 million ha with an average annual growths in area, production, and yield at 2.8, 4.1, and 1.3%, respectively. The largest expansion in vegetable area was in Azerbaijan, but Uzbekistan experienced a negative trend. Overall increase in yield was mainly attributed to a relatively high positive trend in Kazakhstan despite a decline in Azerbaijan, Georgia, Tajikistan, and Turkmenistan (Table 78).

Overall cereal production increased with an average annual growth of 2.4%. A sharp decline in production took place from 1993 to 1995, which later took a fluctuating slow rise until 2002, but set on the declining trend again. This trend was mainly driven by Kazakhstan. The area under cereals in the CAC region consistently fell from 25.5 million ha in 1993 to 17.4 million ha in 2004 with an average annual decline of 2.8%, which is attributed to the largest decline in Kazakhstan. On the other hand, the per-ha yield improved at an average annual rate of 5.1%, observed in all member countries except Georgia (Table 78).

Vegetable production remained stagnant or even declined in countries where the increase in cereal production was high, indicating the adverse effect to the vegetable industry caused by self-sufficiency in these countries. Similarly, the highest increase in vegetable production was in countries where cereal production declined or the increase was relatively small. Hence, the positive trend in vegetable production in the region is due to a shift in emphasis in cereal

Table 78. Trend in area, production, and yield of cereals and vegetables in CAC region by country

Country	Area (1000 ha)		Production (million t)		Yield (t/ha)		Growth during1993–2004 (% per year)		
	1993	2004	1993	2004	1993	2004	Area	Production	Yield
Vegetables and melons									
Armenia	22	27	0.45	0.67	20.3	25.3	1.0	3.1	2.0
Azerbaijan	35	106	0.53	1.39	15.2	13.1	12.8	11.4	-1.4
Georgia	31	47	0.41	0.45	13.2	9.5	5.0	1.3	-3.7
Kazakhstan	97	158	0.99	2.44	10.2	15.5	5.1	11.3	6.1
Kyrgyzstan	17	42	0.28	0.71	16.9	16.8	5.4	9.5	4.1
Tajikistan	32	38	0.59	0.57	18.4	14.9	1.9	-0.1	-2.0
Turkmenistan	46	53	0.53	0.53	11.7	9.9	1.1	-0.2	-1.3
Uzbekistan	212	167	3.67	3.30	17.3	19.8	-1.8	0.3	2.2
Total	492	638	7.46	10.06	15.2	15.8	2.8	4.1	1.3
Cereals									
Armenia	187	193	0.31	0.42	1.7	2.2	1.7	3.2	1.6
Azerbaijan	702	806	1.14	2.04	1.6	2.5	2.1	7.9	5.8
Georgia	228	326	0.40	0.70	1.8	2.2	3.9	3.7	-0.2
Kazakhstan	21,781	12,786	21.53	12.14	9.9	1.0	-4.0	-0.4	3.6
Kyrgyzstan	626	594	1.54	1.70	2.5	2.9	0.0	3.8	3.7
Tajikistan	268	387	0.26	0.71	1.0	1.8	4.0	10.0	6.0
Turkmenistan	432	940	1.01	2.81	2.3	3.0	6.8	11.0	4.2
Uzbekistan	1,302	1,359	2.16	5.07	1.7	3.7	-0.3	7.2	7.5
Total	25,526	17,391	28.36	25.60	1.1	1.5	-2.8	2.4	5.1

Source: FAOSTAT data

production rather than any fundamental reform in the production or marketing systems of vegetables. However, Azerbaijan is the exception where both cereal and vegetable production improved simultaneously, and most of the increase in vegetable production and some increase in cereal production came from productivity enhancement.

Per capita availability

The per capita availability of vegetables, fruits, and cereals from domestic sources changed at the annual rates of 3.8%, -1.5%, and -0.5%, suggesting changes in the agricultural production pattern in the CAC region. The availability of vegetables dramatically increased in Kazakhstan, Azerbaijan, and Kyrgystan, while it decreased in Tajikistan, Turkmenistan, and Uzbekistan. The decline in cereal availability came mainly from Kazakhstan, Tajikistan, and Uzbekistan, while the decrease in fruit availability is more thoroughly spread except in Kyrgystan, Kazakhstan, and Uzbekistan (Table 79).

International trade

In 2003, total trade in vegetables from and to the CAC region amounted to about 0.5 million t with a value of over US$26 million. Imports constituted about one-sixth of the total trade, and trade surplus amounted to 0.34 million t valued over US$71 million. The trade surplus remained positive from 1993 to 2003, ranging from US$46 million to US$133 million. Less than 5% of the domestic production in the CAC region is exported, and vegetable trade in the region is quite erratic (Table 80).

Vegetable prices for export normally remained lower than import prices. Some of this difference is due to added transportation cost on the imported vegetables. The difference over and above the transportation cost, however, reflects that the CAC region imports high value (or high quality) and exports low value (or low quality) vegetables. Targeting production to high value export markets can reverse this situation.[12]

[12] The difference in import and export prices, if there is any, after controlling for the difference in quality, may reflect the competitiveness of the CAC region in vegetable export.

Table 79. Changes in per capita availability of cereals, fruits, and vegetables in CAC region by country

Country	Cereals (kg/year)		Fruits (kg/year)		Vegetables (kg/year)		Annual growth rate (%)		
	1993	2003	1993	2003	1993	2003	Cereals	Fruits	Vegetables
Armenia	231	226	53	61	131	223	1.8	-2.4	3.5
Azerbaijan	265	343	100	67	65	170	5.6	-3.0	11.7
Georgia	250	309	135	89	76	111	4.2	-8.9	2.6
Kazakhstan	1,008	537	11	12	59	158	-1.2	3.3	13.2
Kyrgystan	528	338	12	28	61	145	1.0	8.4	10.9
Tajikistan	326	186	41	28	106	86	-3.4	-2.1	-2.3
Turkmenistan	520	524	38	36	134	108	2.0	-0.5	-2.4
Uzbekistan	233	215	43	44	162	141	-1.3	1.0	-1.4
Overall/Total	469	329	47	41	105	143	-0.5	-1.5	3.8

Source: FAOSTAT data

Table 80. International trade in vegetables (including pimento) from CAC region during 1993–2003

Year	Import			Export			Total trade		Trade surplus	
	Quantity (1000 t)	Value (million $)	Price (US$/100 t)	Quantity (1000 t)	Value (million $)	Price (US$/100 t)	Quantity (1000 t)	Value (million $)	Quantity (1000 t)	Value (million $)
1993	23.3	11.1	47.8	186.2	78.5	42.2	209.5	89.6	163.0	67.4
1994	38.9	18.6	47.7	469.7	151.5	32.3	508.6	170.1	430.7	132.9
1995	60.2	35.1	58.3	395.3	100.9	25.5	455.5	136.0	335.2	65.8
1996	122.8	67.4	54.9	388.9	145.0	37.3	511.8	212.5	266.1	77.6
1997	76.2	56.4	74.0	388.3	147.0	37.9	464.5	203.5	312.0	90.6
1998	66.9	61.1	91.4	287.4	106.9	37.2	354.3	168.1	220.6	45.8
1999	47.9	13.1	27.5	435.7	63.2	14.5	483.6	76.3	387.9	50.1
2000	42.6	12.6	29.6	355.2	60.4	17.0	397.8	73.0	312.6	47.7
2001	57.2	16.5	28.9	235.1	66.2	28.1	292.3	82.7	177.9	49.7
2002	78.6	24.0	30.5	400.3	76.7	19.2	478.9	100.7	321.7	52.7
2003	87.2	27.5	31.5	427.8	98.7	23.1	515.0	126.2	340.6	71.3

Source: FAOSTAT data

Big annual fluctuations in international prices of vegetables make it hard for the farmers to plan their production activities for export (Table 80). Part of this fluctuation is attributed to the poor infrastructure and weak links with international markets. The low international vegetable prices during 1999–2003 may have discouraged the CAC farmers to invest in vegetables.

Vegetables, fresh and dried (with little value addition), are the major form of vegetable exported from the CAC region, while preserved vegetables and vegetable juices are the major form of vegetables imported. This balance needs to be reversed by creating value-addition activities in the region.

In 2003, dried onion was the single major vegetable exported from the region, contributing about one-fourth of the total exported value, while 11% of imported value was also onion. The major value-added single vegetable product exported was tomato paste, but it also consumed a substantial percentage of import value (although value of export was higher than import). To become a major player in the international vegetable trade, the CAC region has to broaden their export base.

Vegetables in the cropping system

One impact of change in the vegetable area in the region is the increase in its share in total crop area. In 2004, the ratio in percentage terms stood at 2.2% against 1.0% in 1993 with an average annual growth of 7.1%, with high variation across the region. The largest annual growth in the ratio was in Azerbaijan, which declined in Turkmenistan and Uzbekistan, and remained stagnant in Armenia (Table 81). Although the growth rate in vegetable share in the cropping system was relatively high in Kazakhstan, the share still remained the lowest among all the CAC member countries. This variation in the improvement of vegetables' position may be attributed to different degrees of success of market-oriented structural reforms introduced by the CAC member countries.

More than 30 types of vegetables are produced and consumed in CAC member countries. Tomato, watermelon, cabbage, onion, cucumber, and carrot occupy more than four-fifth of the total vegetable area of the region. Tomato is the major vegetable in Armenia, Kyrgyzstan, and Uzbekistan; watermelon dominates in Azerbaijan, Kazakhstan, and Turkmenistan, while cabbage is the top-ranking vegetable in Georgia. Other major vegetables by country can be seen in Table 82.

Different countries in CAC lead in the production of various vegetables. For instance, shallot is exclusively grown in Armenia and garden radish in Georgia. Similarly, leafy types are mainly grown in Georgia, table beet in Kazakhstan, and melon in Uzbekistan (Table 83).

As so many vegetables are grown in the region, no country can do research in every vegetable species. In setting regional priorities, this implies that the leading role of research and development for different vegetables should be assigned to the countries having the major share of production of the commodity in the region. The countries having a smaller share in certain vegetables can learn from the countries leading in those commodities. Establishing a synergistic interaction among cooperating institutions or organizations will improve the efficiency of limited human and financial resources engaged in vegetable research.

To investigate the structural changes in vegetable production, the vegetables grown in the region were classified into three groups, namely: fruit, root and bulb, and leafy and flower types. It was found that the leafy and flower type vegetables are being replaced with the fruit type in the CAC region. As a result, the

Table 81. Percentage of vegetable to total crop area in CAC region by countries during 1993–2004

Countries	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Annual growth (%)
Armenia	4.5	5.0	5.5	5.3	5.3	4.8	5.5	5.2	4.8	5.0	5.4	5.1	0.4
Azerbaijan	2.0	2.4	2.3	2.7	2.6	3.4	5.9	5.8	6.0	6.1	6.6	6.3	12.5
Georgia	5.0	5.2	4.5	4.6	4.5	6.6	6.7	7.1	6.4	6.3	6.6	7.0	3.9
Kazakhstan	0.3	0.3	0.4	0.4	0.6	0.8	0.9	0.9	0.9	0.9	0.9	0.9	11.7
Kyrgyzstan	1.3	1.9	2.9	2.9	3.1	3.4	4.1	4.3	4.4	2.4	3.4	3.7	6.3
Tajikistan	3.7	4.3	4.3	3.7	3.9	4.4	5.1	4.3	4.4	4.4	4.2	4.5	1.3
Turkmenistan	3.0	3.6	3.1	2.8	2.5	3.1	2.9	2.8	2.9	2.9	2.4	2.7	-1.8
Uzbekistan	4.6	4.6	4.2	3.8	3.4	3.7	3.8	3.6	3.8	3.7	3.9	3.9	-1.4
Overall	1.0	1.2	1.3	1.4	1.5	2.0	2.3	2.2	2.3	2.1	2.2	2.2	7.1

Table 82. Major vegetables by country in CAC region in 2003

Country	Major vegetables (percentage share in total vegetable area in a country)
Armenia	tomato (27), cabbage (12), watermelon (9)
Azerbaijan	watermelon (28), tomato (21), bulb onion (12), cucumber (10)
Georgia	cabbage (19),tomato (15), leafy type (11)
Kazakhstan	watermelon (22), cabbage (13), carrot (12), bulb onion (11)
Kyrgyzstan	tomato (19), cucumber (15), carrot (14), bulb onion (13), cabbage (11), watermelon (11)
Tajikistan	watermelon (26), bulb onion (23), tomato (22)
Turkmenistan	watermelon (25), tomato (24)
Uzbekistan	tomato (42), watermelon (26), cabbage (13)
Overall	tomato (23), watermelon (22), cabbage (11), onion (10), cucumber (8), carrot (6)

Source: Estimated from the survey data provided by country collaborators.

production share of fruit-type vegetables increased from 47% to 55%, root and bulb types from 22% to 25%, while the share of leafy and flower types declined from 31% to 20%.

Comparative yields

The yields of major vegetables in the region are generally higher compared to the tropical and subtropical countries, but lower than in developed countries in the temperate region (Table 84). This shows the potential as well as challenges to the vegetable sector in the region.

Policy implication

In the CAC region, vegetable cultivation presents great challenges as well as opportunities. Firstly, relatively poor farm-to-market infrastructure, the absence of a well-defined market network, and primitive postharvest handling make it extremely costly to connect local producers with the consumers in the domestic and international markets, causing high seasonal and annual fluctuations in vegetable prices. Secondly, the farmers cannot afford to make big investments in vegetable cultivation because of the limited purchasing power of domestic consumers. A limited labor supply further constraints vegetable cultivation. Thirdly, diversity in vegetable production and consumption is low: only three vegetables (tomato, watermelon, and cabbage) cover about 60% of the total supplies. Finally, the goal of self-sufficiency in grain has created a bias against high-value vegetable crops in certain countries of the region. Despite all these challenges, however, the moderate summer provides an opportunity to exploit the increasing demand for hygienic vegetables in the international market, as the pest infestation under such an environment is low without many plant protection measures, and yields of these vegetables are relatively high compared to those in the tropics.

The growth in vegetable production in the CAC region seems impressive on the surface. However, most of this growth came from area expansion, especially in those countries where cereal production suffered from the grain self-sufficiency drive. This trend, therefore, does not seem to be supported by

Table 83. Leading countries in the cultivation of different vegetables in CAC region in 2003

Country	Major vegetables (percentage share of the country in total area of the region of that species)
Armenia	shallot (100), cauliflower (35), sweet pepper (26)
Azerbaijan	eggplant (48), watermelon (35), chili pepper (34), peas (28), garlic (26), cucumber (25), onion (23)
Georgia	garden radish (100), leafy type (88), cauliflower (49), sweet pepper (29), eggplant (25), table beet (24)
Kazakhstan	table beet (58), carrot (51), pumpkin (46), chili pepper (41), sweet pepper (40), watermelon (37), cabbage (31), onion (29), cucumber (26)
Kyrgyzstan	garlic (20), cauliflower (16), carrot (16)
Tajikistan	onion (17), carrot (12), watermelon (12)
Turkmenistan	watermelon (7), carrot (6), pumpkin (6)
Uzbekistan	melon (77), tomato (46), garlic (45), peas (43), pumpkin (34), cabbage (30)

Source: Estimated from the survey data provided by country collaborators.

Table 84. Per hectare yield (t/ha) of major crops in CAC region in comparison with other countries in 2004

Name of vegetables	CAC region	Tropical underdeveloped country			Developed country in the temperate region	
		India	Indonesia	Philippines	United States	United Kingdom
Tomato	22.7	14.1	12.7	9.7	73.9	177.8
Bulb onion	16.4	10.3	9.4	9.2	54.4	43.7
Cucumber	12.0	6.7	8.5	6.2	14.1	31.5
Watermelon	13.4	12.8	-	18.9	29.2	-
Cabbage	25.8	21.4	19.6	12.0	24.9	21.4
Carrots	18.7	14.6	15.5	-	39.7	73.9

Source: FAOSTAT data

technological and institutional innovations in the production marketing systems. The export of vegetables remained erratic and low compared to its potential. Moreover, the diversity in vegetable cultivation, especially micronutrient-dense varieties, needs to be improved through collaboration with international organizations.

Setting vegetable research and development priorities in Central Asia and the Caucasus region for a market-oriented production system

The purpose of this analysis was to identify and prioritize the issues to be tackled in a collaborative mode among national programs and with AVRDC–The World Vegetable Center in a regional networking framework. This will lay the foundation of a regional partnership by generating consensus on common vegetable research priorities, which will ultimately enhance synergies, efficiency, and impact. The opinion survey from top agricultural policy makers and brainstorming meetings of experts and stakeholders were used for a priority-setting exercise in the member countries of the CAC region. The survey was conducted in all the CAC member countries in March 2005 and the results of this analysis were discussed in the meeting held in April 2005. A pre-designed questionnaire with the necessary guidelines for obtaining information was developed for this purpose. The information sought in the questionnaire pertained to contributions of various production systems and ecological regions in the total vegetable supply, identification of major pests in the order of priority in major vegetables grown in each country, and priority-order of researchable issues and development strategies in their respective countries.

Eco-regional distribution of vegetable production

The analysis of the area under different vegetables under different ecosystems suggests that more than one half of total vegetable production in the CAC region is concentrated in the peri-urban lowland. Surprisingly, the overall contribution of the home garden in supplying vegetables is about the same as cotton or wheat in an extensive system. However, the distribution for certain vegetables deviates from the overall distribution. For example, cauliflower and garlic are mainly grown in the home garden. The contribution of the production systems in supplying vegetables varies across countries. The home garden, in small sizes surrounding the house, contributes a much higher percentage in Armenia and Azerbaijan than in any other countries, while peri-urban systems in Georgia provide two-thirds of the supply.

Vegetable cultivation in the CAC region is seasonal. For example, about one-half of the supplies come in autumn (August–September), and another one-fourth in the hot dry summer (June–July). The concentration of vegetable availability during the autumn is from the harvest of the crop sown after monsoon rains. Very few (about 15%) vegetables are available during the winter (November–January) and early spring (February–March). This clearly underlines the serious seasonality problem in vegetable supplies in the region.

Some crops, for example onion, cucumber (open field), and radish are concentrated more in summer than in other seasons, while sweet pepper, garlic, and other leafy vegetables, are almost equally distributed between summer and autumn. Oversupplies of these crops are likely during the summer in the CAC region. Therefore, market infrastructure and information should be developed to encourage the export of these crops in other parts of the world, especially in the tropics where these crops are difficult to grow during the hot season.

On the other hand, a large percentage of tomato and cucumber (both from greenhouse) and table beet supplies originates in early and late spring (February to May). Similarly, a reasonable percentage of supplies of cabbage, cauliflower, radish, peas, and 'other' leafy vegetables, mainly lettuce, comes during the winter season (November to January). More importantly, in some countries of the CAC region like Uzbekistan, some of these crops have a larger share of supplies concentrated in the winter and early spring than in others. The trade of certain vegetables should be encouraged from the regions having comparative advantage in growing these crops in the winter and early spring. The yield improvement of the vegetable species grown in winter, especially through enhancing tolerance to cold and drought, will also help overcome the seasonality problem. Another possible way out are cold-tolerance technologies such as greenhouses. However, the economics of these technologies should be carefully evaluated by counting all the costs, including the environmental costs, at competitive market prices without government subsidies.

Major pests

The respondents were asked to identify three major diseases and insects, in order of priority, for the major vegetables grown in their respective country. The ranking order of a pest was recorded on a scale of 1 to 3: '1' for the most important and '3' for the least important. To estimate overall ranking of different pests, the order of these ranks was first inverted, that is, '3' was assigned for the most important pest and '1' for the least important. Then the weighted average summation of the inverted ranks across all CAC countries was taken, using the relative share of the area grown to vegetables in each country to the total area of the region as weights. The highest number obtained was considered as the most important pest.

The three most important insects by crop in the whole region are reported in Table 85. Aphids and mites are the most common insects of most vegetables in the CAC region.

The three most commonly spread diseases in the region are: Fusarium wilt, downy mildew, and powdery mildew (Table 86).

Resources for vegetable research

Before discussing the research priorities of the vegetable sector, it is advisable to see the resources available for vegetable research in the CAC region. Overall, 4.3% of the total resources allocated to agricultural research go to vegetable research; the share is even less in terms of available technical manpower (Table 87). These shares are in line with the vegetable share in total area of all crops, but far below their contribution in generating agricultural income and employment. This relative laxity in allocating resources for vegetables by policy makers becomes more serious as one looks at the number of crops and diverse constraints that need to be tackled in the vegetable production and marketing system.

Table 85. Three highest priority insect pests infected on different vegetables in CAC region

Vegetable	Priority 1	Priority 2	Priority 3
Tomato	Whitefly	Mite	Tomato fruitworm
Eggplant	Colorado potato beetle	Noctuid moth	Aphid
Sweet pepper	Aphid	Tomato fruitworm	Mole cricket
Chili pepper	Aphid	Thrips	Whitefly
Cucumber	Aphid	Mite	Noctuid moth
Watermelon	Aphid	Mite	Greenhouse thrips
Melon	Melon aphid	Aphid	Mite
Pumpkin	Aphid	Mite	Whitefly
Carrot	Rust fly	Noctuid moth	Leafhopper
Table beet	Noctuid moth	Weevil	Black bean aphid
Onion	Onion fly	Tobacco thrips	Noctuid moth
Cabbage	Aphid	Noctuid moth	Cabbage butterfly

Table 86. Three highest priority diseases infected on different vegetables in CAC region

Vegetable	Priority 1	Priority 2	Priority 3
Tomato	Phytoplasma	Tobacco mosaic virus	Late blight
Eggplant	Brown spot	Fusarium wilt	Early blight
Sweet pepper	Fusarium wilt	Stem and root rot	Bacterial fruit rot
Chili pepper	Fusarium wilt	Verticillium wilt	Potato virus Y
Cucumber	Downy mildew	Powdery mildew	Anthracnose
Watermelon	Downy mildew	Fusarium wilt	Powdery mildew
Melon	Powdery mildew	Fusarium wilt	Downy mildew
Pumpkin	Powdery mildew	Downy mildew	Gray mold
Carrot	Black rot	Septoria leaf spot	Watery soft rot
Table beet	Powdery mildew	Downy mildew	Cercospora leaf spot
Onion	Downy mildew	Powdery mildew	Smut
Cabbage	Olpidium root infection	Downy mildew	Clubroot

Table 87. Resource allocated to funds and scientific manpower for vegetable research in the CAC region

Countries	Percentage share	
	Funds for vegetable research	MSc and PhDs for vegetable research
Armenia	3.9	6.9
Azerbaijan, Republic of	7.5	10.1
Georgia	1.3	2.5
Kazakhstan	4.0	3.0
Tajikistan	10.0	3.9
Uzbekistan	2.5	2.8
Overall	4.3	3.4

Researchable issues

The analysis of the priority score for research and development issues suggests that developing improved technology for adoption is the highest priority theme in the CAC region. This is followed by collection and utilization of germplasm, and the development of seed and the seedling industry. The next three important themes for research in order of priority are: 1) improvement of the germplasm or varietal development for enhanced productivity; 2) disease-resistant varieties; and 3) development of information systems. There are variations for the priority issues across individual crops. For example in tomato, development of an information system and collections of germplasm and disease resistance are more important than developing advance management technologies. In radish and cauliflower, postharvest is one of the most important issues. In leafy vegetables, development of improved high-yielding varieties is the single most important theme.

The policy makers in each country were asked to rank different production/ecosystems with respect to each researchable issue by assigning a priority score to each region/system in a way that the score added up to 100 for each issue. This analysis suggests that peri-urban is the most important production system for almost all researchable issues in the CAC region. In fact, very little variation and disagreement exists in assigning the top priority for the peri-urban system across researchable themes. This is followed by the wheat-cotton intensive system and home-gardening, both have almost similar importance in most researchable issues. The production system dimension of various issues is in line with the relative importance of these systems in supplying vegetables.

The relative importance of different ecologies depends upon the issue. For example, highest importance was given to summer in tackling varietal improvement for disease, developing technologies to reduce pesticide use, and the exploitation of modern information technology, while autumn is more important for the collection and utilization of indigenous vegetables, and the development of postharvest technologies.

Research and development issues

In the analysis of the priority score for the three suggested strategies to reduce pesticide use in the vegetable sector, that is, production technology, farmers' training, and biological control, policy makers hoped to allocate about half of the resources for the development of safe vegetable production technologies such as low tunnels. Allocation for farmers' training remains in the range of 20–40%; while biological control, which was least preferred, was allocated the lowest portion.

Among various types of information required to develop the vegetable sector in the region, the policy makers gave highest rank to the information related to improved varieties and their yield potentials in alternative cropping systems. The information on the optimum use of inputs, major diseases and their control, major insects and their control, and seed sources obtained almost equal priority ranks, but were markedly lower than the rank given for improved varieties and their yield potential. This suggests how important improved varieties are in the region, and how keenly policy makers are searching for these varieties.

Among the types of information required to conduct policy research, the leaders of the vegetable sector in CAC region gave the highest priority to generate forecasts on supply, demand, and prices of major vegetables followed by information on production costs of major vegetables in various production systems in their respective countries. Next came information on markets costs, forecasts of supply, demand, and prices in other countries, and international quality standards. This indicates a strong demand for initiating projects that can generate information about commodity forecasts and production costs. Such information will not only improve policy formulation for the vegetable sector, but also help reduce the seasonal and annual fluctuation of its supply and prices.

On technology transfer, policy makers gave the highest ranks to on-farm training of production technologies in a participatory mode, closely followed by demonstration trials. Providing guide sheets on new technologies to farmers and extension agents was considered important, while decision-making computer tools were not considered to be very important.

Among the available tools to strengthen the research capacity of the National Agricultural Research and Extension Systems (NARESs), the leaders of the vegetable sector in CAC region gave highest priority for collaborative adoptive research trials and varietal testing trials. This was followed by gemplasm exchange. Training of researchers and short- and long-term courses obtained low priority, probably because these tools are more geared to helping individual scientists.

Policy implications

To identify the constraints limiting production, comprehensive data at disaggregated level are needed. However, institutions to collect and synthesize such data in CAC countries are lacking. To overcome this problem, key policy makers are involved in quantifying the agro-ecological dimension of vegetable production, to prioritize the researchable issues, and to identify development tools for the vegetable sector in the region.

From the survey of the respondent policy makers, it is clear that vegetable-supplies face serious seasonal fluctuations. Vegetable cultivation is mostly concentrated during autumn and summer seasons, but little is grown during winter and early spring, which are quite long in some countries. New suitable crops and technologies for winter need to be identified and tested to overcome seasonality in supplies and expand biodiversity in production. Another approach could be to encourage vegetable production where winter is mild, and link supplies from such regions to the regions where winter production is costly. To adopt such an approach, however, infrastructure, especially transport and storage, needs to be improved. Moreover, CAC governments have to remove the biases towards cereal self-sufficiency and adopt policies that can promote competitiveness in the agriculture sector. The export potential in high-income markets demanding low pesticide use on vegetables should be exploited. Moreover, markets in the tropics where vegetables are in short supply during the summer should be explored to export surplus vegetables from the region during this season.

The analysis of vegetable distribution across production system suggests that peri-urban is the major system contributing more than 50% of total vegetable supplies. Therefore, establishment of vegetable storage and processing facilities in peri-urban areas and integrating vegetable producers with these facilities will certainly enhance vegetable supplies to remote areas as well as enhance intra-regional trade. However, as the relative contributions of various production systems vary across vegetable species, researchers should focus on major production system for each vegetable.

The agro-ecological dimension of various researchable issues varies from country to country. With limited resources devoted to agriculture research and development, this creates an opportunity for networking. One country can specialize in certain issues for certain agro-ecologies, and leave other issues and other agro-ecologies on others. They can then share the information across issues and agro-ecologies. The experience of AVRDC in developing such networks can be helpful.

An important outcome of this survey were the identification and prioritization of insects and diseases for major vegetable crops in the CAC region. This information is expected to facilitate the prioritization of research on insect and disease management in the region. The policy makers believed that improved production technology such as low tunnels and greenhouses should be the best way to control insects.

The respondent policy makers were of the opinion that collaborative adoptive research trials are the most important tool to improve the capacity of the national research system to work on vegetables. On-farm training of the farmers was considered an important development tool to improve the vegetable sector in the region. The collaboration between the private sector and public organizations for the development of the vegetable sector was considered important, although its mode remained undefined.

While this survey helps to prioritize the production system and ecologies with respect to vegetable supplies, insects and diseases, and development issues, this is not a complete substitute for a detailed survey conducted on these issues and data collected by statistical bureaus throughout the country. Therefore, it is suggested to establish institutions and procedures for conducting more detailed surveys for the purpose of having more complete and accurate data on various aspects of the vegetable sector.

Contact: Mubarik Ali

Postharvest loss in priority vegetable crops in Cambodia

Vegetable production levels and revenues in the Greater Mekong Subregion (GMS) are severely constrained by postharvest losses, reducing profits for farmers and traders. Postharvest losses reduce opportunities for export and export revenues. International trade is growing fast due to trade liberalization and market reforms but successful competition requires quality control and product standardization. Currently, little information is available on the extent of postharvest losses, storage infrastructure, or trade specific to vegetables within the GMS. To understand the dynamics of the harvest-to-consumption chain, it is essential that this information is collected and made available. A supply chain study was thus conducted in Cambodia to understand the extent of postharvest losses and possible technological interventions.

Materials and methods

In analyzing the supply chains for vegetables in Cambodia, detailed interviews were conducted with 200 respondents in Phnom Penh, Kandal, and Kampong Cham. These interviews were carried out to seek information on tomatoes, yardlong bean, Chinese kale, and cucumber separately. Through expert discussions, these crops had been selected for their high economic value, and because they were affected by large postharvest losses.

A downstream interview approach was applied. First, interviews with 70 retailers were conducted. Information was sought on monthly quantities purchased and sold, prices paid and received, and on postharvest losses experienced. At the conclusion of the interview, the retailers were asked to identify the traders (wholesalers) with whom they most frequently interacted with. Based on the names received, 40 wholesalers were selected, distributed relatively and equally among the three provinces, and were asked similar questions. Names of collectors whom they most frequently interacted with were then solicited from these wholesalers. Twenty-six collectors were selected to provide the contact details of 64 farmers—32 in Kandal and 32 in Kampong Cham—who were then interviewed regarding production and harvesting practices, postharvest losses experienced as quantities, and prices achieved. This information from farmers was collected based on the past three production cycles in that year.

For farmers, postharvest loss was quantified and calculated as a percentage based on total harvested quantity. For collectors, wholesalers and retailers, loss was estimated as the difference between quantity purchased and quantity sold in relation to total quantity purchased. Traders were requested to estimate the total percentage share of postharvest loss by season. However, these estimates were found to exceed the postharvest loss estimated based on the difference in quantities traded by a factor of two. In this paper, loss is considered as the difference between quantities purchased and sold, although this may include small errors due to personal consumption.

Results

The supply chain for vegetables in Cambodia generally follows the following pattern, although there are slight differences by crop (Figure 28). The product is collected at the farm through collectors, who are responsible for transport to wholesalers. The wholesale markets in Phnom Penh and Kampong Cham are nightly gathering points for collectors who sell vegetables in bulk to the wholesalers. The wholesalers, in turn, mainly sell to wet market dealers, who also cater to restaurants, grocery stores, and supermarkets. They also sell to street vendors, who peddle their vegetables to the final consumers on the streets.

The supply chain is slightly shorter for yardlong bean, which collectors usually sell directly to wet market vendors, with little wholesaler involvement. A certain contingent of vegetables is supplied by importing suppliers. There is evidence that during certain months when local production is low, the share of imports is substantial. However, this study only focuses on local farmers and their production.

Monthly prices that retailers and farmers achieve for their product were also analyzed. Figure 29 shows that retailer prices fluctuate the most for Chinese kale. Chinese kale and tomato both achieve highest prices towards the end of the wet season, and lowest prices during the dry season. Yardlong bean has peak prices during the late dry season. Cucumber prices are relatively stable across the year, with only small fluctuations.

The share of farmgate price in retail price, shown by the yellow line, fluctuates strongly. The share farmers achieve in total retail price is usually highest when the quantities they supply to local markets are highest—and when retailers receive the lowest price. This appears to indicate that contrary to general opinion, farmers do not alone carry the risk of seasonal high production and subsequent low prices. Partly, the risk is shared by retailers.

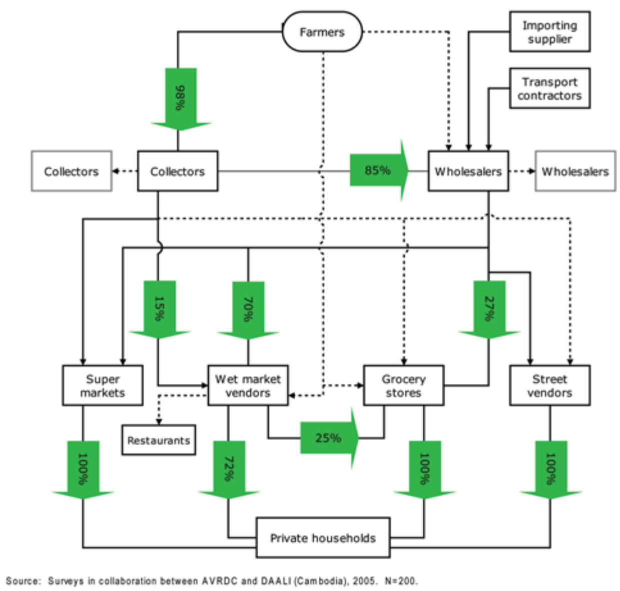


Figure 28. Vegetable supply chain in Cambodia.

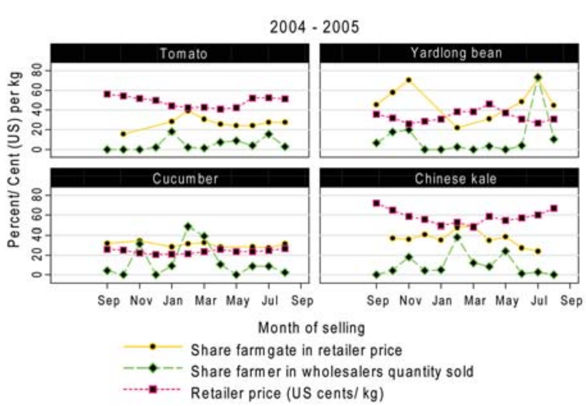


Figure 29. Farmgate share in retail price.

Incidence of postharvest loss is high, with 95% of all farmers, all traders, and 93% of retailers reported to have experienced it. Approximately half of farmers (53%) reported that they use blemished and damaged vegetables for household consumption, rather than throw it away. Three-quarters of farmers report that they experience price reduction because of blemished product. Average price reductions is largest for tomato (11%) and smallest for Chinese kale (4%).

Postharvest losses were estimated separately for the wet and dry season (Table 88). The results show that in the dry season, nearly 20% of the crop is usually lost between harvest and sales to the final consumer. During the wet season, the loss is as high as 27% for tomatoes, and slightly lower at 24% and 22% for yardlong bean and cucumber, respectively. Losses are usually highest for farmers. On the other hand, retailers experience the highest loss of Chinese kale.

Table 88. Estimates of postharvest losses

Crop	Supply chain actor	Season Dry 1	Dry 2	Wet
Tomato	Farmer	6	6	13
	Collector	1	2	2
	Wholesaler	8	4	7
	Retailer	5	6	6
	Total	21	19	27
Yardlong bean	Farmer	8	4	8
	Collector	2	3	4
	Wholesaler	3	4	5
	Retailer	6	6	6
	Total	20	17	24
Cucumber	Farmer	5	5	9
	Collector	4	5	4
	Wholesaler	4	4	5
	Retailer	4	5	4
	Total	17	19	22
Chinese kale	Farmer	4	4	3
	Collector	3	3	3
	Wholesaler	4	6	4
	Retailer	5	5	5
	Total	17	18	15

Source: Surveys in collaboration between AVRDC and DAALI (Cambodia), 2005. N=200. Seasons are based on the months of first harvest or selling. Dry 1 season is from November to January, Dry 2 is from February to April, and wet season is from May to October.

Farmers and traders provide different reasons to explain loss (Table 89). For farmers, for all four crops under consideration, diseases are an important reason as are hot weather during harvest; for cucumber, insect damage. Traders and retailers experience losses because they cannot sell all their vegetables, and because the product is already damaged upon purchase. The latter may be due to damage during transport. Tomatoes also suffer loss due to high storage temperatures.

A large share of respondents tried to ensure cool temperatures, either during harvest or collection or in subsequent storage, to prevent loss (Table 90). Collectors also demand farmers to harvest at an optimal time to minimize losses. In addition, retailers maintain high hygienic standards and purchase high-quality vegetables. It is striking that appropriate packaging, as a strategy to minimize loss, was named only by a few respondents among retailers, although poor packaging during transport appears to be one of the major reasons for postharvest loss.

To obtain a value of loss experience, actual loss in kg was multiplied with the average selling price (Table 91). This value was divided by the total amount of vegetables produced or purchased by each agent in kg, to obtain a value of loss based on a uniform denominator, and added across all agents in the supply. The loss value for each kg produced or handled is similarly high for Chinese kale, yardlong bean, and tomato, but comparably low for cucumber (at around 5 cents per kg).

Since individual crop production data for Cambodia is not available, values of daily market transactions for Phnom Penh were used and extrapolated for the entire year to obtain total annual value of loss for individual crops (data for Chinese kale was not available). In addition, the average value of loss was used to calculate the value of total postharvest loss for major vegetables in the Phnom Penh market only. This is around 1.6 million USD on an annual basis.

Table 90. Main strategies to prevent postharvest loss

Respondent	Strategy
Farmer	Harvest during cool weather (78%)
	Spray water after harvest (68%)
	Careful harvest as not to damage (53%)
Collector	Collect during cool weather (76%)
	Ensure cool storage (42%)
	Demand time of harvest (42%)
Wholesaler	Take care during transport (58%)
	Ensure cool storage (53%)
	Collect during cool weather (48%)
Retailer	Ensure cool storage (47%)
	Ensure good hygiene conditions (46%)
	Buy high-quality vegetable crop (46%)

Source: Surveys in collaboration between AVRDC and DAALI (Cambodia), 2005.

Discussion

Developing appropriate postharvest technologies for vegetables crops is crucial to increase income of farmers and traders. Postharvest losses translate into important economic losses. Total annual vegetable production in Cambodia is approximately 125 thousand t. Based on the average loss value calculated above, postharvest losses have an average value of 6.125 million USD per annum. Thus, growth in value added through vegetable production could be substantial

Table 89. Main reasons for postharvest loss

Crop	Farmer	Traders and retailers
Tomato	Diseases (100%)	Vegetables cannot be sold (71%)
	Hot weather during harvest (94%)	High temperature in storage facility (62%)
Yardlong bean	Diseases (100%)	Vegetables cannot be sold (91%)
	Hot weather during harvest (100%)	Poor quality of purchased vegetable (79%)
Cucumber	Insect damage (94%)	Vegetables cannot be sold (80%)
	Diseases (75%)	Poor quality of purchased vegetable (50%)
Chinese kale	Hot weather during harvest (100%)	Vegetables cannot be sold (74%)
	Humid weather during harvest (100%)	High temperature in storage facility (68%)
	Diseases (100%)	

Source: Surveys in collaboration between AVRDC and DAALI (Cambodia), 2005.
N=200. Multiple response question.

Table 91. Average loss in US$ (100 cents) per kg of produce dealt with in Phnom Penh market

Supply chain agent	Tomato	Yardlong bean	Cucumber	Chinese kale	Average
Farmer	1.4	1.4	0.5	0.9	1.0
Collector	0.4	0.9	0.5	1.0	0.7
Wholesaler	1.1	1.0	0.9	1.6	1.2
Retailer	2.2	2.4	1.0	2.4	2.0
Total	5.1	5.7	2.8	5.9	4.9
Daily market transactions (2003)[a] (kg)	8,464	6,086	26,570	n.a.	94,630
Annual value of loss (US$)	157.557	126.619	271.545	n.a.	1,692.457

Source: Surveys in collaboration between AVRDC and DAALI (Cambodia), 2005.
N = 200.
[a]Sokhen, Kanika, Moustier (2004).

with only small improvements in postharvest technology. Technologies should focus on farm level, since a large share of loss is incurred at the farm. It appears that improving disease resistance and heat tolerance of crops could be a major strategy to improve postharvest losses. Other entry points for technological interventions include packaging to minimize damage during transport, and improving coordination among supply chain agents to reduce the quantity of unsalable produce.

Quality management in horticultural exports from Vietnam

As world exports of horticultural products grow, quality and safety-related issues become more important in international trade. Developing countries are challenged to improve their international competitiveness. For this purpose, a firm's strategy to stay competitive in international trade was analyzed in a recently conducted survey[13] among horticultural processing firms in Vietnam. The survey was based on a representative sample of 50 registered firms in Vietnam. It was found that two-thirds of the interviewed firms are exporters and almost all of them sell at least to some customers in high-income countries like the European Union (EU), the United States (US), or Japan. As food quality and safety requirements are stricter in high-income countries, there is a growing importance for processing firms within developing countries to adopt quality and safety on a par with those that exist in high-income countries.

Horticultural processing firms in Vietnam are faced by the country's expected entry to the World Trade Organization (WTO). Most of Vietnam's trade competitors in Southeast Asia are already member of the WTO, thus they are more integrated in international markets. These are considered more experienced and efficient in adhering to horticultural quality and safety requirements. Vietnamese firms therefore are confronted with new challenges to maintain their export markets or find access to new markets. For this reason, Vietnam offers a good example to study factors that are associated with developing countries' ability to meet the level of quality and safety that is required in international markets.

Quality management schemes are one way for food processing firms to secure and increase their market shares vis-à-vis food quality and safety. In the survey of processing firms, it was found that 73% of the exporters and 41% of the non-exporters use a formal quality management system, as shown in Table 92.

Among exporters, there is a higher frequency of firms that comply with private, internationally known quality assurance programs, for example, International Organization for Standardization (ISO), Hazard Analysis and Critical Control Points (HACCP), or EuroGAP. Most of the other firms with formal quality management systems follow guidelines of the Vietnamese Safe Food initiative. The higher incidence of compliance among exporting firms shows that quality assurance programs are increasingly becoming important in proving the quality and safety of horticultural products in international trade.

[13] The study is carried out within the research project *Food safety in fruits and vegetables in Vietnam—Consumer demand and firms' compliance.* It is funded by the German Federal Ministry of Economic Cooperation and Development (BMZ) and the German Technical Cooperation (GTZ) (project number 04.7860.2–001.00).

Table 92. Share of exporting and non-exporting horticultural processing firms using a formal quality assurance program

	Total n = 50 (%)	Non-exporters n = 17 (%)	Exporters n = 33 (%)	Ratio	Difference (%)	*P*-value
Formal quality assurance	62	41	73	1.77	32	0.04
Private, international	26	12	33	2.83	22	0.17
Other	36	29	39	1.34	10	0.35

Source: Own calculations with survey data.

Quality assurance programs have been coined 'commercial barriers to trade,' as firms lacking them, face comparatively more difficulties in accessing foreign customers or modern domestic retail institutions. A great majority of horticultural processing firms confirmed advantages in complying with a quality assurance program, though. It helps them to get access to new customers (93% of firms), either in export or in domestic markets. Furthermore, they are able to realize higher prices (69% of firms).

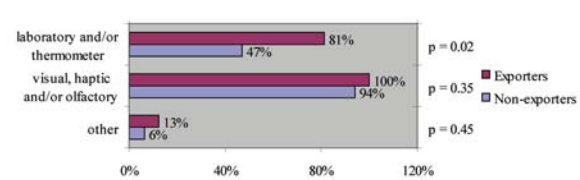
The implementation of quality management programs is a recent strategic change in the industry. All firms with private, internationally known quality assurance programs implemented them in year 2000 or later. In most cases (71%), the implementation of a quality assurance program was the firm's initiative, indicating that these firms were having a strong strategic behavior towards quality assurance. However, in other cases, customers required the firms to comply with a quality assurance program.

One of the reasons why firms hesitate to implement a quality assurance program is the average 9% higher cost compared to not being certified, mainly due to investments in more sophisticated equipment. The estimate of extra cost is from enterprise managers. Similarly, there is a 25% increase in management time as compared to not being certified because of higher requirements to supervise the workforce, to deal with control officials, and to find suitable suppliers, among others.

The credibility of quality and safety requirements rests on control mechanisms being in place. Almost all horticultural processing firms carry out basic quality and safety controls by visual, haptic, or olfactory means, regardless of whether a firm exports or not (Figure 30). However, there is a significant association between export status and the use of more sophisticated quality and safety control tools like thermometers or laboratory testing of samples. Such tools were mostly used by exporting firms and only to a lesser extent by non-exporting firms. It gives a clear indication of higher sophistication in the means to secure quality and safety of products in the former group.

In the context of food safety, traceability is a key concept to avoid and cope with incidents of unsafe products as it holds upstream actors in supply chains accountable for their products. In developed countries like EU and the US, traceability is increasingly becoming mandatory. This can have an impact on processing firms in Vietnam through requirements for cross-boundary traceability. In the survey, 92% of the horticultural processing firms enforce a system that allows them to identify the primary producers of their supply if the need arises. For most firms, traceability comes in the form of a written label attached to products, while a smaller share relies on oral information from direct suppliers, either farmers or intermediaries. The incidence of written labels was higher among exporters, whereas oral information was more important among non-exporting firms. A more formalized traceability system is therefore favored by exporters.

Quality assurance programs do not necessarily constitute a barrier to trade. Rather, their implementation can be considered as a means for firms to overcome trade barriers of importing countries. The survey results show that more attention is required to implement formalized quality assurance programs in



Source: Own calculations with survey data.

Figure 30. Share of Vietnamese horticultural processing firms using different quality and safety monitoring tools.

the horticultural industry to sustain existing export market niches and penetrate new ones. Relevant information must be in place for firms to upgrade their equipment and facilities, to train their workforce and implement required procedures. It is also necessary to support farmers and their organizations by training and linking them with processors. As quality assurance in food products starts at the primary production level, it can be achieved only through an integrated approach.

This study was conducted by a PhD student, Marcus Mergenthaler, from the University of Hohenheim in collaboration with AVRDC, the Post Harvest Technology Center (PHTC) of Lao PDR, and the Research Institute of Fruit and Vegetable (RIFAV) of Vietnam.

Role of indigenous vegetables for micronutrient consumption in Southern Tagalog, Philippines

Consumption of vegetables, which are generally a good dietary source of vitamins and minerals, is crucial in providing a diversified and nutritious diet. One promising strategy to enhance dietary diversification and enhanced vegetable consumption is through home and school gardens. In this regard, the role of IVs for micronutrient supply deserves greater attention. IVs are considered rich sources of vitamins and minerals, and encouraging the planting and use of indigenous vegetables could play a vital role in increasing micronutrient supply to poor households.

The following assessment was thus carried out to identify consumption patterns among poor households participating in a school garden project, with emphasis on indigenous vegetables. The objective of this assessment was to estimate the effects of IV consumption on micronutrient status of survey participants.

Materials and methods

Survey site and respondents. The dietary assessment was based on consumption data of 172 households in the Philippines, collected in June 2004. The surveyed households are participants of school garden projects in three different sites in Region 4-Southern Tagalog. The schools are all located in the peri-urban area and sites were selected to cover resource-poor households. A representative of the family was interviewed using a questionnaire that includes household demographic and socioeconomic variables, attitude towards and knowledge of IV crops, and a 24-hour food consumption recall. The representative of the family was generally the person responsible for meal preparation.

The 24-hour food consumption recall. The 24-hour food consumption recall specified the food items consumed per meal. A detailed list of commonly used food items for the Philippines was provided to the enumerator to facilitate the recording. All food items reported by the 172 households were coded and entered in SPSS. The quantities consumed were converted into grams using standard conversion factors (for example, 1 glass = 125 g). The calculation of energy and nutrient intake is based on the Philippine Food Composition Table provided by the Food and Nutrition Research Institute (FNRI)[14] which is very elaborate with respect to micronutrient values for IVs. Conversion rates for vegetables into micronutrients were based on boiled material. Missing values of special food items and several IVs were supplemented with values from the NUTRISURVEY project[15] and the AVRDC-Nutrition Unit.

For the dietary assessment, the household requirements were estimated based on household composition, since individual food intake figures were not available. Detailed information on the composition of age groups within the household was available. Requirements for these age groups were estimated based on the Dietary Reference Intakes (DRIs), Food and Nutrition Board, Institute of Medicine (IOM), 2004.

Estimation of energy and nutrient requirements. The recommendations provided by IOM or the World Health Organization (WHO)/FAO are graded in age and gender specific groups. The Recommended Dietary Allowance (RDA) is the dietary intake level that is sufficient to meet the nutrient requirements of nearly all individuals in the group (IOM, 2004). Characteristics of these groups are obvious factors that may affect requirements, i.e., age, gender, and weight. The aim in selecting appropriate age ranges is to reflect the physiological characteristics of men and women, including changes in rate of growth, body composition, and patterns of food intake (FAO 1991).

With regard to the implementation of consumption studies and dietary assessments, deciding appropriate age ranges within the questionnaire is very important.

[14] The Philippine Food Composition Tables. FNRI FCT + Menu Evaluation, CD-Rom. 2002.
[15] www.nutrisurvey.de

Otherwise, the interpolation between specific ages and their recommendations may be inadequate, and statements on the nutrient intake or recommended levels fulfilled may be unreasonable. Therefore, during the planning of a consumption survey, it is recommended to consider the age ranges provided by dietary references.

The recommendations used in this study are based on the IOM recommendations, which provided the closest age ranges in the consumption study. In cases where the age ranges differ, appropriate average values were chosen. The recommended values are presented in Table 93.

The food items encountered in the records showed that the diet among the surveyed households was based on rice, fish, and vegetable, with low consumption of meat. Therefore, the requirements for iron intake were estimated assuming a general intermediate bioavailability of the diet of 10%.

Recommendations for vitamin A intake are usually expressed in µg retinol equivalent (RE)/day, assuming the conversion rate from β-carotene to vitamin A is 6:1. Based on recent research, IOM (2002) estimated the retinol equivalency ratio for β-carotene from food in a mixed diet including fruits and vegetables to be 12:1, expressed in retinol activity equivalent (RAEs). This study uses the RAE.

Energy and micronutrient intake. The dietary pattern of all 172 analyzed households shows major similarities. In most cases, the diet is composed of rice, fish, and vegetables. Meat, dairy products, and fruits are rarely consumed. The total number of different food items consumed is 142, with an average of 12 food items recorded per household (Table 94). Altogether, 43 different vegetables were consumed, of which more than 80% are IVs. The diversity concerning IVs in the three sites is almost equal.

Table 94. Diversity of food consumed

Food items counted	Tranca	Rizal	Masaya	Total
Food items by site	87	101	109	142
Food items per household by site	12	12	12	
IVs by site visited	27	29	28	35

Source: Survey conducted by AVRDC in collaboration with the University of the Philippines, the Philippine Council for Agricultural Resources Research and Development (PCARRD), and Bureau of Plant Industry (BPI), June 2004.

Table 93. Recommended energy and nutrient intakes per day by age range

Age range	Energy (kcal/d) [a]	Protein (g/d)	Fat (%/energy/day)	Carbo-hydrates (g/d)	Calcium (mg/d)	Phosphorous (mg/d)	Iron (mg/d) [b]	Vitamin A (µg/d) [c]	Vitamin C (mg/d)	Vitamin B1 (mg/d)	Vitamin B2 (mg/d)	Niacin (mg/d)[d]
Male adults > 15 years	2,490	55	> 20–35	> 130	1,125	840	18	900	87	1.20	1.30	16
Female adults > 15 years	2,267	46	> 20–35	> 130	1,125	840	30	700	73	1.10	1.10	14
Male children 5–14 years	2,138	> 26.5	> 25–35	> 130	1,050	875	18	500	35	0.75	0.75	10
Female children 5–14 years	1,900	> 26.5	> 25–35	> 130	1,050	875	18	500	35	0.75	0.75	10
Male children < 5 years	1,350	> 13	> 30–40	> 130	500	460	14	300	15	0.50	0.50	6
Female children < 5 years	1,350	> 13	> 30–40	> 130	500	460	14	300	15	0.50	0.50	6

[a] Recommendations based on FAO/WHO energy and protein requirements, 1991.

[b] Iron recommendation calculated for a plant-based diet. The requirement is approximately twofold greater than for those consuming an animal-based diet (where 75% of iron is from heme iron sources).

[c] As retinol activity equivalents (RAEs). 1 RAE = 1 µg retinol, 12 µg β-carotene, or 24 µg- β-carotene, or 24 µg α-cryptoxanthin. The RAE for dietary pro-vitamin A carotenoids is twofold greater than retinol equivalents (RE), whereas the RAE for performed vitamin A is the same as RE.

[d] As niacin equivalents (NE). 1 mg of niacin = 60 mg tryptophan.

Based on the assessment, the dietary intake for several nutrients is too low to fulfill daily dietary needs. The energy intake is low, reaching on the average only 74% of the recommendation. Equally low is the intake of fat, adding up to only 16.5% of total energy intake per day, while recommendations suggest around 30%. In comparison, protein and carbohydrate intake exceed the recommended values by 70% and more than 100%, respectively. The supply of micronutrients is by far not adequate, especially vitamin A, iron, and calcium which are merely reaching 40% of the recommended levels.

The average per capita nutrient intake for all three sites surveyed is presented in Table 95.

Table 95. Per capita nutrient intake

Indicators	This study[a]		FNRI 2003[b]	FNRI 1993
	Mean	SD	Mean	Mean
Energy (kcal)	1,597	527	1,905	1,684
Protein (g)	63.5	24.8	56.2	50.0
Calcium (mg)	445	419	435	390
Iron (mg)	7.7	2.9	10.1	10.0
Vitamin A (µg RAE)	226	502	455	392
Vitamin C (mg)	38.89	50.32	46.5	47.00
Thiamin (mg)	0.63	0.27	0.88	0.67
Riboflavin (mg)	0.58	0.31	0.73	0.56
Niacin (mg NE)	20.78	7.77	20.60	16.00
Carbohydrates (g)	272	110	-	-

[a] Survey conducted by AVRDC in collaboration with the University of the Philippines, PCARRD, and BPI, June 2004.
[b] Source: FNRI, official files data.

These results are comparable with values from the National Nutrition Survey conducted by FNRI in the years 2003 and 1993, shown in Table 95. Values for energy intake and micronutrients are lower in the present study, which can be explained with the survey selection of resource-poor households.

By reason of choosing the conversion factor for carotene, with 1 µg β-carotene = 0.167 µg RE, the per capita intake for vitamin A reported by FNRI is higher compared to results shown in this study. Taking this into account, the per capita vitamin A intake in both studies resembles at a very low level.

Vitamin A Deficiency (VAD) and Iron Deficiency Anemia (IDA) cause public health problems in almost all 16 regions in the Philippines. Thirteen of the 16 regions have VAD as a major problem, affecting mostly pregnant women and children under the age of five (FNRI 1998a). In Southern Tagalog, four in every 10 children (six months to five years) have low to deficient vitamin A levels (FNRI 1998b). Prevalence rates of iron deficiency anemia for children under five years of age are as high as 32%, even reaching 44% and 42% for pregnant and lactating women, respectively (FNRI 2003).

The low micronutrient intake values and high prevalence of micronutrient deficiencies show the magnitude of malnutrition and strongly imply that intervention strategies are needed to enhance micronutrient supply in the Philippines.

Role of vegetables for micronutrient consumption. The dietary assessment so far showed that the energy and nutrient intake levels are not adequate. Looking at the dietary pattern in more detail, it is important to analyze which food items consumed are contributing to micronutrient supply. Table 96 shows an equal allocation of nutrient intake per day for lunch and dinner, while the nutrient intake during breakfast is lower.

Table 96. Average share of nutrient intake per meal

	Percent (%)							
	Energy	Protein	Fat	Calcium	Iron	Carotene	Vit A	Vit C
Breakfast	25	22	27	25	24	14	19	16
Lunch	38	38	37	38	39	44	41	40
Dinner	36	39	35	35	37	38	38	28
Snack	7	4	7	9	4	9	5	21

Source: Survey conducted by AVRDC in collaboration with the University of the Philippines, PCARRD and BPI, June 2004.

As mentioned before, vegetables are rich sources of vitamins and nutrients, and in many developing countries considered as the main contributor to vitamin A supply. Out of 172 households, 143 consumed exotic and indigenous vegetables while the rest did not eat any vegetables at all. The overall per capita vegetable consumption is 119 grams. This is slightly higher than half of the recommended intake per capita of 200 g. Equally low is the value reported by the FNRI survey (2003), with a per capita vegetable intake of 111 g. Comparing the three sites visited, Tranca has the highest vegetable consumption of 138 g, followed by Paciano Rizal and Masaya with 120 g and 111 g, respectively.

The overall contribution of vegetable intake to vitamin A supply is 12%. Given the overall share of recommended level fulfilled for vitamin A at 37%, more than one-third of vitamin A supply comes from vegetables.

More than 90% of vegetables consumed are indigenous vegetables. Earlier results of the AVRDC project show that almost 80% of households consume IVs 2–4 times/week or even on a daily basis (AVRDC 2004). Indigenous vegetables are a frequent component of the family meal contributing to one-third of the vitamin A supply, more than 60% of the vitamin C supply, and still 14% to overall iron supply and 12% to calcium supply. Table 97 shows the quantity of indigenous vegetable intake per capita and share of recommended level fulfilled for iron, vitamin A, vitamin C, and calcium.

Fruits are consumed by only 17 households, or only 10% of all surveyed households. Food items coming from animal sources are consumed by 168 households, where 132 reported to consume fish (Table 98). The per capita quantity consumed of 168 g is higher than the overall vegetable intake, with 127 g belonging to fish sources. Animal sources contribute 38% to the overall iron supply, 70% to vitamin A supply, and 60% to calcium supply. Approximately 100% of protein recommendations are fulfilled through consumption of animal sources.

In all three sites, indigenous vegetables are a frequent component of the daily meals. Overall, resource-poor households are not able to meet the minimum recommended vegetable levels. These households fail to meet the recommended level of micronutrient intake to live a healthy life. Vitamin A, iron, and calcium supply are especially too low. Indigenous vegetables are considered rich sources of vitamin A and iron, which can enhance micronutrient supply. Table 99 shows IVs with high β-carotene content and their contribution to vitamin A supply. Cassava leaves and taro leaves are high sources of vitamin A.

The results show that in the case of the Philippines, it is not only a matter of substituting indigenous vegetables for exotic vegetables but also increasing the overall vegetable intake to meet daily dietary needs. It is in this context where IVs with high micronutrient contents play an important role in enhancing the micronutrient supply and reaching daily dietary needs. For example, an increase of 100 g in the overall vegetable consumption to meet the 200 g vegetable intake recommended by FAO/WHO would increase vitamin A supply to 20% of the recommended level fulfilled. Similarly, an increase of 50 g per capita in consumption of IVs high in β-carotene, presented in Table 99, could enhance vitamin A supply to 66% of RDA.

Table 97. Quantity of IV intake and share of RDA fulfilled

Site	N	Per capita (g)		% Iron fulfilled		% Vitamin A fulfilled		% Vitamin C fulfilled		% Ca fulfilled	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Tranca	28	124	132	5.0	4.8	8	19.0	46	62.6	5	3.6
Paciano Rizal	54	114	120	5.0	5.3	16	44.8	47	71.0	6	7.5
Masaya	61	98	122	4.5	4.3	8	10.2	36	57.0	5	5.3
Total	143	109	122	5.0	4.8	11	29.6	42	63.4	5	6.0

Source: Survey conducted by AVRDC in collaboration with the University of the Philippines, PCARRD and BPI, June 2004.

Table 98. Quantity of animal source intake and share of RDA fulfilled

Site	N	Per capita (g)		% Protein fulfilled		% Iron fulfilled		% Vitamin A fulfilled		% Ca fulfilled	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Tranca	31	158	107.0	102	70.0	15	9.4	54	172.0	24.0	45.5
Paciano Rizal	65	169	86.0	96	58.4	13	8.4	17	18.5	14.5	22.6
Masaya	72	166	104.7	108	72.4	15	13.0	18	26.5	36.0	49.0
Total	168	166	97.8	102	66.7	14	10.7	25	77.0	25.5	41.0

Source: Survey conducted by AVRDC in collaboration with the University of the Philippines, PCARRD and BPI, June 2004.

Table 99. Quantity consumed: IVs with high β-carotene content

Selected IVs	N	Per capita intake (g)	Carotene (mg)	Vitamin A in (μg RAE)	% Vitamin A fulfilled	
					Mean	Median
Taro leaves	2	70	14.8	1,233	36	36
Horseradish tree	10	34	4.7	391	12	12
Cassava leaves	3	111	8.8	7,334	175	129
Capsicum	7	15	2.8	239	8	8
Lemongrass	1	0.6	0.3	24	0.5	0.5
Pepper leaves	6	36	4.2	348	10	10
Total	29	39	13.3	1,109	29	12

Source: Survey conducted by AVRDC in collaboration with the University of the Philippines, PCARRD and BPI, June 2004.

This study shows that intervention strategies to enhance micronutrient consumption in the Philippines are needed. Indigenous vegetables are affordable and a constant dietary source of vitamins and minerals. These are accepted and consumed by Filipinos and thus, have the potential to fill the micronutrient gap and enhance micronutrient intake.

The assessment of the dietary quality and micronutrient contribution of indigenous vegetables for this study was carried out by MSc student Mireille Hoenicke from the University of Hohenheim.

Contact: Katinka Weinberger

Communications, Training, and Information

Publications and multimedia presentations

AVRDC wrote and published more documents in 2005 than in any previous year of the Center's history. Several of these were strategic documents, including the *AVRDC Medium-Term Plan 2005–2007*. This rolling plan discusses trends in the vegetable sector and defines the Center's specific research and development (R&D) goals. The document highlights several successful projects, including the development of disease-resistant tomato lines as well as the tsunami relief efforts. The Center's new initiatives on global horticulture, micro-irrigation, postharvest technology, and work in Afghanistan were highlighted in the plan.

The booklet/proposal, *The Global Horticulture Initiative,* was written to support the Center's efforts to develop a funding agency for international horticulture R&D. This document begins with a discussion on the importance of horticulture in international development, followed by a description of this initiative's mission, organizational structure, and research themes.

The bulletin, *Horticulture for Poverty Alleviation—The Unfunded Revolution*, highlights the growing importance of fruit and vegetable production and how these crops can contribute to poverty alleviation and economic development. The authors call for increased funding for horticulture R&D and describe a series of R&D activities that will help resource-poor farmers to take advantage of expanding opportunities in horticulture production and marketing.

The booklet, *A Partnership for Poverty Alleviation: The Asian Development Bank and AVRDC–The World Vegetable Center*, describes a series of successful Asian Development Bank-funded projects that AVRDC has conducted. Examples include the development of disease-resistant mungbean lines that have improved incomes and diets throughout Asia, promotion of indigenous vegetables that increase food security in Southeast Asia, and the development of IPM technologies that reduce the use of pesticides in vegetable production throughout Asia.

Two technical bulletins were published in 2004. *A Comparison of Lycopene and Other Phyto-chemicals in Tomatoes Grown under Conventional and Organic Management Systems* describes the effects that organic and conventional cropping practices in Taiwan have on the content of lycopene and other nutritional components in tomato. *Vegetable Production in Bangladesh—Commercialization and Rural Livelihoods* is an analysis of the long-term impact of AVRDC's work in Bangladesh from 1991–2000. Included are analyses of the impact of vegetable commercialization on marketing channels, supporting input industries, and off-farm employment. Special attention is directed toward effects related to poverty reduction.

Many guides were written for use in farmer training programs. *Saving Your Own Vegetable Seeds—A Guide for Farmers* was written by a team of trainers from Kasetsart University and AVRDC. The bulletin teaches farmers how to produce, select, and save seed of all major vegetable crops grown in Asia. *Integrated Management of Bacterial Wilt* discusses the pathogen, the environments favorable to the disease, and how to manage the disease to reduce yield loss. This brochure was published in English and Chinese. Several brochures on controlling pests in eggplant crop production were published in English, Bengali, Gujarati, Hindi, Khasi, and Oriya. A film documentary was also prepared on this topic and produced in these languages.

A brochure that introduces AVRDC was published in English and later translated into Spanish and Japanese. This brochure is widely distributed to our contacts at meetings and to visitors.

The proceedings of two workshops were published. *Proceedings of the APSA-AVRDC Workshop of Collaborative Vegetable Research* is a summary of activities at a workshop jointly held by AVRDC and the Asia & Pacific Seed Association (APSA). The document includes 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. *Vegetable Production in Central Asia—*

Status and Perspectives is a collection of papers presented by researchers of AVRDC and selected countries of Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan). The document provides an overview of the status, constraints and opportunities for the vegetable sector in this region.

Fifty-six fact sheets on pepper and tomato diseases were written or updated. These will be developed into books in 2006. Production guides on chili pepper and non-heading Chinese cabbage were also published.

Numerous scientific findings were published in refereed scientific journals. All AVRDC publications in 2005 are listed at the back of this document. The Communication and Training Office facilitates the peer review of these publications, as well as edits major proposals prepared by AVRDC Management and scientists.

The Communication and Training Office (CTO) also provides support to Management by preparing numerous papers and PowerPoint presentations that are used to increase awareness of the Center and to generate funds. In 2005, CTO prepared a record number of posters for a multitude of international meetings and conferences.

The CTO mailing list currently contains 1944 entries, including 618 libraries in 163 countries. The office printed more than a quarter of a million pages, shot thousands of photos, disseminated hundreds of books and slide sets, and handled numerous art requests from Center scientists.

Training

In 2005, 101 scholars from 26 countries received training in vegetable research and development at AVRDC headquarters in Taiwan (a complete list of trainees can be found at the back of this document). Scholars came from Afghanistan, Azerbaijan, Bangladesh, Bhutan, Cambodia, China, Germany, India, Indonesia, Japan, Kazakhstan, Lao PDR, Malaysia, Mongolia, Nicaragua, North Korea, Philippines, Singapore, South Korea, Taiwan, Thailand, Tunisia, Turkmenistan, United States, Uzbekistan, and Vietnam. This is one of the largest and most diverse groups of scholars ever trained at our Center.

The trainees experienced productive and useful trainings at AVRDC. All of the scholars reported that their training would be useful in their work. Nearly all (98%) stated that they would like to come to AVRDC again for further training and 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 3.80, the quality of their instruction from trainers at 4.35, and the assistance from the Communication and Training Office at 4.25. These ratings are among the highest ever at AVRDC. Trainees were most appreciative of the international atmosphere of the Center, the peaceful environment, and the kindness of the Center's staff.

Internships and fellowships

Sixty-eight scholars completed research internships and fellowships. In these one to 18-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 major highlight of 2005 was a training course on conducting trials of promising vegetable varieties attended by scientists from 15 countries in Asia. After completing the course, the trainees returned to their countries and are currently working in collaboration with AVRDC to evaluate varieties from AVRDC and other seed sources. Another highlight was a training course on using molecular markers in tomato production. Sponsored by APSA, this will be the beginning of a series of training courses offered by AVRDC working in collaboration with APSA.

Four post-doctoral fellows came to AVRDC for advanced training. Dr. Ramasamy Srinivasan from India studied insect pest-plant interactions related to chemical ecology. Dr. Mounira Elbaz from Tunisia conducted research projects on interactions between plants and pathogens with special emphasis on interactions between tomato and bacterial wilt. Dr. Elaine Graham from the USA used molecular-based tools for developing genetic resistance of tomato to geminiviruses and other major diseases. Dr. Sengoda Venkatesan from India conducted gene transformation studies related to virus diseases of tomato.

A sabbatical scientist from Academia Sinica in Taiwan, Dr. Teng-yung Feng, conducted gene transformation studies.

Undergraduate and graduate student training

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 30th consecutive year, AVRDC hosted undergraduate students from universities in Taiwan. Sixteen students from five universities in Taiwan were trained in 2005. 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 at Los Baños came to AVRDC for training in genetic improvement, germplasm management, and crop production. A student from Technical University of Munich developed skills in screening plants for diseases. Students from the University of Hohenheim and Justus Liebig University developed skills in socio-economic applications related to the utilization of indigenous vegetables.

English language training

A total of 18 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.

AVRDC website 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 2005, AVRDC added 40 publications to its web site, which contains all of the Center's publications since 1997. This includes annual reports, books, bulletins, production guides, and over 130 fact sheets. In 2005, approximately 127,000 unique visitors from 123 countries downloaded this information freely and instantly over the Internet. A total of 621,755 web pages from the AVRDC website were downloaded. This was an increase of 28% from 2004. Over 140,000 educational documents in Adobe Portable Document Format (PDF) were downloaded for printing from the AVRDC website. Twelve online tutorials on vegetable production were accessed by approximately 15,000 persons during 2005.

An intranet that includes campus newsletters, grant development information, a weather log, office forms and regulations, PowerPoint templates, and logos for publications was launched for staff employees. The center also launched a photo gallery on its website. Over 100 photos of vegetables and vegetable diseases are available for downloading.

Collecting and sharing tropical vegetable information

This subproject is handled by the Center's library. In 2005, the library acquired over 216 new books and over 1768 serial publications. Subscriptions to 82 journals were renewed.

The library updated the Center's bibliographic databases to facilitate information storage and retrieval. A total of 128 books, 1531 general and crop documents, and 44 new serial titles were indexed and added to the library database. This in-house database, which now holds 44,113 bibliographic records and 3935 journal records, was placed online in 2005 and can be readily retrieved by staff and collaborators via computer. A total of 282 journal issues were bound. This hard copy collection of journals now totals 16,289 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 2005. Twenty-nine issues of SDI bulletins and six issues of recent AVRDC Library acquisitions were established on the library website in 2005. A total of 922 users from 32 countries accessed the SDI services via the Internet.

Library staff conducted 24 literature searches on the Tropical Vegetable Information Services in-house database for internal and external users. A total of 162 articles were requested for internal researchers, and 478 electronic documents were delivered to 128 external users in 65 libraries in 17 countries through Taiwan's national document delivery service.

Visitors

A total of 866 government leaders, scientists, development specialists, and businessmen from 49 countries visited AVRDC headquarters in Taiwan. Dignitaries included the President and Minister of Foreign Affairs from Taiwan, the President and his delegation from Gambia, the Prime Minister and his delegation from Tuvalu, the President of Zamorano University in Honduras, and the Minister of Agriculture and Livestock of Honduras. In most cases, the visitors were presented with an introduction to AVRDC and were then toured around research laboratories or fields related to their particular interests. Many of the visitors were invited through the Council of Agriculture or Ministry of Foreign Affairs of Taiwan. Several of these visits were useful in establishing communication and future collaboration with AVRDC and international partners.

Approximately 380 local researchers, extension specialists, and growers attended field day events that displayed new fertilizer technologies, tropical broccoli varieties, and IPM strategies to control pests in tomato production.

Contact: Thomas Kalb

International Cooperation

Regional yield trials

Variety selection is just as important in the overall success of vegetable production as other operations. The process often called regional yield trials (RYTs), usually involves testing of promising lines under a range of locations for several years. The purpose of current RYTs is to serve as one of the means for transferring AVRDC's research to Taiwan and beyond. In preparation for evaluations in other countries, RYTs were first conducted to evaluate promising AVRDC lines/varieties in the field under different seasons and locations in Taiwan.

Tomato leaf curl virus-resistant fresh market tomato

This trial was conducted to identify promising fresh market hybrids with heat tolerance, late blight, Fusarium wilt race 1, Tomato mosaic virus, bacterial wilt, and Tomato leaf curl virus resistance for summer production in the lowlands. Four large-fruited promising lines: FMTT1029, FMTT1047, FMTT1048, and FMTT1098 were evaluated along with check varieties, Taichung-ASVEG No. 10, from 18 February to 9 June 2005 (with mean day/night air temperatures at 27.3/19.3°C, and a total of 701 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 6 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 side dressed two weeks after transplanting, one month afterwards, and every month after that.

FMTT1047 and FMTT1029 gave the highest yield at 31.8 and 30.5 t/ha, respectively. All the tested lines significantly outyielded the check variety Taichung-ASVEG No. 10 (15.3 t/ha) (Table 100). FMTT1029 had significantly higher solids/acid ration than other three ToLCV-resistant lines. FMTT1047 gave the higher color value at 2.0, and the content of lycopene (6.9 mg/100 g) was significantly higher than the check variety. Although the yield of FMTT1098 was lower than the other three ToLCV lines, it gave the significantly highest beta-carotene content of 2.3 mg/100 g. Its fruit color was orange. The incidence of ToLCV for the FMTT lines was low (24–37%), whereas 87% of check variety was infected and had lower color value. The results of the incidence of ToLCV revealed FMTT lines with stable resistance. Besides ToLCV resistance, the tested lines held on to LB, FW, ToMV, and BW resistance.

Table 100. Regional yield trials of fresh market tomato hybrids at AVRDC, February–June 2005[a]

Lines	Days to maturity	Fruit set (%)	Fruit weight (g/fruit)	Yield (t/ha)	ToLCV incidence[b] (%)	Solids (°Brix)	Acid[c] (%)	Solids/acid	Lycopence (mg/100 g)	β-carotene (mg/100 g)	Color[d] (a/b)
FMTT1029	71.2	58.8	105.1	30.5	28.7	4.28	0.37	11.74	6.28	0.20	1.44
FMTT1047	71.4	56.2	107.2	31.8	27.6	4.85	0.46	10.50	6.90	0.24	2.00
FMTT1048	71.7	54.4	112.9	25.9	24.0	4.70	0.46	10.24	5.49	0.24	1.83
FMTT1098	72.2	57.6	127.1	25.3	37.5	4.73	0.50	9.57	1.53	2.30	0.66
Taichung-ASVEG No. 10	70.7	51.9	146.8	15.3	87.0	4.95	0.48	10.28	2.95	0.76	1.43
Mean	71.4	55.8	119.8	25.8	41.0	4.70	0.45	11.49	4.63	0.75	1.47
LSD (5%)	1.0	6.6	14.9	2.9	10.3	0.31	0.04	1.03	1.63	0.16	0.35

[a] Lines sown on 18 February, transplanted on 25 March, and harvested from 20 May to 9 June 2005.
[b] ToLCV incidence was investigated on 8 June 2005.
[c] Equivalent of citric acid
[d] 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.

The same lines were evaluated in I-lan branch of Hualien District Agricultural Research and Extension Station (DARES) (121°45´E, 24°46´N). Based on the preliminary results obtained in 2005, farmers were interested in FMTT1098 due to its orange fruit color, high beta-carotene, ToLCV resistance, and novelty for the market. Hualien DARES is in the process of releasing this line in 2006.

High soluble solids and beta-carotene cherry tomato

This trial aimed to select promising cherry tomato hybrids with high soluble solids and beta-carotene, heat tolerance, and resistance to ToLCV, FW race 1 and 2 and ToMV for summer production. Four cherry tomato hybrids: CHT1417, CHT1421, CHT1438, and CHT1442, and check Hualien-ASVEG No. 13 were evaluated in AVRDC from 18 February to 28 June 2005 (with mean day/night air temperatures at 27.8/ 20.2°C, and a total of 2075 mm rainfall). The experimental design was RCBD with four replications, two rows per plot, and 50 cm between plants. Plot size was 6 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 side-dressed two weeks after transplanting, one month afterwards, and every month after that.

Based on the results in 2005, CHT1438 gave the highest yield at 20.5 t/ha, followed by CHT1417 at 16.3 t/ha, significantly outyielding the check 'Hualien No. 13' and the other two CHT lines (Table 101). The incidence of ToLCV for three CHT lines was low (9.9–18.8 %). However, CHT1421 had significantly higher ToLCV incidence (37.5%). For the check variety, 93% of the plants were infected. The test lines had better fruit-setting than the check variety. CHT1438 had significantly higher solids/acid ration than the other three ToLCV-resistant lines. Although the solids/acid ration of the check variety was higher than CHT1438, it had a higher cracking percentage and is without ToLCV resistance. Cooperating researchers and farmers valued CHT1438 and CHT1417 due to their high solids contents and stable incidence of ToLCV. Hualien DARES is in the process of releasing lines derived from CHT1438 and CHT1417.

Vegetable soybean

Nine promising lines of vegetable soybean, including two from AVRDC, two from Tainan District Agricultural Research and Extension Station (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 spring 2005 (February 1–May 11, with mean day/night air temperatures at 25.8/ 17.2°C, a total of 269 mm rainfall), and autumn 2005 (September 8–November 25, with mean day/night air

Table 101. Regional yield trial of cherry tomato hybrids at AVRDC, February–June 2005[a]

Lines	Days to maturity	Fruit set (%)	Fruit weight (g/fruit)	Yield (t/ha) (%)	ToLCV incidence[b]	Solids (°Brix)	Acid[c] (%)	Solids/ acid	Lycopence (mg/100 g)	β-carotene (mg/100 g)	Color[d] (a/b)
CHT1417	78.0	88.8	17.3	16.3	18.8	6.68	0.48	14.00	0.27	1.88	0.28
CHT1421	75.0	79.0	15.7	11.3	37.5	7.18	0.55	13.08	0.44	1.89	0.36
CHT1438	77.8	79.8	16.3	20.5	9.9	7.00	0.47	15.07	1.04	1.59	0.38
CHT1442	78.3	77.5	14.8	12.4	17.2	7.25	0.60	12.18	0.62	1.84	0.38
Hualien-ASVEG No. 13	70.7	58.8	18.7	3.9	93.2	6.75	0.43	15.85	0.49	1.44	0.26
Mean	76.0	76.8	16.6	12.9	35.3	6.97	0.51	14.74	0.57	1.73	0.33
LSD (5%)	3.8	7.9	1.6	3.8	14.3	0.36	0.04	1.38	0.89	0.48	0.06

[a] Lines sown on 6 February, transplanted on 4 March, and harvested from 21 May to 24 June 2004.
[b] ToLCV incidence was investigated on 8 June 2005.
[c] Equivalent of citric acid.
[d] 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.

temperatures at 30.6/22.3°C, a total of 122 mm rainfall). The experimental design was RCBD with four replications. Plot size was 5 m x 3 m, and spacing was 50 cm between rows and 10 cm between plants.

In spring, Kaohsiung DARES's KVS1195 produced the highest graded pod yield (11.05 t/ha), and significantly outyielded the check varieties, KS#1, KS#5, and KS#6 by 86%, 55%, and 302%, respectively (Table 102). It also had the second highest shelled bean ratio. Another Kaohsiung DARES's line, KVS1197, gave the second highest yield at 10.73 t/ha, which significantly outyielded check varieties by 81%, 50% , and 290%, respectively. AGS429, an AVRDC line, had the best performance in terms of 100-fresh-seed weight, pod no./500 g, and shelled bean ratio, and its yield was the third highest (10.43 t/ha). Among the top five high-yielding lines, AGS429 (9.28%) had the highest percentage of soluble solids (Table 103).

In autumn, Kaohsiung DARES's KVS1197 gave the highest yield at 9.83 t/ha, which significantly outyielded the check varieties by 39 to 56.0% (Table 104). Its 100-fresh-seed weight was significantly higher than KS#1, and comparable with KS#5 and KS#6; while its shelled bean ratio was equal to that of KS#1, comparable to KS#6, but significantly lower than KS#5. KVS1195 was the third highest yielder (8.93 t/ha), and its pod no./500g was lower than all check varieties, and like KVS1197, KVS1195's 100-fresh-seed weight was comparable with KS#5 and KS#6 but significantly higher than KS#1.

KVS1195, KVS1197, and AGS429 had stable high graded pod yields in three seasons from autumn 2004 to autumn 2005. Among them, AGS429 had better performance in terms of shelled bean ratio, pod no./

Table 103. Quality analysis of vegetable soybean lines tested in regional yield trials at AVRDC during spring of 2005

Entry	Dry matter (%)	Protein (%)	Oil (%)	Sugar (%)	Color value (grade)
KVS1195	31.00	43.90	21.16	6.80	4.95
KVS1197	29.07	43.80	21.04	7.03	4.75
KVS1198	31.07	42.18	19.87	9.33	4.29
KVS1269	29.15	33.71	20.91	6.60	4.90
KVS1314	30.55	44.99	21.15	7.35	5.03
TS90-19V	31.73	43.56	20.07	8.27	4.15
TS90-22V	32.27	45.49	19.42	8.03	4.84
AGS429	29.99	42.28	20.74	9.28	4.73
AGS430	30.70	41.43	20.44	8.90	3.95
KS1 (check)	33.94	43.57	20.13	8.10	4.70
KS5 (check)	30.97	43.66	20.22	8.11	4.14
KS6 (check)	29.73	40.11	19.33	11.72	4.72
Mean	30.85	42.39	20.37	8.29	4.58
LSD (5%)	2.57	8.29	0.61	1.03	0.49

Table 102. Yield and horticultural characteristics of vegetable soybeans tested at AVRDC during spring of 2005[a]

Lines	Days to maturity	Podding height (cm)	Plant Height (cm)	Shelled bean ratio (%)	Pod no./ 500 g	100-fresh-seed weight (g)	Pod length[b] (cm)	Pod width[b] (cm)	Graded pod yield (t/ha)
KVS1195	100.00	10.33	44.23	54.75	136.00	78.75	4.68	1.36	11.05
KVS1197	98.75	10.78	45.58	53.50	140.75	77.75	4.59	1.34	10.73
KVS1198	98.75	7.80	31.75	42.50	110.75	83.75	5.26	1.53	1.48
KVS1269	98.00	8.25	47.63	51.50	137.50	81.75	5.16	1.43	8.60
KVS1314	91.00	6.40	28.35	49.25	138.50	76.75	5.14	1.47	4.23
TS90-19V	93.00	7.55	36.33	50.25	136.25	89.00	5.14	1.48	3.65
TS90-22V	95.00	7.68	36.30	47.50	126.25	90.00	5.60	1.53	7.00
AGS429	95.00	8.15	43.18	54.00	127.50	103.50	5.01	1.39	10.43
AGS430	93.00	8.10	40.18	49.75	142.50	78.00	5.08	1.43	7.03
KS1 (check)	93.00	8.58	41.20	53.00	168.00	54.00	4.14	1.24	5.93
KS5 (check)	96.50	8.40	48.78	55.50	150.25	70.50	4.48	1.33	7.13
KS6 (check)	91.00	7.23	28.45	45.00	125.50	87.50	5.18	1.49	2.75
Mean	95.29	8.27	39.33	50.54	136.65	80.94	4.96	1.41	6.66
LSD (5%)	5.96	1.21	3.13	3.98	17.72	9.69	0.23	0.07	0.69

[a] Lines sown on 1 February and harvested 2–11 May 2005.
[b] Measured from double-seeded pods.

Table 104. Yield and horticultural characteristics of vegetable soybeans tested at AVRDC during autumn of 2005[a]

Lines	Days to maturity	Podding height (cm)	Plant height (cm)	Shelled bean ratio (%)	Pod no./ 500 g	100-fresh-seed weight (g)	Pod length[b] (cm)	Pod width[b] (cm)	Graded pod yield (t/ha)
KVS1195	75	12.68	52.45	49.50	156.50	72.25	4.53	1.31	8.93
KVS1197	77	13.63	51.63	56.00	157.25	71.50	4.43	1.30	9.83
KVS1198	75	12.90	49.63	47.50	145.75	81.25	5.21	1.36	6.98
KVS1269	75	14.45	60.58	53.00	163.75	72.75	5.57	1.33	8.95
KVS1314	72	11.38	40.93	57.25	153.75	80.75	4.76	1.38	6.28
TS90-19V	75	12.30	51.73	61.00	152.25	81.50	4.56	1.38	8.10
TS90-22V	77	12.98	52.68	56.50	144.00	82.50	5.14	1.38	8.00
AGS429	72	12.70	56.55	60.25	149.50	80.50	4.76	1.31	8.10
AGS430	70	14.18	50.53	51.75	158.25	63.25	4.73	1.36	8.15
KS1 (check)	70	12.63	46.68	56.00	179.75	56.25	4.58	1.27	6.30
KS5 (check)	72	12.65	52.35	60.50	162.00	74.25	4.61	1.33	6.83
KS6 (check)	70	13.20	45.70	58.75	162.25	75.00	4.45	1.30	7.05
Mean	73.13	12.97	50.95	55.67	157.08	74.31	4.78	1.33	7.79
LSD (5%)	0.42	1.63	5.12	3.08	9.97	10.13	0.90	0.06	0.91

[a] Lines sown on 8 September and harvested 11–25 November 2005.
[b] Measured from double-seeded pods.

500 g, and 100-fresh-seed weight. Further regional yield trials will be conducted to evaluate the stability of yield, 100-fresh-seed weight, and shelled bean ratio in spring 2006.

Six promising lines of taro-flavor vegetable soybean were evaluated at AVRDC headquarters in spring 2005 (February 1–May 12; with mean day/night air temperatures at 25.8/17.3°C, a total of 271 mm rainfall), and autumn 2005 (September 8–November 22; with mean day/night air temperatures at 30.7/22.5°C, a total of 122 mm rainfall). In spring, Kaohsiung DARES's KVA11 produced the highest graded pod yield (9.55 t/ha), which significantly outyielded the check varieties, Shon-gi, and Black-5-leave by 135.8% and 63.2%, respectively, and the rest of the test lines, except KVA17 which gave comparable graded pod yield (Table 105). KVA11's shelled bean ratio was significantly higher than Shon-gi (check), but comparable with the other check variety, Black-5-leave (check). Similarly, its 100-fresh-seed weight was significantly higher than Shon-gi (check); however, it was significantly lower than Black-5-leave (check).

Table 105. Yield and horticultural characteristics of taro-flavor vegetable soybean tested at AVRDC in spring of 2005[a]

Lines	Days to maturity	Podding height (cm)	Plant height (cm)	Shelled bean ratio (%)	Pod no./ 500 g	100-fresh-seed (g)	Pod length[b] (cm)	Pod width[b] (cm)	Graded pod yield (t/ha)
KVA11	101.00	8.30	51.15	54.50	134.25	73.25	4.78	1.38	9.55
KVA14	101.00	10.83	47.08	59.25	141.00	83.25	4.83	1.28	7.48
KVA17	99.00	11.50	45.95	54.50	143.50	75.50	5.80	1.38	9.20
KVA20	94.00	6.43	28.23	63.50	158.50	84.75	4.73	1.43	5.95
KVA22	99.00	7.08	32.95	55.50	166.25	75.25	5.55	1.28	3.45
TS85-21V	90.75	6.83	29.60	46.25	171.50	64.25	5.38	1.53	4.00
Shon-gi (check)	88.00	8.23	32.70	49.00	172.00	65.75	5.30	1.50	4.05
Black-5-leave (check)	94.00	7.48	30.33	53.75	143.25	83.75	4.65	1.33	5.85
Mean	95.84	8.33	37.25	54.53	153.78	75.72	5.13	1.38	6.19
LSD (5%)	2.86	1.25	2.77	2.80	9.46	6.66	0.29	0.12	0.99

[b] Lines sown on 1 February and harvested 29 April–12 May 2005.
[b] Measured from double-seeded pods.

KVA20 had the highest 100-fresh-seed weight and shelled bean ratio and produced significantly higher yields than both check varieties. The check varieties, Shon-gi and Black-5-leave, had significantly higher mean percentage of soluble solids than all experimental lines. Among the new lines, TS85-21V (9.56%), KVA22 (8.48%), and KVA11 (7.70%) had higher mean percentage of soluble solids than others (Table 106).

In autumn, KVA11 produced the highest graded pod yield (10.30 t/ha) continuously, and significantly outyielded the check varieties, Shon-gi and Black-5-leave by 112.4% and 64.8%, respectively (Table 107).

Table 106. Quality analysis of taro-flavor vegetable soybean lines tested in regional yield trials at AVRDC during spring of 2005

Entry	Dry matter (%)	Protein (%)	Oil (%)	Sugar (%)	Color value (grade)
KVA11	31.92	42.30	21.53	7.70	5.21
KVA14	30.82	43.20	22.34	4.65	3.68
KVA17	31.47	40.23	22.62	7.11	5.21
KVA20	31.18	42.33	21.63	7.55	4.19
KVA22	28.64	41.14	20.90	8.48	3.48
TS85-21V	29.08	42.27	18.51	9.56	4.28
Shon-gi (check)	4.96	28.09	41.20	17.41	11.19
Black-5-leave (check)	30.19	43.14	17.31	10.99	5.20
Mean	30.17	41.97	20.28	8.40	4.53
LSD (5%)	0.86	0.56	0.37	0.44	0.53

Its 100-fresh-seed weight was highest than all tested lines, and its shelled bean ratio was between Shon-gi and Black-5-leave. Further regional yield trial will be conducted to evaluate the stability of yield in spring 2006.

The first AVRDC Tomato leafcurl virus-resistant fresh market tomato hybrid released in Taiwan

Based on the results of RYTs, Taiwan's Council of Agriculture released the Tomato leafcurl virus-resistant fresh market tomato hybrid FMTT906 developed by AVRDC on 24 November 2005. It is officially named as Taiwan Seed-ASVEG No. 15. This is the eleventh AVRDC improved tomato line and the first with Tomato leafcurl virus resistance released by the host country since the Center's inception. The unique traits of this hybrid are its deep globe-shaped, firm fruit with less cracking, early-maturing, high heat tolerance, and resistance to Tomato mosaic virus and Fusarium wilt race 1.

Development and extension of indigenous vegetables as new vegetable crops

The objective of this project is to introduce diverse indigenous vegetables from the tropics, and to domesticate them as new health-promoting vegetables. Acquisition on the information and materials of IVs are continued. A total of 181 lines (including 38 species belong to 29 genus of 18 families) were collected in

Table 107. Yield and horticultural characteristics of taro-flavor vegetable soybean tested at AVRDC in autumn of 2005[a]

Lines	Days to maturity	Podding height (cm)	Plant height (cm)	Shelled bean ratio (%)	Pod no./ 500 g	100-fresh-seed weight (g)	Pod length[b] (cm)	Pod width[b] (cm)	Graded pod yield (t/ha)
KVA11	76	13.25	55.45	58.00	153.00	73.25	4.59	1.37	10.30
KVA14	76	12.03	50.60	62.00	172.25	67.25	4.46	1.32	8.23
KVA17	76	13.98	54.05	54.50	188.00	70.00	4.72	1.29	7.95
KVA20	71	9.80	37.15	59.00	161.75	70.00	4.21	1.35	6.43
KVA22	71	11.95	47.30	53.00	179.50	61.50	4.59	1.29	8.75
TS85-21V	62	10.65	33.78	52.50	197.50	56.75	4.04	1.30	4.03
Shon-gi (check)	62	11.95	38.23	58.50	207.50	57.25	3.84	1.29	4.85
Black-5-leave (check)	62	10.70	36.58	53.75	181.00	68.50	4.55	1.34	6.25
Mean	69.5	11.79	44.14	56.41	180.06	65.56	4.37	1.32	7.10
LSD (5%)	0	1.32	5.30	5.81	8.82	10.68	0.21	0.05	0.81

[a] Lines sown on 8 September and harvested 8–22 November 2005.
[b] Measured from double-seeded pods.

2005. Some of the materials were planted in AVRDC's indigenous vegetable observation plot for an evaluation of their adaptability under AVRDC environmental conditions. While the materials were being grown in the plot, their growth and development were observed and recorded and some samples taken for other studies. Below are highlights of 2005 R&D activities.

A study was conducted to investigate the possibility of using tender tripinnate leaves of *Moringa oleifera* as new leafy vegetable. Six accessions (TOT4100, TOT4880, TOT4893, TOT4951, TOT4977, and TOT5169) were evaluated at the AVRDC experimental field. An RCBD with three replications was employed. Plot consisted of twin rows spaced 1.2 m apart; with plants 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 17 February and transplanted to the field on 17 March 2004. Harvesting of the top 20 cm of tender tripinnate leaves was done eight weeks after transplantation on a biweekly basis at the beginning. After that, saplings were decapped at 1.2 to 1.5 m high, and tender leaves were harvested weekly. From 17 May 2004 to 9 December 2005, the mean accumulated yield was 21.47 t/ha (Table 108). Variations of yields among these six accessions were not significant. The optimum harvesting time was 51 to 58 days (mean day/night air temperatures at 31.8/25.1°C) after 1st detopping and 58 to 72 days (mean day/night air temperatures at 24.9°C/15.4°C) after 2nd detopping.

The harvested leaves were also analyzed for nutritional quality for four seasons (7 January, 11 April, 8 July, and 7 October 2005). Contents of vitamin C and minerals and antioxidant activities were higher in winter than in summer, whereas a reverse trend was found for vitamins A and E. However, there was no significant difference among accessions for these traits.

Asystasia gangetica, *Corchorus capsularis*, and *Corchorus olitorius* are often collected wild as vegetables in Africa and Southeast Asia. Previous studies at AVRDC show that these hold potential as new vegetables. To assess their potentials in the hot-wet season, trials were conducted to evaluate their tolerance to flooding. Seeds of *C. olitorius* (TOT6749, TOT4541, and TOT4312), *C. capsularis* (TOT4051), and *A. gangetica* (TPS0005), were sown in the seedling flats, 28 cm in width, and 53 cm in length in the greenhouse. All the seedlings of five accessions were transplanted to plastic pot four weeks later, one plant per pot, and placed in the greenhouse. An RCBD was employed with three replications for *C. olitorius* and *C. capsularis*; seven replications for *A. gangetica*. Sowing date, transplanted date, and waterlogging date of *C. olitorius* and *C. capsularis* were 4 July 2005, 20 July 2005, and 26 July 2005, respectively. In *A. gangetica*, sowing date, transplanted date, waterlogging date were 4 July 2005, 25 July 2005, and 1 August 2005, respectively. Plots each with10 plants were placed in the nethouse. Two treatments of waterlogged and nonwaterlogged (as control) were applied. Flooding was imposed after transplanting. For waterlogged treatment the pots were

Table 108. Yield of *Moringa olefeira* tender leaves conducted at the AVRDC experimental field from 17 May 2004 to 9 December 2005

			1st Optimum harvesting time		2nd Optimum harvesting time	
Lines	Accumulated yield (t/ha)	Average yield (t/ha)	Days after detopping	Yield (t/ha)	Days after detopping	Yield (t/ha)
TOT4100	24.15	0.39	54.22	8.0	62.45	3.83
TOT4880	21.11	0.34	55.54	6.3	66.42	3.49
TOT4893	17.18	0.28	53.58	5.7	63.73	2.51
TOT4951	19.69	0.32	54.11	6.1	64.37	2.99
TOT4977	21.27	0.34	55.15	5.9	62.11	3.29
TOT5169	25.40	0.41	53.81	7.7	64.64	3.77
Mean	21.47	0.35	54.40	6.61	63.95	3.31

waterlogged up to 1 cm above the soil surface for 10 days, and for non-waterlogged treatment, pots were free-draining and watered daily. Five plants per plot were sampled with labels for data collection. After waterlogging, the pots of waterlogged treatment were drained and continued to be investigated up to 14 days after waterlogging. Results show that TOT4541 of *C. olitorius* was the most flood-tolerant.

In 2005, a total of 15 IV species were evaluated for nutrient contents and antioxidant activity. The results showed that seven species were rich in beta-carotene (> 3.5 mg/100 g), six species high in calcium content (> 200 mg/100 g), three species rich in vitamin E content (> 6 mg/100 g), and three species outstanding with antioxidant activity (> 20000 TE/100 g).

From 120 IV species, an earlier study has identified and selected 50 accessions (34 species) that contain high total phenolic contents. These were further evaluated in 2005 for antimicrobial activities against the three most common bacteria, that is, *Escherichia coli*, *Salmonella typhimurium,* and *Staphylococcus aureus*, which cause food-borne illness. Results show that *Bidens bipinnata*, *C. capsularis*, *Houttuynia cordata, M. oleifera, P. odoratum, Ruta graveolens, Cedrela sinensis* have strong activities against *S. aureus*.

Previous studies at AVRDC showed that *Coccinia grandis* thrives well under high temperatures and its tender shoots have beta-carotene and protein contents. It has a great potential to be a new health-promoting vegetable crop. Thus, a field day was held on 29 September 2005 to introduce this vegetable crop to local researchers and extension agents. Activities included crop introduction, field demonstrations of crop management and harvest, culinary preparations, acceptability survey, and sample seed release. Among 79 participants, 94% of them would accept tender shoots of *C. grandis* as a new vegetable, and 71% of them would like to grow it for commercial purposes. In the following days, several newspaper and professional magazines introduced this new vegetable crop.

The aforementioned IV observation plot with around 200 species IV in any season has attracted over 600 visitors from 45 countries in 2005. Many of them expressed interest to collaborate with AVRDC for further studies on IVs.

Training workshop on evaluation of promising vegetables

An ROC-supported workshop was organized to extend the improved vegetable lines and technologies developed by AVRDC to Southeast Asia, North Asia, and Central Asia. The organization of the workshop entailed survey of production constraints and needs, seed multiplication of promising vegetables and curriculum preparation before the workshop, and coordinated regional trials of promising vegetables after the workshop. The pre-workshop surveys revealed that the four major vegetable crops are tomato, pepper, eggplant, and lettuce, which are constrained by various diseases and insect pests (Table 109).

The workshop was held from 25 September to 8 December 2005. There were 31 participants from 27 research institutes of 15 countries, that is, Afghanistan, Azerbaijan, Kazakhstan, Turkmenistan, Uzbekistan, North Korea, Mongolia, Cambodia, Indonesia, Lao PDR, Philippines, Singapore, Thailand, Vietnam, and Taiwan. The participants of 13 countries have contributed 149 lines from 18 crops as exchange materials and control varieties (Table 110). A manual of conducting yield trials was prepared. The AVRDC researchers provided classroom lectures and field practices (Figures 1–3) on trials and scientific reports. All the participants appreciated the opportunity and committed themselves to the regional trials of promising varieties.

AVRDC has provided the seeds of promising lines of tomato, pepper, lettuce, vegetable soybean, mungbean, okra, broccoli, and Chinese cabbage for the participants to conduct yield trials in their respective countries. Ten participants from seven countries also received sample seeds of 73 promising varieties from 16 crops of Known-You Seed Company (Table 111).

Participants from Cambodia, Lao PDR, Philippines, Thailand, and Vietnam have immediately started the trials after the workshop, involving six crops (tomato, chili pepper, sweet pepper, lettuce, okra, and mungbean) in 12 sites (Table 112). The progress of the trials is being monitored by the AVRDC researchers. Other nine countries will start the trials in spring of 2006.

Table 109. Pre-workshop survey results on priority crops and major production constraints[a]

Region[b]	Priority[c]	Crops	Biotic constraints (weighting %)					Abiotic constraints (weighting %)					
			Fungi[d]	Bacteria[e]	Viruses[f]	Insects[g]	Weeds	Flooding	Drought	Heat	Chilling	Salinity	Nutrient deficiency
SE Asia	1	Tomato	27	27	14	27	4	36	27	36	0	0	0
		Chili pepper	26	16	37	21	0	25	38	12	12	0	12
		Sweet pepper	31	23	15	23	8	38	38	25	0	0	0
	2	Eggplant	20	10	10	60	0	25	75	0	0	0	0
	3	Lettuce	20	40	0	40	0	33	67	0	0	0	0
	4	Veg. soybean	25	0	25	50	0	0	100	0	0	0	0
		Okra	25	12	25	38	0	33	33	0	33	0	0
North Asia	1	Lettuce	0	50	0	50	0	14	29	29	0	0	29
	2	Tomato	33	0	17	33	17	0	33	17	17	0	33
		Chili pepper	40	0	20	40	0	20	20	20	20	0	20
		Sweet pepper	50	0	25	25	0	20	20	20	0	0	40
		Eggplant	25	0	25	25	25	20	20	40	0	0	20
CAC	1	Tomato	22	22	17	28	11	0	38	38	8	8	8
	2	Chili pepper	50	0	0	50	0	0	50	50	0	0	0
		Sweet pepper	23	23	15	23	15	0	43	43	14	0	0
	3	Carrot	33	17	0	33	17	17	33	33	0	17	0
		Cucumber	20	20	20	20	20	0	50	50	0	0	0

[a] Data are from 12 countries and 19 respondents.

[b] SE Asia: Indonesia, Lao PDR, Philippines, Thailand, Vietnam and Singapore; North Asia: Mongolia and DPR Korea; CAC: Azerbaijan, Kazakhstan, Turkmenistan, and Uzbekistan.

[c] Priority order: 1 > 2 > 3 > 4.

[d] Fungi: late blight, early blight, leaf blight, Fusarium wilt, damping-off, anthracnose, powdery mildew, downy mildew, rust, head rot, soft rot or fruit rot, storage rot, watery soft rot, brown rot, Septoria leaf spot.

[e] Bacteria: bacterial wilt, bacterial spot.

[f] Viruses: ToMV, Cucumber mosaic virus (CMV), ToLCV, Cucumber veinal mottle virus (CVMV), Potato virus Y (PVY), Tomato spotted wilt virus.

[g] Insects: thrips, aphid, armyworms, grasshopper, leaf hopper, tomato fruitworm, mites, whitefly, pod border, fruit and shoot borer, cutworm, leaf miner, noctuid, Colorado potato beetle, leaf beetle, bollworm, carrot rust fly, mole cricket.

Table 110. Vegetable seeds[a] collected from the participants of the training workshop on conducting trials of promising vegetable varieties

Country	TM	CP	SP	EG	MB	OK	LE	RA	CC	CR	CU	ON	AM	AL	YB	WG	LU	CA	Total
Afghanistan	2			1		1													4
Azerbaijan	3	1	1	2	2		1												10
Kazakhstan	12		9							14									35
Turkmenistan	5		1								3								9
Uzbekistan	2		2							2	1	2							9
Subtotal in CAC	24	1	13	3	2	1	1			16	4	2							67
Cambodia				5							2		2	2	4	2	2		19
Indonesia	1	1		1											1				4
Lao PDR	2	4		3															9
Philippines	5		3	2	2		3												15
Thailand				1		1													2
Vietnam	7	14		2															23
Subtotal in SE Asia	15	19	3	14	2	1	3				2		2	2	5	2	2		72
DPR Korea				1			1	1	1									1	5
Mongolia	2	1	1	1															5
Subtotal in North Asia	2	1	1	2			1	1	1									1	10
Total	41	21	17	19	4	2	5	1	1	16	6	2	2	2	5	2	2	1	149

[a] TM: tomato; CP: chili pepper; SP: sweet pepper; EG: eggplant; MB: mungbean; OK: okra; LE: lettuce; RA: radish; CC: Chinese cabbage; CR: carrot; CU: cucumber; ON: onion; AM: amaranth; AL: angled luffa; YB: yardlong bean; WG: wax gourd; LU: luffa; CA: cabbage

Figure 31. Hands-on practice on sowing lettuce seeds to the seedling tray (left) and land preparation (right).

Figure 32. Hands-on practice on mulching with rice straw after transplanting of lettuce (left), and staking of eggplant (right).

Figure 33. Hands-on practice on harvesting (left) and data collection (right) of lettuce trial.

Table 111. Sample seeds provided by Known-You Seed Co. Ltd. for the workshop participants to test in their countries

Country	Crop (number of varieties)	Total number of crops (varieties)
Cambodia	sweet pepper (2), tomato (4), broccoli (5), muskmelon (4)	4 (15)
Lao PDR	pepper (4), tomato (5), cauliflower (2), coriander (1), eggplant (1), cabbage (1), lettuce (1)	7 (15)
Mongolia	pepper (1), tomato (2), broccoli (1), cabbage (2), cucumber (1), eggplant (1), cauliflower (1)	7 (9)
Afghanistan	pepper (1), sweet pepper (1), tomato (1), cauliflower (1), carrot (1), corn (1), cucumber (1), eggplant (1), okra (1)	9 (9)
Azerbaijan	snap bean (1), carrot (2), cauliflower (1)	3 (4)
Kazakhstan	sweet pepper (1), Chinese cabbage (1), carrot (2), cauliflower (2), lettuce (1)	5 (7)
Uzbekistan	pak-choi (2), carrot (2), cauliflower (2)	3 (6)

Table 112. Regional yield trials conducted in 12 organizations by the workshop participants from five Southeast Asia countries

Country	Trials conducting organization	Crops (number of lines) evaluated
Cambodia	Kbal Koh Vegetable Research Station, Department of Agronomy and Agricultural Land Improvement DEY ETH-SRE AMPIL Agricultural Research and Development Center	Tomato (16), Pepper (4), Mungbean (3)
Lao PDR	Haddokkeo Horticulture Research Center, National Agriculture and Forestry Research Institute	Cherry tomato (4), Pepper (4)
	Vegetable production unit, Crop Multiplication Center, Department of Agriculture	Cherry tomato (4), Pepper (4)
Thailand	Kanchanaburi Horticultural Research Center	Pepper (4), Okra (3)
	Phichit Horticulture Research Center	Cherry tomato (6)
Vietnam	Research Institute of Fruits and Vegetables Group of vegetables, Southern Fruit Research Institute	Tomato (18), Pepper (4), Okra (3)
Philippines	Department of Agriculture, Regional Field Unit 10 Northern Mindanao Integrated Agricultural Research Center Baguio National Crop Research and Development Center, Bureau of Plant Industry Bureau of Agricultural Research, Department of Agriculture, Regional Field Unit 4-A Bureau of Plant Industry Los Baños National Crop Research and Development Center	Tomato (18), Sweet pepper (4), Lettuce (3) Tomato (18), Lettuce (3), Sweet pepper (4) Mungbean (3)

Contact: George Kuo

Grant Development

Vegetable seed kits for the survivors of the Tsunami

On 26 December 2006, a tsunami hit the coastal areas of Southeast and South Asia. AVRDC supplied 25,000 vegetable production kits to the survivors of the Tsunami in Sri Lanka and Indonesia. All kits included: 1) seed of fast-growing leafy vegetables (100 g pak-choi and 500 g kangkong) to provide nutritious food 30–35 days from planting; 2) in total, over 5 t of different vegetable seeds (tomato, eggplant, tomato, cucumber, watermelon, kale, edible rape, yardlong bean, cabbage, hot pepper, butternut, and squash) were donated by private seed companies; 3) 2 kg fertilizer; 4) a hoe; and 5) a growing instruction written in the local language which describes cultural practices for each vegetable species. Since vegetables can be grown on limited areas of land under economically viable conditions, the distribution of seed kits to home gardeners is a sustainable approach to rebuild agricultural production in the affected areas and to ensure food security. The project addressed issues of human nutrition among survivors and recreated the capacity of families to produce nutritious food for themselves.

The vegetable seed kits were packed to permit sowing of 100 m^2. All vegetable species are cultivated in Southeast Asia and are, therefore, adapted to the soil and climate there. All seeds were sent to the AVRDC Asian Regional Center in Bangkok for germination tests and repackaging. In Bangkok, 25,000 individual packets were prepared, each containing a hoe, seeds, fertilizer, and growing instruction, before they were shipped to Sri Lanka and Indonesia. Additional seeds (pak-choi and kangkong) and fertilizer were purchased in Thailand, while the hoes were bought locally in Sri Lanka and Indonesia.

AVRDC negotiated the selection criteria of the beneficiaries with the local partners namely, the Ministry of Agriculture, Sri Lanka Council for Agricultural Research Policy (SLCARP), and the Indonesian Agency for Agricultural Research and Development (IAARD). AVRDC and its partners agreed on the following principles:

Beneficiaries should: 1) be tsunami-affected farmers and home gardeners who are recognized as tsunami victims, including registered and non-registered victims; 2) have lost their production assets or had production assets badly damaged; 3) be owners of a home garden; 4) be farmers who have been identified as to have incurred agricultural losses; and 5) be individual farmers and not commercial business owners.

Priority is given to: 1) families who lost their production assets and have no other means to restore their livelihoods; 2) families whose house was destroyed; 3) families who lost their head of household (man or woman); 4) households that lost family member(s) of working age; and 5) families who have not received other assistance, except government compensation.

The beneficiaries for the vegetable seed kits were identified and selected by representatives of concerned communities such as village heads in close consultation with the stakeholders/villagers. The distribution was managed by SLCARP and IAARD. Each village head, who was involved in the distribution at the village level, agreed to the abovementioned selection criteria in writing and acknowledged the receipt of the delivered vegetable seed kits. The list of village heads and recipients included information such as name, title, address, and the area where the vegetable seed kits were to be distributed. The distribution was managed by AVRDC staff.

The adoption rate of the vegetable seed kits can be summarized as very high in Sri Lanka. In Aceh, Indonesia, where the damage caused by the tsunami was more severe, the overall adoption rate was lower and largely depended on the local conditions. In one village the adoption rate was 100%, while the adoption rate in the next village 5 km away was only 10%. This variance was due to many reasons, including topographic conditions, which influenced the impact of the Tsunami. While most of the farmers could already continue their agricultural activities, some farmers were not yet ready to go back to their daily activities, having lost some family members, property, and their agricultural land. These farmers stated that they will wait 'for better times' and plan on growing the seeds as soon as their family's situation stabilizes.

On issues concerning vegetables, the new variety of kangkong is widely grown, while pak-choi is also popular and is now available in markets. Many farmers planted the hybrid seeds donated by private seed companies for the first time.

Contact: Markus Kaiser

Asian Regional Center

Collaborative vegetable research network for Cambodia, Lao PDR, and Vietnam

The objectives of the ADB-funded RETA No. 6011 Collaborative Vegetable Research Network for Cambodia, Lao PDR, and Vietnam (CLVNET Phase II) include: 1) development and dissemination of high-yielding varieties and appropriate management practices; 2) integrated pest management of diamond-back moth; 3) improved seed production technologies; and 4) capacity building, information exchange, technology transfer, and impact assessment. This project was initiated in April 2002 and concluded in October 2005.

During project implementation, the NARSs were able to select superior vegetable varieties and demonstrate these to farmers under different environmental conditions. In Cambodia, on-farm adaptive trials were conducted on 11 promising CLVNET-I varieties of seven vegetables, namely tomato, cherry tomato, eggplant, hot pepper, yardlong bean, mungbean, and grain soybean. Yields of promising lines were 14–88% higher compared to the local varieties and seasonal variations of yields were reduced. In Lao PDR, 73 varieties of nine vegetable crops were evaluated in observational trials at Hatdokkeo Horticulture Research Center (HHRC) during 2002–2005. On-farm demonstrations were conducted on nine newly introduced promising varieties of six vegetable crops. In Vietnam, promising vegetable varieties of tomato, hot pepper, French bean, yardlong bean, mungbean, vegetable soybean, soybean, and cucumber were demonstrated to farmers under different ecological conditions during project implementation. A total of 3425 germplasm samples were released to Cambodia, Lao PDR, and Vietnam (CLV) countries within the project period.

Through the project, establishment of parasitoids of the diamondback moth (DBM) was widely confirmed in major crucifer producing areas. Difficulties in establishing parasitoids related to each parasitoid's limited environmental range as well as the farmer's excessive use of chemical pesticides. The benefits of educational programs focusing on the usefulness of natural enemies of DBM and the establishment of parasitoids were evident. Through the training conducted, the technology of handling parasitoids was established in CLV countries and a manual on DBM was made in local languages.

Significant progress was also made in each participating country. Seeds of many vegetable varieties were multiplied, government officials received advice on developing regulations for vegetable seed production in their respective countries and linkages with the private sector and non-government organizations (NGOs) were initiated.

One hundred forty-four extension specialists and a total of 593 lead farmers were trained on various vegetable production technologies.

Human resource development for the Mekong region

The goal of the Human Resource Development Project for the Mekong Region Phase IV (HRDP-IV), funded by the Swiss Agency for Development and Cooperation (SDC), is to increase income from vegetable production and to increase consumption of vegetables by farming households in upland and remote areas of Vietnam, Lao PDR, and Cambodia. The objectives of HRDP-IV include: 1) Increase capacities of researchers and of the five national partner institutions to conduct relevant, need-based vegetable research for farmers in upland and remote areas; 2) Increase capacities of selected agricultural extension institutions to define and use improved vegetable production, processing, and marketing techniques and deliver need-based effective extension services; 3) Benefit male and female farmers in uplands and remote areas with improved vegetable, processing, and marketing techniques imparted by lead farmers; 4) Strengthen institutional knowledge and information sharing on vegetable production, processing, and marketing for poor areas of the Mekong region.

Six researchers completed the 23rd Regional Training course at AVRDC-Asian Regional Center (ARC) and eight researchers and two lecturers attended the 24th Regional training course. Seventeen on-farm trials were conducted in all five NARS centers. Links with NGOs (national and international) have been initiated.

Nine extension staff completed the 23rd Regional Training course at AVRDC-ARC and a similar number are participating in the 24th course. Seven in-country trainings on vegetable production for extension staff were conducted. A training course on advanced statistics for 19 Myanmar agricultural scientists was conducted on 9–13 May. Several handbooks were translated into local languages.

Thirteen in-country trainings on vegetable production technologies for lead farmers were carried out in 2005. Additional knowledge and skills on vegetable production were gained by 524 lead farmers.

The ARC website is updated regularly to facilitate sharing of information on vegetable production technologies. The website will be upgraded to enhance this sharing by alumni of the training courses.

Physiological functionalities of indigenous vegetables in Southeast Asian countries

Vegetables are not only important for human health by supplying major nutrients such as carbohydrates, protein, and lipid, but also because these supply various compounds to maintain wellness called functional components such as vitamins, antioxidants, anti-mutagens, among others. Thousands of indigenous plants have been used as vegetable in Southeast Asian countries. However, the kinds of vegetables found in the market have gradually decreased. The economic values of vegetables have been evaluated on various aspects such as color, shape, nutrients, flavor, and marketing quality. Recently, some indigenous vegetables have been found to be beneficial to human health because these contain physiologically important functional components. Value addition to vegetables is very important to attract consumers. Nowadays, vegetable consumers are attracted not only by flavor, taste, shape, and price, but also pay more for safe and healthy foods such that production of value-added vegetables would enable poor farmers to increase their incomes.

In this JIRCAS-funded research project, indigenous vegetables were evaluated from the perspective of physiologically functional components such as antioxidant activity and antimutagenic activity.

In 2004–2005, selected indigenous vegetables were cultivated in winter (from November to mid-February), summer (from mid-February to May), and the rainy season (from June to October). The plant samples used were grown at Kamphaeng Saen Campus of Kasetsart University, Nakhon Pathom, Thailand.

The plant samples were harvested and separated into leaves or stems if necessary and cut into small pieces (2 cm long) with a pair of scissors. Ten grams of the plant material was put together with solvents such as 1% formic acid-aqueous solution, 1% formic acid-methanol solution or dichloromethane solution into 250 ml volume of a WARING blender and homogenized for one minute. The blended mixture was transferred into a 250 ml beaker and was allowed to stand still for 30 minutes with a watch glass on the top of the beaker. The mixture was then filtered with a filter paper, Whatman's No.4, and the filtrate was collected in a 500 ml Erlenmeyer flask. Analysis of antioxidant activity was measured by spectrophotometer.

The results in Table 113 showed that in general, high antioxidant activity can be obtained when using dichloromethane as solvent; water, on the other hand, is best for amaranth; while for other crops, high activity was observed when using methanol as solvent.

Table 114 shows the 13 selected indigenous vegetables based on the highest antioxidant activity (> 0.100 mmol/g FW). These indigenous vegetables were classified into six annuals such as amaranth AS239, pak-kayang, water convolvulus WC 077, water convolvulus WC 087, water convolvulus WC 089, Jute CC009, and seven perennials such as sweet basil OC175, lead tree, mui, neem, sacred basil OC034, sacred basil OC039, and acacia leaf. Furthermore, comparison of antioxidant activity during winter, summer, and rainy seasons showed that in general, high acitivity can be detected on plants planted during winter.

Out of 54 kinds of indigenous vegetables evaluated, 13 showed high antioxidant activities and showed highest antioxidant activities during winter season.

It was found that amaranth showed highest antioxidant activities when extracted with water, acacia leaf with dichloromethane, while water convolvulus, sacred basil, jute, sweet basil, pak-kayang, lead tree, sauropus leaf, mui, and neem with methanol.

Table 113. Evaluation on antioxidant activity of selected indigenous vegetables using different solvents

Crop	Edible part	Solvent: water (mmol/g FW)	Solvent: methanol (mmol/g FW)	Solvent: dichloromethane (mmol/g FW)
Acacia	Young shoot	0.026	0.032	0.217
Amaranth	Leaves	0.060	0.042	0.008
Jute	Leaves	0.049	0.078	0.006
Lead tree	Young shoot	0.215	0.260	0.038
Micromelum	Young inflorescence	0.278	0.623	0.074
Neem	Young inflorescence	0.541	0.952	0.035
Pak-kayang	Young shoot	0.116	0.150	0.007
Sacred basil	Leaves	0.161	0.279	0.118
Sweet basil	Leaves	0.105	0.175	0.008
Water convolvulus	Whole plant	0.039	0.163	0.002

Table 114. Highest antioxidant activity of selected accessions of indigenous vegetables by season

Plant samples	Solvent	Winter 2004–2005	Summer 2005	Rainy 2005
Amaranth AS239	water	0.160	0.049	0.036
Pak-kayang	methanol	0.150	0.123	0.134
Sweet basil OC175	methanol	0.175	0.050	0.170
Lead tree	methanol	0.260	0.153	0.213
Mui (shoot)	methanol	0.756	0.548	0.552
Mui (young inflorescence)	methanol	0.489	–[a]	–
Neem (young inflorescence)	methanol	0.952	–	–
Sacred basil OC034	methanol	0.318	–	0.247
Sacred basil OC039	methanol	0.239	–	0.232
Water convolvulus WC 077	methanol	0.124	–	0.119
Water convolvulus WC 087	methanol	0.125	0.103	0.09
Water convolvulus WC 089	methanol	0.117	0.080	0.084
Jute CC009	methanol	0.101	–	0.107
Acacia leaf	dichloromethane	0.217	0.136	0.159

[a] No data

Effect of biological liquid manure on growth of Chinese kale and water convolvulus

Biological liquid manure is one kind of organic fertilizer resulting from the fermentation of plants residue by microorganisms in water to improve soil fertility and encourage decomposition of organic matter in the soil. Biological liquid manure is easier to prepare compared to compost and green manure. It is applied not only as biological liquid manure during growing period to add plant nutrition but also convenient for farmers to harvest with short-cycle growth vegetables.

The objective of this study was to evaluate the effect of biological liquid manure to growth of Chinese kale which is a high-value vegetable. The study aimed to find out the most appropriate kind of biological liquid manure to water convolvulus on experimental soil in Kamphaeng Saen, Nakhon Pathom, Thailand.

Three kinds of biological liquid manure applications were experimented on Chinese kale from December 2004 to March 2005. The effect of bio-liquid manure on yield and other agricultural characteristics of Chinese kale was evaluated. There were different effects among the three kinds of bio-liquid manure, chemical fertilizer, and control in terms of yield, number of plants per plot, percent dry weight, leaf area index, plant height, and plant weight. Cow biological liquid manure produce significantly higher yield at 16.5 t/ha, while the chemical fertilizer had the highest yield at 11.2 t/ha (Table 115).

Significant difference on the yield of water convolvulus in response to bio-liquid manure was observed. Yield production varied from 5.04 t/ha to 11.25 t/ha. Analysis of variance showed that chemical fertilizer was significantly different compared to other bio-liquid manure and control. The chemical fertilizer gave highest yield at 11.25 t/ha followed by hog bio-liquid manure at 7.71 t/ha and control at 7.25 t/ha (Table 116).

Yield trial of selected vegetable soybean line

AVRDC has included vegetable soybean as a principal crop for research and development. Increasing interest and demand for vegetable soybean in many countries encouraged AVRDC to broaden its research scope to cover adaptation of crop to the tropics and subtropics. It can be grown year-round if well-adapted cultivars are used.

This experiment was aimed at evaluating vegetable soybean lines in terms of yield and other agronomic traits to maximize its potential during the dry season and determine which varieties are suitable to Kamphaengsaen condition.

Eight vegetable soybean varieties: AGS 190, AGS 292, AGS 328, AGS 370, AGS 373, AGS 373, AGS 375, and NT3 were evaluated from November 2004 to March 2005. Marketable yield significantly differ among the lines. AGS 372, AGS 375, and AGS 190 gave the highest marketable yield at 7.05 t/ha, 6.23 t/ha, and 5.67 t/ha. The average pod length ranges from 3.62 to 5.60 cm, the width from 0.88 to 1.45 cm, and the pod weight from 0.73 to 2.88 g. AGS 328 had the highest pod length, width and weight, followed by AGS 292 and AGS190. All the varieties were harvested from 62 days to 78 days.

AGS 372, AGS 375, AGS 190, and AGS 373 are suitable for growing during the dry season. These varieties had high yield compared with the AGS 292

Table 115. Yield and other agricultural traits of Chinese kale in a replicated yield trial, AVRDC-ARC, Kasetsart University, Nakhon Pathom, Thailand, November 2004–April 2005

Treatment	Number of plants/plot	Total yield (t/ha)	Dry matter (%)	Leaf area index	Average plant height (cm)	Average plant weight (g)
Duck manure	116	12.6	11.5	9.8	36.6	85.9
Cow manure	108	16.5	11.7	14.8	45.2	126.3
Hog manure	113	14.0	14.0	14.9	39.7	96.2
Chemical fertilizer	111	17.0	12.1	13.8	43.8	113.9
Control	114	10.0	13.1	9.5	35.3	78.7
Mean	112 ns	14.9 ns	12.2 ns	13.2 ns	41.5 ns	100.2 ns
C.V. (%)	3.32	35.0	10.4	32.2	18.8	47.3

ns = not significant.

Table 116. Yield and other agricultural characteristics of water convolvulus in a replicated yield trial, AVRDC-ARC, Kasetsart University, Nakhon Pathom, Thailand, November 2004–April 2005

Treatment	Total yield (t/ha)	% Dry matter	Leaf area index	Average plant height (cm)	Average plant weight (g)
Duck manure	6.13 b	11.0	2.95	26.0	6.6
Cow manure	5.04 b	10.5	3.45	26.4	6.4
Hog manure	7.71 ab	10.1	3.21	29.7	7.9
Chemical fertilizer	11.25 a	10.0	5.59	33.2	11.6
Control	7.25 b	10.2	4.09	28.3	7.6
Mean	7.47 *	10.3 ns	3.86 ns	28.7 ns	8.0 ns
C.V. (%)	31.80	10.8	44.10	19.8	43.2

ns = not significant; * = significant at 5%.

(check). AGS 372 had the highest yield among varieties tested. Marketable yield of vegetable soybean was found to be positively correlated to the size and weight of the pod. AGS 292 and AGS 328 had the heaviest pod but these varieties had low yield. AGS 190 had lower pod weight than AGS 292 and AGS 328 but this variety had higher marketable yield and good seed storability during normal room temperature from 8 to 10 months. Hence, AGS 190 is suitable for marketable production.

Large-scale methods of storing soybean seeds using baked limestone and Burned Rice Straw

Two soybean seed varieties, namely AGS292 and AGS 375, were stored in big containers with baked limestone and Burned Rice Straw on a ratio of 2:1 (2 kg of seed : 1 kg of CaO). AGS 375 showed high percentage of germination after six months (81.25%) when stored with baked limestone. In contrast, AGS 292 showed lowest percentage of germination (1%).

This study confirmed that baked limestone is the best desiccant to store soybean seed but Burned Rice Straw can also store soybean seed but for a short period of time (3–6 months).

Inheritance of Bruchid (Coleoptera: Bruchidae) resistance in mungbean (*Vigna radiata* (L.) Wilczek)

Bruchid beetles or seed weevil is a group of insect that causes considerable loss to mungbean (*Vigna radiata*) and other legume seeds during storage. Generally, chemicals are used to control these insects, however, economic and environmental considerations favor plant resistance. In this study, inheritance of seed resistance to two bruchid species viz. *Callosobruchus chinensis* and *C. maculatus* in two resistant mungbean accessions is reported. Bruchid-resistant mungbean accession V2709 and V2802 were crossed reciprocally to bruchid-susceptible cultivar Kamphaeng Saen 1 (KPS 1). F_2 seeds were grown to produce F_3 seeds and bioassayed with *C. chinensis* and *C. maculatus*. In each cross combination, 20 F_3 seeds from individual F_2 plants were infested with 40 newly emerged adults of *C. chinensis* or *C. maculatus* for one week and then the insects were discarded and the seeds were kept at room temperature. Fifty days after insect infestation, the number of damaged seeds was counted and converted to percentage. Plants with 55–100% damaged seeds were classified as susceptible, while plants having 0–50% damaged seeds were considered as resistant. Using this criterion, the postulated genetic models were tested using Chi-square analysis.

Frequency distribution is continuous between resistant and susceptible groups. Reaction to both *C. chinensis* and *C. maculatus* showed a 3 resistant : 1 susceptible ratio, indicating monogenic inheritance of the resistance. When the F_2 populations were pooled across direct and reciprocal crosses as well as among crosses, the genetic segregation also fitted with the same ratio. These results conformed to the postulated genetic model proposed by AVRDC that the resistance in V2709 and V2809 was governed by a single dominant gene. Bruchid resistance in the accession TC1966 (wild mungbean) is also influenced by a dominant gene. However, it is suspected that these are of different loci. Bruchid bioassay in backcross generations is required to confirm the results as well as to test for allelism of the resistant accessions.

Screening of AVRDC eggplant accessions for resistance to eggplant fruit and shoot borer damages

Among the several insect species found to attack eggplant, eggplant fruit and fruit borer (EFSB) *Leucinodes orbonalis* Guénee caused significant damage to the crop. Even insecticides were found to be ineffective as a result of the overuse and the scheduled spray program of these chemicals. Another factor of the failure of insecticide application is due to the behavior of this insect pest. The larval injury was localized into the young fruit and shoot, which are fully protected against insecticide contact. Breeding resistant eggplant aims to reduce insecticide usage on the crop. For this purpose, 43 eggplant lines/varieties including the resistant EG058 and the susceptible EG075 were transplanted in field. A distance of 1.5 m between two adjacent rows was maintained. Damaged shoots from eggplant fruit and shoot borer were monitored weekly. At each harvest, the number of damaged fruit was recorded to calculate the percentage of damaged fruit and the percentage of damaged fruit by weight. The data was analyzed using analysis of variance (ANOVA) followed by least significant difference (LSD) at 5% probability level.

The response of various eggplant genotypes to this pest are summarized in Table 117. All 43 lines/varieties

Table 117. Eggplant fruit and shoot borer damage of various eggplant accessions

Lines/ Varieties	Resistance to CLH	Marketable yield (g)	% Damaged fruit in number	% Damaged fruit in weight
6-5	MR	1,045.00 fg	64.63 ab	64.85 ab
7-4	HR	885.00 fg	19.17 g-k	22.42 e-i
43-9	MR	2,040.00 c-g	9.38 i-k	12.55 g-i
49-4	S	2,530.00 c-g	26.22 d-k	27.80 c-i
53-6	MR	3,090.00 c-g	17.97 h-k	21.35 e-i
84-1	HR	2,725.00 c-g	45.12 b-e	48.97 bcd
107-7	HR	7,160.00 a	25.14 e-k	25.84 c-i
128-3	S	2,823.00 c-g	22.22 f-k	23.16 d-i
131-4	MR	2,875.00 c-g	22.40 f-k	27.87 c-i
132-9	S	1,910.00 c-g	31.43 d-i	40.87 b-f
134-10	S	2,678.00 c-g	27.34 d-k	32.16 c-g
134-4	MR	2,570.00 c-g	27.08 d-k	35.58 c-g
139-8	S	1,770.00 d-g	26.22 d-k	29.30 c-h
144-7	S	1,605.00 d-g	35.99 c-h	39.05 c-f
148-10	MR	2,890.00 c-g	23.56 e-k	29.84 c-h
150-6	HR	4,025.00 bcd	32.10 d-h	38.48 c-g
158-9	MR	2,540.00 c-g	17.98 h-k	17.56 f-i
167-2	MR	3,935.00 b-e	20.87 f-k	23.37 d-i
167-3	MR	1,260.00 fg	21.27 f-k	25.50 d-i
168-1	S	2,405.00 c-g	27.00 d-k	32.85 c-g
184-7	HR	1,355.00 fg	41.17 c-g	36.24 c-g
191-10	HR	1,170.00 fg	41.57 c-f	43.21 b-f
191-6	HR	825.00 g	55.00 abc	51.63 abc
201-1	HR	1,380.00 fg	47.51 bcd	46.23 b-e
201-2	HR	1,510.00 efg	25.27 e-k	25.46 d-i
212-5	HR	1,335.00 fg	33.03 d-h	36.74 c-g
214-2	MR	950.00 fg	29.02 d-j	30.59 c-h
BangOon1	S	2,745.00 c-g	23.59 e-k	25.21 d-i
ChaoChomT2003	HR	3,130.00 c-g	23.46 e-k	25.56 d-i
EG058	S	1,170.00 fg	30.59 d-i	28.72 c-i
EG075	HR	770.00 g	69.53 a	72.74 a
EW041004	MR	1,200.00 fg	27.36 d-k	29.30 c-h
FarmerLong704	HR	4,240.00 bc	33.84 d-h	37.88 c-g
Fitness1506	HR	6,980.00 a	26.12 d-k	26.74 c-i
KangKob	S	2,908.00 c-g	24.80 e-k	27.80 c-i
KangKobLong	S	2,065.00 c-g	21.57 f-k	26.17 c-i
Maya	MR	5,233.00 ab	25.43 e-k	28.51 c-i
Panda95	S	1,950.00 c-g	24.00 e-k	25.93 c-i
Rolex039	MR	1,710.00 d-g	31.74 d-h	42.57 b-f
Snow38	S	2,618.00 c-g	24.43 e-k	25.93 c-i
Supan1	MR	1,695.00 d-g	5.88 k	3.40 i
Tiger085	S	2,265.00 c-g	40.53 c-g	43.41 b-f
Turbo	MR	3,333.00 b-f	8.19 jk	4.91 hi

Response of eggplant to cotton leaf hopper (CLH): HR means highly resistant; MR means moderately resistant; and S means susceptible to this pest.
Means followed by the same letter in each column are not significantly different with DMRT test at 5% level.

of this species had significantly damaged fruit and marketable yield. The highest marketable yield was recorded for 107-7. EFSB population was low in Supan1 and Turbo, which gave a lower percentage of damaged fruit than the resistant line EG058. In addition, these entries are resistant to cotton leaf hopper, *Amrasca biguttulla biguttulla*, which is a serious pest of eggplant during the dry season. Turbo and Supan1 are long, green fruit while 107-7 are medium-sized purple fruit. The resistant lines, however, can be developed to reduce pest damage and pesticide use in combating eggplant fruit and shoot borer.

A new high yielding mungbean line 'VC 6506-127' resistant to Cercospora leaf spot disease

VC 6506-127 was developed at AVRDC-ARC Kasetsart University Kamphaengsaen Nakhonpathom Thailand during 2003–2005 from a cross between VC 6370-92 and VC 3541B followed by seedling and line selections for bigger seed size and higher yield (Figure 34). 'VC 6506-127' has shown high resistance to Cercospora leaf spot during the rainy season. The plant has purple hypocotyl with dark green leaf, has vigorous growth, yields at about 1.6 t/ha, and with large seed size at 78 g per 1000-seed weight. This line has early flowering, about three days earlier than VC1973A (Figure 34). It has better growth in the early or late rainy season before the main cropping period with short maturity duration at 65–70 days.

Figure 34. VC 1973A and VC 6506-127.

The relationship of pod-synchronized maturity and degree of determinate in advanced mungbean lines

The purpose of this study is to identify short-time maturing pods for one-time-only harvesting. The degree of determination (*DD*) is general information about the duration of vegetative growth periods from floral initiation to harvesting time. The information showed that measuring synchrony from timing to flowering date (*DDd*) and plant height (*DDh*) did not have significant correlation to the percentage of first seed yield harvest. The *DD* cannot determine the synchronized pods maturity. Non-synchronized lines had long vegetative growth and also higher yield supported by more pods and bigger seeds. The highest uniform yield with about 85–96% of first harvests consisted of three lines: VC1973A, VC2778A, and VC6492-58-1 at 1.28, 1.29, and 1.20 tons per hectare, respectively. The higher yield per hectare from the first harvest consisted 70% of total yields from lines VC6510-151-1, VC6506-127-1, and VC6507-142-1 which yielded 1.35, 1.30, and 1.29 ton per hectare, respectively. These new promising high-yielding lines are sufficiently advanced to do farmer yield trials.

Training

Regional training course

For the 23rd Regional Training Course in Vegetable Production, Research, and Extension held from 01 November 2004 to 01 April 2005, a total of 15 participants: 3 from Cambodia, 4 from Lao PDR, 2 from Myanmar, and 6 from Vietnam (2 from the northern part, 2 from central, and 2 from the southern part). All the participants were supported by the SDC.

An interview was conducted for the trainees from Cambodia, Lao PDR, Thailand, and Vietnam who were nominated or selected by the National Coordinators of the SDC-HRDP IV. The participants from Myanmar were selected by their respective Ministry or Department of Agriculture. There were nine male and six female participants in the group. In terms of job description, seven are involved in extension, six are in research, while two are involved in both research and extension.

Certificates of recognition for exemplary academic performance were awarded to three training scholars: Mr. Ngo Xuan Chinh and Ms. Nguyen Thi My Dung from Vietnam, and Mr. Kim Chantha from Cambodia.

The 24th Regional Training Course started on 31 October 2005 and will complete on 31 March 2006. A total of 23 candidates from seven countries: 1 from Afghanistan, 4 from Cambodia, 4 from Lao PDR, 5 from Myanmar, 4 from North Korea, 1 from Thailand, and 4 from Vietnam (2 from the northern part, 2 from central, and 2 from the south) participated. All participants from Cambodia, Lao PDR, and Vietnam plus three of the five participants from Myanmar are being supported by the SDC-HRDP IV grant; the other two from Myanmar are being supported by the Committee of 101 Veterans, Inc. from the United States working in the Shan State; the participant from Afghanistan by a grant the United States to Kabul University in Afghanistan; while the participant from Thailand is supported by AVRDC-ARC.

Similar to the 23rd training course, an interview was made with the candidates selected by the national coordinators in Cambodia, Lao PDR, and three areas in Vietnam (northern, central, and southern). Nomination for Thailand candidates was made by the Department of Agricultural Extension while selection of candidates from Myanmar, North Korea, and Afghanistan was left to the decision of the concerned agencies. The training group consisted of 61% participants working or involved in extension and 39% working on or involved in research. By gender, 57% of the participants are male and 43% are female.

To meet the demands of a global development environment to ensure ‘need-based research’ in participating project countries, AVRDC-ARC modified the existing curriculum to facilitate awareness on the needs to strengthen collaboration between research and extension and to help farmers empower themselves to become development partners with researchers and extension workers.

In-country training course

An in-country training course on General Vegetable Production Techniques was organized in Sri Lanka from 1 to 12 August 2005. The training was agreed upon by AVRDC and Sri Lankan Government in relation to AVRDC activity to assist the tsunami-affected areas of the country through vegetable seed distribution. After the vegetable seeds were donated to Sri Lanka for distribution to the affected areas, it was felt that there was a need to increase the knowledge of the extension workers about vegetable production. The 10-day training course covered various topics such as vegetable classification, cultural management, pest management, and seed production. A total of 25 participants from all over the country attended the course. Post-course evaluation showed that the participants were satisfied with the course content but indicated that more time should have been allotted for practical exercises.

Contact: Peter Ooi

Regional Center for Africa

AVRDC-Regional Center for Africa (RCA) is the link between AVRDC and NARES in Africa. The RCA is based in Arusha, Tanzania and conducts applied research on a range of topics in Vegetable science. In 2005, AVRDC-RCA implemented activities for four projects, namely: 1) 'Promotion of neglected indigenous leafy and legume vegetable crops for nutritional health in Eastern and Southern Africa' funded by BMZ/GTZ; 2) 'Germplasm collection, evaluation and improvement of African leafy vegetables' funded by USAID; 3) 'Empowering small-scale and women farmers through sustainable production, seed supply, and marketing of African IVs in Eastern Africa' funded by Maendeleo Agricultural Technology Fund - Gatsby and Rockefeller Foundation's; and 4) 'Technology transfer of promising vegetable lines through sustainable seed production in East Africa' funded by Rockefeller Foundation.

AVRDC-RCA also implemented the 12th Africa Regional Vegetable Crops Production and Research Training Course from July to November 2005. Additionally, 20 two- to three-day training courses in vegetable crops production, processing, and preservation were conducted from January to December. A total of 430 participants from self-help women groups, small-scale farmers, and university students attended the courses.

A planning meeting was conducted during September 19–20, 2005 to prepare a workplan for the Rockefeller Foundation funded project 'Technology Transfer of Promising Vegetable Lines Through Sustainable Seed Production in East Africa.' Twenty five participants mainly from Tanzania, Uganda, and Kenya attended the meeting.

A number of new initiatives are being undertaken with EU, Forum for Agricultural Research in Africa (FARA), and McKnight Foundation in the coming year and proposals have been submitted.

Evaluation of neem kernel extract as an alternative to synthetic chemicals to control diamondback moth on cabbage

Diamondback moth (*Plutella xylostella* (L.) is recognized as a widely distributed and the most serious pest of cabbage and other Brassica crops worldwide. Despite the effort in IPM approaches, damage caused by DBM is still very high. On the other hand, the resistance of DBM to chemicals requires the use of increasing insecticidal doses or/and new insecticides, as well as several repeated applications for effective control. The insecticide residues that accumulated in the edible plant parts can be harmful to consumers. In such circumstances, the trend towards the use of biological insecticides represents a sustainable approach.

Extracts from the seeds or leaves of the neem tree (*Azadirachta indica*) contain several insecticidal compounds, the main active ingredient being azadirachtin. This compound repels and kills many insect species including caterpillars, thrips, and whitefly. Hence this experiment was carried out to evaluate neem kernel extract as an alternative product to control DBM.

The experiment was carried out at AVRDC-RCA, Arusha, Tanzania from June 2004 to November 2005 using the cabbage variety Gloria of Enkhuizen. In 2004, the trial was carried out three consecutive times with seeds of the first experiment sown on 15 June and transplanted on 12 July 2004. For the second experiment, seeds were sown on 26 July and transplanted on 20 August. The third experiment was sown on 8 September and transplanted on 12 October. Neem cake extract at 12.5, 25, and 50 g/l was tested. To prepare the neem extract, neem cake was weighed and soaked in water overnight a day before application. The other treatments included Selecron (1.0, 1.5, 3 ml/l), Actelic (1.0, 1.5, 3 ml/l) and water as control. The experiment was laid out in RCBD with three replications. Five rows were planted for each treatment with 12 plants/row spaced at 40 cm within rows and 60 cm between rows. Two guard rows were also planted on both ends of each replication. NPK (20-10-10) and urea were applied at the respective rates of 150 kg/ha and 45 kg N/ha two weeks after transplanting and 45 kg N/ha of additional urea was applied two weeks thereafter after the first application. Furrow irrigation was carried out twice a week and weeding was done when needed. Data were collected only on the three inner rows of each treatment. Scouting for signs and the presence of DBM was carried out regularly. The data were subjected to ANOVA analysis using COSTAT analytical software.

In 2004, there was no infestation by DBM. It seems that the natural enemies released by Insect Physiology and Ecology (ICIPE) 12 km from RCA experimental station may have spread and are now controlling DBM. There were no significant differences for total head yield for all the treatments in 2004 (Table 118) and 2005. In 2005, DBM occurred at a relatively low level and Actelic and Selecron showed the best control (Table 119). Neem at 50 g/l used to be as efficient as Actelic at 1.5 ml/l (AVRDC Report 2003). In the 2005 experiment, neem was very close to the water control and this may be attributed to poor quality of the neem cake used.

Table 118. Effect of Selecron, Actelic, and neem kernel extract on head yield of cabbage, Arusha, Tanzania, June–November 2004

Treatment	Yield (kg/plant)	Yield (t/ha)	Head width (cm)	Head length (cm)
Actelic (3ml/l)	2.47 a	104.60	20.33 a	14.53 ab
Water	2.36 ab	98.70	19.71 ab	13.90 ab
Selecron (1.5 ml/l)	2.22 abc	94.10	19.51 abc	14.30 ab
Actelic (1.5 ml/l)	2.11 abc	86.60	19.53 abc	14.58 ab
Selecron (1 ml/l)	2.05 abc	82.78	19.55 abc	14.20 ab
Selecron (3 ml/l)	2.01 abc	83.62	18.95 a-d	14.98 a
Neem (50 g/l)	1.98 bc	82.36	18.46 a-d	13.52 ab
Actelic (1 ml/l)	1.94 bc	80.99	18.74 bcd	13.58 ab
Neem (12.5 g/l)	1.94 bc	79.22	17.99 cd	13.55 ab
Neem (25 g/l)	1.73 c	71.38	17.65 d	13.15 b
LSD (5%)	0.49		1.67	1.65
F-test	*	ns	*	*
CV (%)	13.58	10.02	5.11	6.87

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Means within the same column followed by the same letter(s) are not significantly different at 5% probability level based on DMRT.

Table 119. Effect of Selecron, Actelic, and neem kernel extract on head yield of cabbage, Arusha, Tanzania, July–November 2005

Treatment	Average number of larva/pupa	Average number of holes/leaf	% Plant with larva	% Affected plants	Cabbage weight (kg)	Cabbage weight (t/ha)	Cabbage length (cm)	Cabbage width (cm)
Water (Control)	1.081 a	13.523 a	3.360 a	4.756 a	2.123 ab	88.472 ab	16.79 b	14.25 b
Actellic (3 ml/l)	0.206 c	5.613 cde	2.014 b	3.589 cd	2.660 ab	110.833 ab	17.68 ab	16.13 ab
Selecron (1.5 ml/l)	0.105 c	5.349 cde	2.193 b	3.570 cd	2.147 ab	89.444 ab	17.33 ab	14.87 ab
Neem (50 g/l)	0.855 ab	10.670 b	3.138 a	4.585 a	2.867 a	119.444 a	18.9 7 a	16.98 a
Neem (12.5 g/l)	0.832 ab	10.033 b	3.287 a	4.682 a	2.340 ab	97.500 ab	18.31 ab	15.63 ab
Actellic (1 ml/l)	0.188 c	6.131 cd	2.497 b	3.958 b	2.720 ab	113.333 ab	18.82 a	16.70 a
Neem (25 g/l)	0.757 b	10.033 b	3.036 a	4.507 a	1.967 b	81.944 b	16.60 b	14.88 ab
Selecron (3 ml/l)	0.181 c	3.720 e	2.135 b	3.481 d	2.027 ab	84.444 ab	17.43 ab	15.62 ab
Actellic(1.5 ml/l)	0.230 c	6.827 c	2.336 b	3.85 bc	2.403 ab	100.138 ab	18.40 ab	16.68 a
Selecron (1 ml/l)	0.211 c	4.254 de	2.006 b	3.678 bcd	2.593 ab	108.055 ab	17.68 ab	15.55 ab
LSD (5%)	0.239	2.001	0.454	0.305	0.751	31.300	1.714	1.820
F-Test	***	***	***	***	*	*	*	*
CV (%)	29.933	15.220	10.177	4.371	18.364	18.364	5.613	7.041

* significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Means within the same column followed by the same letter(s) are not significantly different at 5% probability level based on DMRT.

Effects of plant population on yield adaptation and horticultural characteristics of promising nightshade lines

Various varieties of African nightshade are among the most important, popular, and nutritious traditional vegetables. The species' potential to improve the diets and incomes of rural resource-poor small-scale farmers, especially women, has been widely recognized.

The species is spread across various habitats ranging from the tropics to the temperate regions. Rapid spread of the species is due to intensified irrigation production systems, wide tolerance to various habitats, and prolific seed production. Most species require moist environments. Nightshade species are semi-cultivated in Africa. However, recent years have witnessed increased cultivation and commercialization of nightshade especially in West Africa and to a lesser extent in East Africa. Young shoots are harvested when plants are 15 cm height (4–6 weeks after transplanting) and before flowering. Regular harvesting encourages lateral growth and extends harvesting time. Leaf yields can reach up to 12–20 t/ha per season. However, several constraints need to be addressed to improve the availability and supply of nightshade to consumers. The aim of this study is to evaluate the effect of spacing on yield characteristics of promising lines of two nightshade species.

The experiment was conducted at AVRDC–RCA research station in Arusha, Tanzania from July 2004 to January 2005. The experiment was laid out in RCDB with three replications in plots measuring 6 m long. Spacing between treatments were 30 x 30 cm, 50 x 50 cm, 70 x 70 cm, and 90 x 90 cm. The seedlings were transplanted on four rows or ridges per treatment. Fertilizer amount applied was 300 kg/ha of NPK (20-10-10) and 120 kg N/ha of urea (46% N). The urea was applied in two splits while the NPK fertilizer was applied all at once with half of the urea fertilizer applied at the same time with NPK 19 and 47 days after transplanting, respectively. One line each of *S. scabrum* (line SS52) and one of *S. americanum* (line SA1) were used. Fresh leaves were harvested from the two middle rows of the plots and weighed. Flowers were also removed to induce more vegetative growth.

Both tested lines were not significantly different for leaf and seed yields and the number of seeds/fruit. Plant spacing did not affect the number of fruits/plant, seed yield/plant, the number of seed/fruit, and fruit size (Table 120). Line SS52 gave the highest fruit yield (32.0 t/ha), largest fruits (0.55 g), and the highest 500-seed weight (1.5 g) as compared to line SA1 (Table 120). The highest number of fruit/plant (2830.4) was obtained with line SA1.

Spacing of 30 x 30 cm gave the highest leaf yield (50.3 t/ha), fruit yield (44.5 t/ha), and seed yield (1.9 t/ha). Leaf yield/ha, fruit yield/ha, and seed yield/ha decreased with increasing plant spacing (Table 120). By contrast, leaf yield/plant, fruit yield/plant, and seed yield/plant increased with increasing spacing.

Spacing of 30 x 30 cm seems to be the best for both leaf and seed production and should be further evaluated in other growing areas before promotion.

Table 120. Effects of genotype and spacing on yield of African nightshade, Arusha, Tanzania, July 2004–January 2005

Treatment	Leaf yield/ plant (g)	Leaf yield (t/ha)	Number of fruits/ plant	Fruit yield/ plant (g)	Fruit yield (t/ha)	Seed yield/ plant (g)	Seed yield (t/ha)	Number of seeds/ fruit	Fruit length (cm)	Fruit width (cm)	Fruit size (g)	500-seed weight (g)
Accession												
SA 1	638.24	23.54	2830.38 a	442.22 b	17.50 b	24.12	1.04	54.29	0.56 b	0.55 b	0.12 b	0.20 b
SS 52	764.38	27.35	843.82 b	1028.28 a	32.03 a	28.62	0.94	42.39	1.36 a	1.20 a	0.55 a	1.53 a
LSD (5%)			765.66	223.26	9.76				0.05	0.04	0.02	0.1
F-test	ns	ns	***	***	**	ns	ns	ns	***	***	***	***
Spacing (cm)												
30 x 30	453.10 b	50.34 a	1765.22	400.25 c	44.47 a	17.44 b	1.94 a	48.85	0.97 a	0.87 ab	0.33	0.77 b
50 x 50	592.49 b	23.70 b	1764.98	589.70 bc	23.59 b	24.72 ab	0.99 b	47.73	0.89 b	0.84 b	0.34	0.81 ab
70 x 70	746.44 ab	15.23 b	2392.97	856.33 ab	17.48 b	31.03 ab	0.63 bc	47.02	0.97 a	0.89 ab	0.34	0.94 a
90 x 90	1013.19 a	12.51 b	1425.24	1094.72 a	13.52 b	32.29 a	0.40 c	49.75	1.00 a	0.92 a	0.34	0.94 a
LSD (5%)	389.1	14.67		315.73	13.8		0.42		0.07	0.06		0.14
F- test	*	***	ns	**	**	ns	***	ns	*	*	ns	*
CV (%)	44.81	46.55	47.60	34.68	45.01	39.91	34.09	32.02	5.51	5.39	7.57	13.17

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Means within the same column followed by the same letter(s) are not significantly different at 5% probability based on DMRT.

Studies on Ethiopian mustard

Ethiopian mustard (*Brassica carinata* L.) is a natural cross between *Brassica nigra* and *B. oleracea.* It is an annual herbaceous crop cultivated for its edible succulent leaves and young stems. It is a domesticated African indigenous vegetable that originated in Ethiopia and has spread throughout Eastern and Southern Africa in both lowlands and highlands. The cultivation of Ethiopian mustard as an oil crop is restricted to Ethiopia, but as a leafy vegetable, it is often grown in Eastern and Southern Africa and less so in West and Central Africa. It grows best in the dry season under irrigation when there are few pests and diseases. Cultivation of the crop succeeds better in well-drained, fertile, preferably alkaline soils and can also be grown on both light and heavy soils. Ethiopian mustard tolerates various temperatures but it prefers a range of 15–20°C. It is a rather versatile crop and can be found in highland regions up to 2600 m with a cool climate (10–15°C). Cool weather followed by high temperatures has been observed to induce early flowering and once the crop flowers, leaf production decreases. Despite its long historical cultivation, it has never been known as a fully commercial field crop.

As a leafy vegetable, it is mostly grown as a kitchen garden crop, although in Tanzania, Malawi, Zambia, and to a lesser extent in Zimbabwe, it is grown as a market crop. Ethiopian mustard's use as a leaf crop appears to be declining because of higher yielding leaf cabbage (*Brassica oleracea*) and leaf mustard (*Brassica juncea*). The low production is a result of the lack of seeds, unsuitable varieties, and poor production and postharvest handling practices. The crop is popular for its leaves in Kenya, Zambia, and Tanzania. Leaves are harvested when they reach an adequate size and are still tender. As a vegetable, leaves can be harvested early (from 35 to 40 days after sowing). Total leaf-yield response varies according to plant population, soil fertility regime, and cultivars. Yields and seed yield of 50–55 and 1.2–1.8 t/ha, respectively have been recorded. Fertilizer application is an important agronomic practice that influences yield and quality of the crops. It has been noted that the crop responds well to application of 100 kg N/ha and 75 kg P_2O_5/ha that can be incorporated into the soil prior to planting. Frequent irrigation is needed to attain good leaf yields. Removal of flowers extends leaf formation. Plant spacing is also an important agronomic practice that greatly influences yield and quality of the crops. Previous studies at AVRDC-RCA have shown that the optimum spacing within rows for leaf production is 60 x 40 cm; while another study has shown that a spacing of 30 cm within row spacing gives highest yield for both lines Mbeya Purple and Mbeya Green. Closer spacing is recommended when harsh harvesting regimes are practiced. It is known that total leaf yield varies considerably between cultivars, of which Mbeya green is one of the best with a 30 t/ha to 55 t/ha. This information, together with the optimum time to start harvesting the leaves, are of great value for growers as the leaves will not lose market quality and value. Several studies were carried out in Arusha, Tanzania to determine the best cultural practices for growing Ethiopian mustard.

Determination of harvesting time on the leaf yield of Ethiopian mustard lines

The objective of this study was to validate the appropriate time to start harvesting Ethiopian mustard leaves to obtain optimum leaf yield.

The experiments were carried out at AVRDC–RCA, in Arusha Tanzania, from July to October 2004 and 2005. The experiments were laid out in RCBD with three replications in plot sizes measuring 6 m long and 0.6 m wide. The treatments included two lines of Ethiopian mustard: namely, Mbeya Green and Mbeya Purple; and seven harvest starting periods, from week 5 up to week 11 after transplanting.

The seeds were sown on a flat bed in an open space where they were given the normal nursery management practices until transplanting, which occurred on July 8th in 2004 and on July 21st in 2005. Each treatment was planted on two double rows/ridges with a spacing of 40 cm between plants within the row, 30 cm between rows of plants, and 60 cm between row/ridges. At 21 days after transplanting in 2004 and 10 days in 2005, fertilizer was applied at a rate of 150 kg/ha of NPK (20-10-10) and 60 kg N/ha of urea. The second application of 60 kg N/ha of urea was carried out three weeks thereafter in 2004 and four weeks in 2005. The plots were hand-weeded, furrow-irrigated, and sprayed as necessary to control damping off (Ridomil at 30 g/15 l), cut worms (Selecron at 20 ml/15 l), and aphids (Actelic at 30 ml/15 l) using a water solution. Since the crop was grown for leaf yield assessment, flowers were routinely removed. Results obtained in both years showed that Mbeya Green had higher leaf yields as compared to Mbeya Purple (Table 121 and 122) confirming previous results obtained at RCA. This is probably due to its higher

Table 121. Effects of time to start harvesting on leaf yield characteristics of Ethiopian mustard, Arusha, Tanzania, July–October 2004

Treatment	Total leaf yield (g/plant)	Marketable leaf yield (g/plant)	Non -marketable (g/plant)	Total leaf yield (t/ha)	Marketable leaf yield (t/ha)	Non -marketable (t/ha)	Leaf size (g/leaf)	Marketable number of leaves/plant	Non -marketable leaves/plant	Average leaf length (cm)	Average leaf width (cm)
Time to start harvesting (WAT)											
5	184.80 bcd	184.80 b	0.00 c	19.25 bcd	19.25 b	0.00 c	15.83 ab	11.00 b	0.00 d	18.44 a	15.14 ab
6	255.67 ab	255.67 a	0.00 c	26.63 abc	26.63 a	0.00 c	15.79 ab	17.33 a	0.00 d	17.48 a	13.34 c
7	300.22 a	187.52 b	112.70 ab	31.27 a	19.53 b	11.74 b	18.51 a	8.00 b	7.67 c	18.61 a	15.49 a
8	163.52 bcd	71.23 c	92.29 b	17.05 cd	7.42 c	9.63 b	10.67 b	3.67 c	12.21 bc	17.10 a	13.85 bc
9	228.57 abc	55.61 cd	172.96 a	28.43 ab	5.79 cd	22.63 a	11.50 b	3.00 c	13.69 abc	17.67 a	14.17 abc
10	142.16 cd	8.00 d	134.17 ab	14.81 d	0.83 d	13.98 b	5.50 c	0.49 c	20.87 a	13.97 b	11.56 d
11	96.71 d	0.00 d	96.71 b	10.08 d	0.00 d	10.08 b	5.01 c	0.00 c	18.59 ab	12.31 b	10.41 d
LSD (5%)	99.42	59.77	66.03	10.44	6.23	7.12	4.86	3.60	6.87	1.77	1.46
F-test	**	***	***	**	***	***	***	***	***	***	***
Line											
Mbeya Green	230.03 a	126.40 a	103.64 a	24.16 a	13.17 a	10.99 a	14.61 a	6.22 a	10.83 a	18.57 a	14.77 a
Mbeya Purple	161.87 b	91.56 b	70.31 a	17.99 b	9.54 b	8.45 a	9.04 b	6.20 a	10.04 a	14.45 b	12.08 b
LSD (5%)	53.14	31.95		5.58	3.33		2.60			0.95	0.78
F-test	*	*	ns	*	*	ns	***	ns	ns	***	***
Interaction	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)	42.75	46.21	63.97	41.75	46.21	61.73	34.61	48.86	55.51	9.05	9.18

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Means within the same column followed by the same letter(s) are not significantly different at 5% probability level based on DMRT.

Table 122. Effects of time to start harvesting on leaf yield characteristics of Ethiopian mustard, Arusha, Tanzania, July–October 2005

Treatment	Total leaf yield (g/plant)	Marketable leaf yield (g/plant)	Non -marketable leaf yield (g/plant)	Total leaf yield (t/ha)	Marketable leaf yield (t/ha)	Non -marketable leaf yield (t/ha)	Leaf size (g/leaf)	Marketable number of leaves/plant	Non -marketable number of leaves/plant
Time to start harvesting									
5	105.76 bc	44.14 b	61.62 b	8.81 bc	5.14 b	3.68 b	9.55 c	13.70 bc	9.85 ab
6	115.08 bc	41.50 b	73.58 b	9.59 bc	6.13 b	3.46 b	12.56 bc	14.54 abc	10.31 a
7	220.84 a	79.26 a	141.58 a	18.40 a	11.80 a	6.60 a	17.32 a	15.39 a	10.48 a
8	137.90 b	31.04 bc	106.86 ab	11.49 b	8.90 ab	2.59 bc	18.27 a	14.72 ab	10.33 a
9	82.17 bc	14.89 cd	67.28 b	6.85 bc	5.61 b	1.24 cd	14.44 ab	13.40 c	9.62 a
10	70.16 c	5.75 d	64.40 b	5.85 c	5.37 b	0.48 d	14.05 abc	13.36 c	9.20 bc
11	68.34 c	3.04 d	65.30 b	5.69 c	5.44 b	0.25 d	11.97 bc	11.06 d	8.39 c
LSD (5%)	54.04	19.18	40.48	4.50	3.37	1.60	4.33	1.17	1.03
F-test	***	***	**	***	**	***	**	***	**
Line									
Mbeya Green	156.02 a	37.37 a	118.65 a	13.00 a	9.89 a	3.11 a	16.54 a	15.00 a	10.66 a
Mbeya Purple	72.63 b	25.38 b	47.25 b	6.05 b	3.94 b	2.11 a	11.50 b	12.47 b	8.82 b
LSD (5%)	28.88	10.25	21.64	2.41	1.80	0.85	2.32	0.63	0.55
F-test	***	*	***	***	***	*	***	***	***
Interaction	ns	ns	ns	ns	ns	ns	ns	ns	ns

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Means within the same column followed by the same letter(s) are not significantly different at 5% probability level based on DMRT.

number of leaves (over 25/plant), which are also heavier (over 15 g). In 2005, leaf yields were lower, probably due to pests, which were more pronounced. The most optimum time to start harvesting in both years was seven weeks after transplanting, which was reflected in all the leaf characteristics measured (Table 121 and 122). Marketable leaf yields started declining significantly at eight WAT on both years. From this study, it is recommended that farmers start harvesting Ethiopian mustard at seven weeks after transplanting to realize higher yields and income with preference for promotion given to Mbeya Green for its higher yields.

Effects of plant population and fertilizer on yield of promising Ethiopian mustard lines

The objective of these studies was to determine the effect of plant spacing and fertilizer on leaf and seed yields of promising Ethiopian mustard accessions.

Three separate experiments were conducted at AVRDC-RCA in Arusha, Tanzania. Two experiments were conducted from July to November 2004 while a third experiment was conducted from July to November 2005.

Trial 1 and 2. The experiments were laid out in RCBD with three replications. In the first experiment, two lines (Mbeya Green and Mbeya Purple) and four spacing treatments (20 x 60, 30 x 60, 40 x 60, and 50 x 60 cm) between plants were tested. In the second experiment, five levels (0, 50, 100, 150, 200 kg N/ha) of urea; and six levels (0, 100, 200, 300, 400, and 500 kg/ha) of NPK (20-10-10) were tested. For experiments one and two, seedlings were transplanted on 8 August 2004. Each treatment was transplanted in four rows each measuring 6 m long and 0.6 m wide. Urea was applied in two splits with half of it applied three days after transplanting, at the rate of 100 kg/ha and the other one, two weeks after the first application. NPK (20:10:10) was applied once, three days after transplanting at the rate of 150 kg/ha. Furrow irrigation was carried out twice a week. Weeding was done three weeks after transplanting and thereafter as necessary. Aphids were controlled by spraying with Selecron at the rate of 20 ml/15 l of water. Two rows were harvested in each treatment for leaf yield data. The remaining rows were used for seed yield data collection.

In trial 1, results indicated that leaf yield decreased with increasing spacing from 11.35 t/ha, at a spacing of 20 x 60 cm, to 6.5 t/ha, at a spacing of 50 x 60 cm (Table 123). The same trend was observed with total dry matter yield while dry matter yield/plant increased with increasing spacing. Seed yield also decreased with increasing spacing from 45 kg/ha at 20 x 60 cm to 30.0 kg/ha at 50 x 60 cm. Plant spacing did not affect leaf size, leaf length and width, 500-seed weight, and moisture content (Table 123). Results also showed that leaf yield was higher with Mbeya Green (11.2 t/ha) as compared to Mbeya Purple (6.5 t/ha) confirming previous results obtained at AVRDC-RCA. The number of leaves/plant, seed yield, 500-seed weight, and moisture content did not differ for both varieties.

Fertilizer type and rate did not affect leaf length and width, seed yields, and 500-seed weight (Table 124). By contrast, fertilizer application slightly affected leaf yield with urea having a slightly better effect as compared to NPK. Dry matter yield also slightly increased with an increase in the amount of fertilizer applied (Table 124).

Trial 3. In the third experiment carried out in year 2005, two distinct trials were carried out on (1) the influence of spacing and (2) the effect of fertilizer on leaf and seed yield. Five lines were used: ST3, ST15, ST18, ST22A, and ST46 for the fertilizer experiment; and for spacing treatment, ST3 (C-1), ST68A, ST4 (C-1), ST50, and ST41. Rows/ridges measuring 6 m long were prepared manually. The seedlings were sown on 28th June and transplanted on 4th August, 2005 for the fertilizer experiment and for spacing experiment transplanting was done on 27th July 2005. The spacing tested were 20 x 40, 30 x 40, 40 x 40, 50 x 40 cm. For the spacing experiment, each treatment was transplanted on three rows/ridges raised 30 cm high. NPK (20-10-10) was applied for the spacing treatment three weeks after transplanting at the rate of 150 kg/ha in one application. Urea was applied as a side-ress at the rate of 100 kg N/ha. For the fertilizer experiment, each treatment was also transplanted on three rows/ridges (raised 30 cm high) also measuring 6 m long with a spacing of 40 cm between plants and 60 cm between rows. Urea was applied three weeks after transplanting at rates of 0, 60, 100, and 150 kg N/ha in two splits of which the second application was carried out three weeks after the first application. Standard cultural practices included furrow irrigation, weeding, and pest management.

Results showed that the five tested lines significantly differed for all the parameters measured, except moisture content (Table 125). Accession ST15 had the highest number total fresh leaf yield (Table 125). Increased spacing slightly improved leaf yield per plant and the number of leaves/plant, but spacing did not affect the leaf size, length, and width. The total fresh and dry matter leaf yield significantly declined with an increase in spacing (Table 125). Results from the fertilizer experiment showed that accession ST22A gave the highest leaf yield (14.7 t/ha) and leaf size (15.3 g), while accession ST3 had the lowest leaf yield (8.3 t/ha) and the lowest number of leaves/plant (12.6). Accession ST18 had the highest number of leaves/plant (25.3) and leaf dry matter yield (Table 126).

The amount of fertilizer applied did not affect leaf yield, the number of leaves/plant, the number of seeds per pod and seed yield (Table 126). By contrast, leaf length, width, and leaf size increased significantly with increasing fertilizer rate up to 100 kg N/ha. The differences in yield characteristics between the two experiments shown in Table 125 and 126 was due to the fact that the experiments were conducted at different locations at the RCA experimental farm, with probably different fertility levels.

In general, application of fertilizer improved all the leaf yield characteristics when compared to control. However, it was observed that seed yields were low during that season, attributed to heavy infestation of the crop by Turnip mosaic virus (TuMV). When compared to previous years, results obtained in this experiment appear lower than earlier obtained mainly due to pest infestations and higher temperatures. It is suggested that this experiment be repeated and also to test various mixtures of NPK and urea, instead of both fertilizers separately.

Table 123. Effects of plant population on leaf and seed yield characteristics of Ethiopian mustard, Arusha, Tanzania, July–November 2004

	Fresh leaf (g/plant)	Fresh leaf yield (t/ha)	Average leaf length (cm)	Average leaf width (cm)	Number of leaves/plant	Leaf size (g/leaf)	Dry matter yield (g/plant)	Dry matter yield (t/ha)	Seed yield (g/plant)	Seed yield (kg/ha)	500-seed weight (g)	Moisture yield content (%)
Spacing (cm)												
20 x 60	136.22 b	11.35 a	14.87	10.95	25.63 b	5.52	12.35	1.03 a	0.54 b	45.34 ab	1.28	90.28
30 x 60	192.38 a	10.69 a	14.66	10.91	41.31 a	4.83	18.65	1.04 a	1.15 a	63.94 a	1.28	91.34
40 x 60	162.22 ab	6.76 b	14.38	10.52	30.97 b	5.53	17.88	0.74 ab	0.56 b	23.24 c	1.27	90.96
50 x 60	196.01 a	6.54 b	14.07	10.66	41.81 a	4.48	15.55	0.52 b	0.90 a	30.02 bc	1.28	88.58
LSD (5%)	41.06	2.06			7.57			0.3	0.33	19.79		
F- test	*	***	ns	ns	***	ns	ns	**	**	**	ns	ns
Lines												
Mbeya Green	220.15 a	11.19 a	17.09 a	12.61 a	36.04	6.39 a	19.94 a	1.04 a	0.79	38.79	1.24	89.91
Mbeya Purple	123.26 b	6.47 b	11.90 b	8.91 b	33.81	3.80 b	12.27 b	0.63 b	0.79	42.48	1.32	90.67
LSD (5%)	29.04	1.46	0.89	0.68		1.21	4.52	0.21				
F- test	***	***	***	***	ns	***	**	***	ns	ns	ns	ns
CV (%)	19.31	18.87	7.06	7.17	17.51	27.1	32.02	29.17	33.67	39.32	13.53	2.45

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Means within the same column followed by the same letter(s) are not significantly different at 5% probability level based on DMRT.

Table 124. Effects of fertilizer application on leaf and seed yield characteristics of Ethiopian mustard, Arusha, Tanzania, July–November 2004

Treatment	Fresh leaf yield (g/plant)	Fresh leaf yield (t/ha)	Leaf length (cm)	Leaf width (cm)	Number of leaves/plant	Leaf size (g/leaf)	Dry matter yield (g/plant)	Dry matter yield (t/ha)	Seed yield (g/plant)	Seed yield (kg/ha)	500-seed weight (g)	Moisture content (%)
NPK (kg)												
0	43.18 c	1.79 c	12.15	9.41	18.85 bc	1.69 b	4.07 d	0.17 d	0.41	16.97	1.63	86.83 ab
100	60.64 bc	2.53 bc	13.37	10.54	22.90 abc	2.22 b	8.57 ab	0.36 ab	0.31	12.78	1.63	74.63 b
200	91.67 ab	2.69 bc	12.75	9.63	29.12 ab	2.20 b	6.45 bcd	0.27 bcd	0.65	27.09	1.67	88.93 ab
300	91.61 ab	3.82 ab	12.47	9.69	30.60 a	2.49 b	8.22 ab	0.34 ab	0.67	28.03	1.47	89.33 ab
400	129.12 a	5.38 a	14.61	11.21	29.90 ab	3.45 ab	11.40 a	0.48 a	0.43	18.02	1.53	88.73 ab
500	100.14 ab	4.17 ab	13.32	10.12	29.51 ab	3.25 ab	7.86 bc	0.33 bc	0.98	40.63	1.57	90.87 a
Urea (kg)												
0	87.35 abc	3.64 abc	12.53	9.79	16.33 ab	5.40 a	4.46 cd	0.19 cd	0.41	17.01	1.53	92.93 a
50	92.25 ab	3.84 ab	12.59	9.52	22.00 abc	3.96 ab	5.84 bcd	0.24 bcd	0.36	14.94	1.53	92.33 a
100	57.44 bc	2.39 bc	13.54	10.12	19.60 abc	2.47 b	5.69 bcd	0.24 bcd	0.42	17.43	1.43	87.97 ab
150	77.70 bc	3.24 bc	13.44	10.00	23.61 abc	3.03 ab	6.30 bcd	0.26 bcd	1.35	56.23	1.57	90.23 a
200	64.50 bc	3.82 ab	13.63	10.42	25.53 abc	2.82 ab	6.21 bcd	0.26 bcd	0.48	20.07	1.77	90.73 a
LSD (5%)	40.32	1.68			10.01	2.36	3.05	0.13				13.82
F-test	*	*	ns	ns	*	*	**	**	ns	ns	ns	*
CV (%)	29.08	29.08	14.42	15.06	24.11	46.2	26.29	26.29	63.92	63.92	13.8	9.12

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Means within the same column followed by the same letter(s) are not significantly different at 5% probability level based on DMRT.

Table 125. Plant spacing and varietal effect on leaf yield characteristics of Ethiopian mustard, Arusha, Tanzania, July–November 2005

Treatment	Leaf yield/ plant (g)	Total leaf yield (t/ha)	Leaf length (cm)	Leaf width (cm)	Leaf size (g)	Number of leaves/plant	Leaf dry matter yield (g/plant)	Total Leaf dry matter yield(t/ha)	Moisture content (%)
Accession									
ST3	485.99 b	38.84 b	20.37 a	16.16 a	19.02 a	20.92 ab	15.56 a	1.19 a	87.50
ST15	507.96 a	40.83 a	15.09 b	12.50 c	11.27 b	16.58 b	9.02 b	0.69 b	90.00
ST18	491.25 b	39.44 b	20.07 a	16.45 a	18.53 a	22.33 ab	16.55 a	1.28 a	90.80
ST22A	500.95 ab	40.17 ab	16.69 b	14.25 b	12.63 b	23.33 a	12.49 ab	1.06 ab	90.80
ST46	490.71 b	39.39 b	15.45 b	12.71 c	8.93 b	25.67 a	9.99 b	0.77 b	90.80
LSD (5%)	15.41	1.31	1.88	1.52	5.31	5.56	4.12	0.36	
F- test	*	*	***	***	***	*	**	**	ns
Spacing (cm)									
20 x 40	493.57 ab	61.69 a	17.95	14.79	15.93	16.33 b	11.65	1.46 a	90.80
30 x 40	502.46 a	41.87 b	17.88	14.73	15.68	21.87 a	11.93	0.99 b	90.80
40 x 40	486.99 b	30.44 c	17.56	14.47	13.67	22.47 a	14.59	0.91 bc	88.10
50 x 40	498.46 ab	24.92 b	16.74	13.67	11.01	26.40 a	12.73	0.64 c	90.00
LSD (5%)	13.78	1.18				4.97		0.32	
F-test	*	***	ns	ns	ns	**	ns	***	ns
CV (%)	3.76	4.00	12.98	12.77	45.67	30.91	39.16	43.17	0.99

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Means within the same column followed by the same letter(s) are not significantly different at 5% probability level based on DMRT.

Table 126. Nitrogen fertilizer and varietal effect on leaf yield characteristics of Ethiopian mustard, Arusha, Tanzania, July–November 2005

Treatment	Fresh Leaf yield/plant (g)	Total fresh leaf yield (t/ha)	Leaf length (cm)	Leaf width (cm)	Leaf size (g)	Number of leaves/plant	Leaf dry matter yield (g/plant)	Total leaf dry matter yield (t/ha)	Number of seeds/pod	Seed yield/ plant (g)
Accession										
ST3	187.03 b	8.25 b	17.05 ab	13.57 a	10.45 ab	12.25 b	11.34 b	0.49 b	11.83 ab	183.02 a
ST15	200.92 b	8.37 b	10.97 c	8.33 c	6.90 b	17.50 ab	9.26 b	0.39 b	10.08 b	117.29 b
ST18	331.19 a	13.80 a	18.09 a	13.99 a	11.28 ab	25.33 a	18.14 a	0.76 a	11.00 ab	128.88 b
ST22A	351.53 a	14.65 a	16.41 b	12.31 b	15.28 a	22.00 ab	17.87 a	0.74 a	13.42 a	112.67 b
ST46	263.42	10.98 ab	16.51 b	13.23 ab	12.63 a	18.67 ab	13.46 b	0.56 b	11.83ab	107.74 b
LSD (5%)	11.81	4.59	1.28	1.07	4.86	10.82	4.14	0.17		21.94
F-test	*	*	***	***	*	*	***	***	ns	***
Urea Fertilizer (kg N/ha)										
0	249.22	10.38	14.54 b	11.34 b	9.49 b	17.33	12.93	0.54	11.6	124.31
60	307.47	12.81	16.44 a	12.58 a	11.47 ab	21.13	13.64	0.57	12.07	133.39
100	259.78	11.19	16.03 a	12.57 a	14.89 a	18.67	15.11	0.65	11.07	125.17
150	250.81	10.45	16.22 a	12.66 a	9.38 b	19.47	14.37	0.60	11.8	136.83
LSD (5%)			1.15	0.96	4.35					
F-test	ns	ns	**	*	*	ns	ns	ns	ns	ns
CV (%)	50.7	49.55	9.81	10.54	52.00	68.39	35.72	35.08	28.02	20.43

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Means within the same column followed by the same letter(s) are not significantly different at 5% probability level based on DMRT.

Evaluation of Ethiopian mustard lines for resistance to diseases

Ethiopian mustard has favorable attributes such as heat and drought tolerance, pod shattering resistance, and good marketing opportunities. However, bacterial, fungal and viral diseases such as Turnip mosaic virus, white rust, and downy mildew limit the leaf production in eastern and southern Africa. Bacterial and fungal diseases can be easily controlled through the use of synthetic chemicals, which often result in detrimental environmental pollution, development of resistance, human poisoning, residues in food produce, and hazards to non-target organisms. For example, ladybird beetles reduce the population of harmful organisms such as aphids, but in most cases these suffer consequences of chemical spraying. On the other hand, small-scale farmers in Africa find it difficult to use synthetic chemicals because of inaccessibility, high costs, and human health exposure, thereby making production of Ethiopian mustard unattractive to small-scale farmers in the region.

To improve marketable yield, farmers have adopted the practice of planting the crop closely so that the plants reach harvesting size within a short time. At maturity, farmers uproot the whole plant. The practice allows farmers to harvest early, but overall leaf yield tends to be low due to competition. Crop hygiene and avoiding and controlling vectors are only partially effective control measures. The difficulties in controlling bacterial, fungal, and viral diseases by preventive or curative measures make it logical to look into the development or identification of resistant varieties as an alternative solution as this will enhance the quality and productivity of the crop species. A field experiment was conducted from July to October 2005 at the Experimental Station of AVRDC–The World Vegetable Center, Regional Center for Africa, in Arusha, Tanzania. The study aimed to evaluate Ethiopian mustard lines for field resistance/tolerance to different pathogens. Forty-four accessions of Ethiopian mustard collected from different regions in Tanzania were used for evaluation of disease resistance.

The experiment was laid out in RCBD with three replications. Seedlings were transplanted at the spacing of 60 cm between rows and 40 cm between plants. Each accession was transplanted in two rows/ridges in plots measuring 6 m long. Fertilizer application was carried out one week after transplanting as a side dress with 150 kg/ha of NPK (20-10-10) and 50 kg N/ha of urea. Another 50 kg N/ha of urea was applied four weeks after the first application. Weeding was carried out as necessary. Watering through furrow irrigation was done twice a week for the first month after transplanting and once a week thereafter. At the seedling stage, application of Ridomil was carried out at the rate of 60 g per 15 l of water to prevent damping off of seedlings while Selecron and Actellic were also applied at the rates of 25 ml and 30 cc per 15 l of water, respectively, to control cutworms. Frequent removal of flowers was carried out to encourage vegetative growth. The disease incidence was recorded every three weeks to determine the number of infected plants. Data were subjected to ANOVA using COSTAT software.

Results showed low TuMV incidence in accessions Sit44, Sit47, Sit22A, and Sit 37. On the other hand, accessions Sit38 (S-2) and Sit3 (C-1) were significantly affected by the TuMV disease (Table 127). Differences in white rust incidence were noted among the accessions. Accessions Sit 44, Sit 47, Sit 22A, Sit 37, Sit 26, Sit 46, Sit 14 (C-4), Sit 30 B, and Sit 42 had the lowest incidences of white rust attack, while accession Sit 53B was severely affected by white rust. There was a variation in incidence of aphids in all accessions with Sit 3, Sit 4 (C-1), and Sit 6 showing relatively lower incidence. However, the incidence of aphids was not well correlated with the incidence of TuMV, which shows that other factors may be involved in the spread of TuMV once aphids, the vector, have transmitted the virus. These preliminary results show promising lines that may be resistant to TuMV and white rust diseases. It is recommended that further validation of results need to be carried out to determine whether genes of resistance exist in the accessions to help confirm the present results.

Table 127. Evaluation of Ethiopian mustard lines for incidence of Turnip mosaic virus (TuMV), white rust, and aphids, AVRDC-RCA, July–November 2005

Accession	TuMV incidence (%)	White rust incidence (%)	Aphid incidence (%)
Sit 38 (S-2)	84.54 a	24.92 d-m	93.64 ab
Sit 3 (C-1)	80.02 ab	66.28 a-d	33.75 fg
Sit 42	77.57 abc	9.29 j-o	81.59 abc
Sit 52 B	74.01 a-d	43.50 b-i	73.69 a-d
Sit 43	73.98 a-d	20.49 f-n	80.49 abc
Sit 3 (C-4)	73.72 ab	43.33 b-i	59.81 b-g
Sit 14 (C-4)	73.20 a-d	3.90 l-o	61.41 c-g
Sit 57 (C-5)	73.05 a-d	38.69 b-k	75.50 a-d
Sit 67 B (S-10)	72.46 a-d	31.20 d-n	57.92 c-g
Sit 45	72.17 a-d	17.48 f-o	78.61 abc
Sit 6	71.37 a-e	57.22 b-f	39.91 d-g
Sit 10 B	71.09 a-e	40.93 b-j	69.18 a-e
Mbeya Purple	70.96 a-f	46.97 b-i	67.53 b-f
Sit 41	70.74 a-e	15.54 h-o	67.81 b-f
Sit 4 (C-3)	70.17 a-f	34.37 c-k	58.43 c-g
Sit 29	69.77 a-e	33.35 c-k	83.79 abc
Sit 50	69.42 a-f	31.84 c-l	83.68 abc
Sit 57 (S-6)	69.10 a-f	70.78 ab	64.56 b-g
Sit 18	68.85 a-f	53.17 b-g	75.20 abc
Sit 8	67.32 a-g	43.81 b-i	85.12 abc
Sit 4 (C-1)	66.71 a-g	16.63 g-o	36.29 e-g
Sit 27 B	66.10 a-g	49.25 b-h	81.59 abc
Sit 3 (C-2)	65.43 a-g	66.24 abc	62.10 c-g
Sit 53 B	65.28 a-g	89.30 a	68.03 b-f
Sit 3 (C-3)	65.07 a-g	53.74 b-h	56.99 c-g
Mbeya Green	64.95 a-g	38.01 b-k	74.53 a-d
Sit 57 (S-8)	64.89 a-g	42.53 b-i	79.64 abc
Sit 14 (C-2)	64.63 a-g	17.06 g-o	65.38 b-g
Sit 30 B	64.16 a-g	7.70 k-o	78.48 abc
Sit 51	64.13 a-g	45.72 b-i	75.36 a-d
Sit 3	63.05 a-h	55.23 b-g	30.47 g
Sit 14 (C-1)	61.91 a-i	16.22 g-o	94.86 a
Sit 4 (C-4)	60.48 a-j	52.86 b-h	59.63 c-g
Sit 38 (S-10)	59.01 b-j	62.64 a-e	73.49 a-d
Sit 15	53.39 c-j	13.73 i-o	79.85 a-c
Sit 14 (C-3)	50.32 d-j	30.73 c-l	76.59 a-c
Sit 15	46.13 e-k	20.46 e-n	65.25 b-g
Sit 68 A	44.99 f-k	70.63 ab	68.32 b-f
Sit 46	42.05 g-k	1.33 no	80.83 abc
Sit 26	40.44 ijk	1.23 no	60.98 c-g
Sit 37	37.30 h-k	1.85 mno	84.22 abc
Sit 22 A	35.27 jk	0.00 m	78.90 abc
Sit 47	23.81 k	5.80 l-o	76.69 abc
Sit 44	22.54 k	1.33 no	80.63 abc
LSD (5%)	13.11	20.82	18.45
F-test	***	***	***
CV (%)	15.31	38.96	19.51

*** highly significant at ($P < 0.001$).
Mean separation in columns by Duncan's multiple range test at $P < 0.05$.

Effects of plant population on horticultural characteristics of promising African eggplant lines

African eggplant (*Solanum aethiopicum/ macrocarpon/anguivi)* is among the important traditional vegetables in many African countries. It plays an important role in diets of many communities in Africa and Asia and contributes to food security, nutrient supply, and income generation of resource-poor communities. Yield potential of African eggplant has not yet been fully exploited or studied due to low use of inputs and lack of information on production technologies. Previous studies carried out at AVRDC-RCA on evaluation of the yield response to variation in plant population of promising African eggplant lines showed that a spacing of 50 x 60 cm gave the most optimum yield. Another study showed that a spacing of 30 x 60 cm significantly increased the fruit yield per plant. The objective of this experiment was to validate previous results on cultural practice of African eggplant.

The trial was conducted at AVRDC-RCA in Arusha, Tanzania from July 2004 to March 2005. Four lines of African eggplant representing all the cultivated species, namely Tengeru white (*S .aethiopicum*), UVPP (*S. macrocarpon*), Toumbot (*S. anguivi*), and AB2 *(S. aethiopicum*) were tested. Seeds were sown in the nursery on April 20th and transplanted on July 1st. Each plot consisted of four rows at four different spacings of 30 x 60, 50 x 60, 70 x 60, and 90 x 60 cm. The 4 x 4 factorial experiment was laid out in RCBD with three replications. The plots were furrow-irrigated twice a week during the initial stage of the seedling growth, then once a week thereafter. Other cultural practices included weeding and spraying of insecticides and fungicides for pest control; as well as application of 400 kg/ha of NPK (20:10:10) in two splits and urea (150 kg N/ha) in three splits, with three weeks interval. The first urea application was carried out at the same time with half of the NPK.

Results showed that Tengeru White gave the highest fruit yield (94.36 t/ha), followed by Toumbot, which yielded 73.16 t/ha. Line UVPP gave the lowest yield (38.14 t/ha) (Table 128) but it has the largest fruit size, length, and width. There was a significant decrease in fruit and seed yield per hectare with an increase in spacing from 30 x 60 to 90 x 60 cm^2. All the other parameters were not affected by spacing.

Table 128. Evaluation of variation in plant population on yield adaptation and horticultural characteristics of promising African eggplant lines

Treatment	Days to 50% flowering	Number of fruits per plant	Fruit yield (g/plant)	Fruit yield (t/ha)	Fruit size (g/fruit)	Seed yield (g/plant)	Seed yield (kg/ha)	Fruit length (cm)	Fruit width (cm)	Seed yield per 1 kg fruit (g)	Number of seeds per plant	Number of seeds per fruit	500-seed weight (g)
Line/Accessions													
AB2	32.08 b	36.71 b	1146.75 b	38.14 b	11.84 c	10.23 c	343.17 c	2.50 bc	1.54 c	5.46 c	4035.69 c	99.88 bc	0.59 b
Tengeru White	68.08 a	83.08 b	2944.75 a	94.36 a	39.02 b	69.06 b	2147.77 b	3.90 ab	5.11 b	24.70 b	28188.44 b	322.11 a	1.37 a
Toumbot	80.83 a	1107.46 a	2346.81 a	73.16 a	2.58 c	120.07 a	3645.02 a	1.29 c	1.85 c	55.69 a	59024.82 a	29.59 c	0.51 b
UVPP	83.33 a	10.76 b	1214.99 b	39.23 b	93.38 a	27.81 c	581.20 c	4.45 a	6.35 a	22.73 b	5184.07 c	204.53 ab	0.54 b
LSD (5%)	19.11	200.97	1006.36	31.10	14.69	26.91	1198.16	1.41	0.89	11.81	11066.48	127.92	0.41
F-test	***	***	**	**	***	***	***	***	***	***	***	***	***
Spacing (cm)													
30 x 60	71.75	266.13	1793.46	99.64 a	40.55	61.25	3053.60 a	3.44	4.06	27.89	25796.58	215.35	0.86
50 x 60	64.42	321.34	1910.10	63.67 b	37.21	49.81	1660.50 b	2.77	3.49	24.69	20156.37	179.24	0.75
70 x 60	63.75	251.96	1597.56	38.04 b	36.02	49.03	1167.44 b	2.91	3.62	29.18	22569.31	157.48	0.76
90 x 60	64.42	398.59	2352.18	43.56 b	33.04	67.07	835.62 b	3.02	3.69	26.82	27910.76	104.04	0.63
LSD (5%)				31.10									
F-test	ns	ns	ns	**	ns	ns	**	ns	ns	ns	ns	ns	ns
CV %	34.69	77.88	63.09	60.92	47.99	56.84	85.58	55.84	28.80	52.17	55.06	93.54	65.65

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Mean separation within the same column at $P < 0.05$ by DMRT.

The results were in partial agreement with previous preliminary results and showed that line Tengeru white should be promoted for its high fruit yield, while a spacing of 30 x 60 cm should be adopted for higher fruit yield characteristics per unit area.

Effect of green manure on amaranth production

The need for implementing organic agriculture technologies has increased, as soil and vegetable crop productivity declines in the East African region.

Selection among alternative sources of nutrients and methods for sustaining fertility, including use of green manure, is an economic decision that depends upon factor prices such as land, labor, and water, as well as the prices of inorganic nutrient sources. When land is abundant, without ownership rights and prices, farmers practice shifting cultivation by clearing land through the slash-and-burn method. Land is left fallow for a number of years and fertility is maintained by incorporating the forest and bush residue during the clearing process. As land scarcity develops with population pressure, crop cultivation intensifies, and methods of fertility management change. Despite the trend of increased use of inorganic fertilizers, green manuring as a source of soil nutrients and as an alternative to maintain soil fertility, has received renewed attention. Many types of algae and aquatic plants or weeds, herbaceous, and perennial woody plants can be used for green manuring, with a special preference for leguminous species for growing vegetables. Besides rejuvenating soil productivity, it has been reported that products obtained through organic farming have lower enzymatic activity, stronger life, and are nutritionally better balanced. Nitrogen fixation systems from leguminous green manure like cowpea offer economically attractive and ecologically sound alternatives to chemical fertilizers. It is also known that green manuring improves the physical, biological, and electrochemical properties of soils. Convincing evidence has been obtained for yield responses exceeding 100% for green manuring in rice-based cropping systems. Legumes may also contribute to weed suppression and provide soil cover to reduce soil and water loss. In an effort to introduce sustainable organic farming in Africa, AVRDC–RCA in Arusha Tanzania has been undertaking research on green manuring to reduce soil degradation, improve fertility, and enhance crop quality and farmers income. The aim of this study was to determine the best green manure crop in improving productivity of vegetables using amaranth as a model species.

An experiment was conducted at AVRDC-RCA in Arusha, Tanzania from July to December 2004. A 3 x 3 factorial experiment in split-plot design with three replications was used. The main plots had three plots each measuring 3 m wide and 6 m long. Each plot had 5 rows spaced 15 cm apart. There were three main treatments: no green manure (control), vegetable soybean, and vegetable cowpea. Vegetable soybean and vegetable cowpea, the green manure crops, were sown on 1 July 2004 on respective plots at an in-row spacing of 10 cm with two seeds per hole which was later thinned to one. The plots were watered once a week using furrow irrigation from sowing date to two days before incorporation into the soil. Incorporation of cowpea and soybean into the soil was carried out 84 days after sowing and just at the beginning of flower development. The main plots were then divided into three sunken bed plots each measuring 1 m wide and 6 m long, separated by a 40 cm path. Three *Amaranthus hybridus* lines from two species (*A. hypochondriatus* and *A. cruentus*) were randomly assigned to the three beds in each plot. Fifty grams of seed of each amaranth line was broadcast on each plot starting one week after vegetable soybean and cowpea had been incorporated into the soil. The beds were mulched with grass and watered three times a week. Weeding was done by hand-pulling weeds whenever needed. No pesticides or chemical fertilizers were applied. Harvesting of amaranth lines was done one month after sowing (for the 1st and 2nd crop) and three weeks after sowing (for the 3rd crop), by uprooting the whole crop and weighing the biological (whole plant) and economic yields (whole plant minus roots). A second and third sowing of amaranth was done immediately after removing the first and second crop to make sure that the residual soil nutrients were used effectively by the succeeding crop before the weeds emerge. A two-way ANOVA was performed using Cohort software.

Results in Table 129 show that overall, vegetable soybean performed better than vegetable cowpea as green manure for producing amaranth. Amaranth grown on plots which received vegetable soybean as green manure always yielded higher than those produced with vegetable cowpea and green manure.

Table 129. Effects of vegetable soybean and vegetable cowpea as green manure for improving productivity of amaranth, Arusha, Tanzania, July–December 2004

Treatment	Biological yield/plant (g)			Biological yield (t/ha)			Economic yield/plant (g)			Economic yield (t/ha)		
	1st crop	2nd crop	3rd crop	1st crop	2nd crop	3rd crop	1st crop	2nd crop	3rd crop	1st crop	2nd crop	3rd crop
Green manure (GM) crop												
Vegetable Soybean	5.14	3.75	2.50	10.34 ab	8.76 a	6.61	3.50	2.19	1.83	7.32 ab	4.08 a	4.78
Vegetable Cowpea	4.66	3.61	2.65	9.58 b	3.36 b	6.22	3.00	2.00	1.85	6.62 b	1.06 b	4.48
No green manure (control)	4.32	3.56	2.55	11.86 a	2.98 b	5.50	2.82	2.22	1.95	8.07 a	1.20 b	3.97
F-test (GM effect)	ns	ns	ns	*	*	ns	ns	ns	ns	*	*	ns
Amaranth line (species)												
AC-NL (*A. cruentus*)	3.58 b	3.78 a	1.88 b	8.64 b	3.04 c	5.25 b	2.48 b	2.28 a	1.50 b	6.08 b	1.65 b	3.90 b
AH-MX (*A. hypochondriacus*)	6.89 a	5.06 a	4.17 a	15.17 a	7.53 a	8.08 a	4.41 a	2.78 a	2.99 a	10.27 a	3.17 a	5.62 a
AC-Zim (*A. Cruentus*)	3.64 b	2.09 b	1.66 b	7.97 b	4.53 b	4.99 b	2.44 b	1.36 b	1.14 b	5.67 b	1.53 b	3.72 b
LSD (5%)	1.80	1.47		1.68	1.00	1.28	1.17	0.89	0.39	1.09	1.26	0.79
F-test (Species effect)	**	*	ns	***	***	*	**	*	*	***	*	**
Interaction (GM x Species effect)	ns	ns	ns	ns	**	ns	ns	ns	ns	ns	ns	ns
CV (%)	37.14	37.28	17.32	14.62	18.29	19.32	36.27	38.47	19.11	13.69	54.89	16.38

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Mean separation within the same column at $P < 0.05$ by DMRT.

However, the amaranth yield decreased in the second and third crop, probably as a result of the uptake of nutrients by each preceding crop. Line AH-MX (*A. hypochondriacus)* gave the highest biological and economical yields when compared to the other lines; with the line giving a biological yield of 15 t/ha and an economical yield of 10.3 t/ha in the first crop. The biological yield per hectare and per plant, however, decreased to 8 and 5.6 t/ha in the third crop, respectively (Table 129). The general trend observed is that for increased vegetable productivity, vegetable soybean should be adopted as a better green manure than vegetable cowpea for improving soil fertility.

Evaluation of spiderplant lines

Spiderplant (*Cleome* or *Gynandropsis spp.* (L.). Briq.) belongs to the family Capparaceae. It is an erect herbaceous annual herb, with prolific branching which sometimes become woody with age. Depending on the environmental conditions, it can grow up to a height of 1.5 m but is usually 0.5–1.0 m tall. The plant is believed to have originated from eastern, central, and southern Africa and spread to other tropical and subtropical countries in the Northern and Southern hemispheres including Southeast Asia. Spider plant grows well up to about 1000 m above sea level in semi-arid, subhumid, and humid climates, and is adapted to many soil types as long as these are deep and well drained with pH of 5.5–7.0. It requires intense light and temperatures between 18°C and 25°C.

Spiderplant is not yet fully cultivated as a commercial crop and is still regarded as a wild volunteer crop, and as semi-domesticated in home gardens or near homesteads in most African countries. Where it is domesticated, it is no longer treated as a weed, but as an indigenous/traditional vegetable. However, the productivity of spiderplant leaves is still very low and information on agronomic and seed production requirements for the crop is still scant (AVRDC 2002). This leafy vegetable is highly nutritious as it is rich in calcium, iron, proteins, vitamin A, and C. Furthermore, various works showed that leaves of spiderplant could be more nutritious than most exotic leafy vegetables. It possesses medicinal, insecticidal, and anti-tick properties. It serves as a food for humans in rural areas (where over 80% of the total population lives) and as forage for bovines, camels, and game animals. In some African countries including Zambia, Zimbabwe, Botswana, Malawi, Uganda, Tanzania, and Kenya, it is sold in rural and urban markets and as such, serves as a source of income. Since 1999, AVRDC-RCA has been involved in research aimed at conserving and increasing productivity of this vegetable as there is a need to improve its yield and nutritive value through selection and/or breeding and to develop efficient agro-management systems with minimum but appropriate input application. To achieve this, both genetic material and biological/botanical, ethnobotanical and agronomic information are necessary. The objectives of this study were to determine diversity in spiderplant and to compare yield characteristics of fifteen spiderplant accessions collected by AVRDC from different African countries to determine superior genotypes which can be used for research and promotional purposes.

The study was conducted at AVRDC-RCA in Arusha, Tanzania from July 2004 to January 2005. The experiment was laid out in RCBD design with three replications. Seeds were sown directly in double rows/ridges (raised 30 cm high) in plots measuring 6 x 1.5 m. The spacing between plants and rows were 20 and 75 cm, respectively. NPK (20-10-10) and urea fertilizers at the rates of 150 kg/ha and 50 kg N/ha, respectively were applied as a side-dress four weeks after sowing. A second urea application of 50 kg N/ha was carried out one month thereafter at the beginning of pod formation. Plants were observed periodically for pest occurrence which were controlled by spraying Decis 2.5 EC at a rate of 1 ml/15 l of water. Furrow irrigation was done twice a week initially for the first one month then once a week thereafter.

There were no significant differences among the accessions for all parameters except seed yields (Table 130). Seed yields were highest for CI-IP 5 (21.7 g) and lowest for IP12 (8.06 g). The number of seeds/pod varied between 53.8 for CI-IP4 and 188.1 for line PS. Leaf yields per plant ranged from 58.3 g to 77.5 g, although the differences were not significant.

Table 130. Yield characteristics of spiderplant, Arusha, Tanzania, July 2004–January 2005

Line/ Accession	Origin	Leaf yield (g/plant)	Leaf yield (t/ha)	Dry matter yield (g/plant)	Dry matter yield (t/ha)	Seed yield (g/plant)	Seed yield (kg/ha)	500-seed weight (g)	Number of seeds/plant	Number of pods/plant	Number of seeds/pod
0454997-IP1	Kenya	68.93	4.59	42.99	2.86	9.53 b	635.33 b	0.69 b	6955.87	95.39	91.49 ab
045446-IP2	Kenya	71.14	4.74	42.92	2.86	14.41 ab	960.44 ab	0.73 b	9699.70	111.34	84.25 ab
045451-IP3	Kenya	77.53	5.17	37.03	2.47	15.29 ab	1019.55 ab	0.69 b	11628.46	151.67	83.51 ab
Cl-IP4	Kenya	74.51	4.97	32.32	2.16	11.29 ab	752.89 ab	0.68 b	8057.62	139.61	53.77 b
Cl-IP5	Kenya	70.52	4.70	42.64	2.84	21.66 a	1443.78 a	0.90 a	12954.38	119.11	103.35 ab
GG-IP6	Kenya	58.59	3.91	29.10	1.94	13.49 ab	899.33 ab	0.73 b	9231.55	97.06	96.42 ab
ZM 4546-IP7	Zambia	61.02	4.07	37.03	2.47	14.93 ab	995.55 ab	0.74 ab	9932.09	113.89	100.72 ab
Cl-10-IP8	South Africa	66.97	4.46	40.16	2.68	13.82 ab	921.56 ab	0.67 b	10980.16	75.94	147.07 ab
Cl-3-IP10	South Africa	66.71	4.45	38.35	2.55	9.44 b	629.55 b	0.73 b	6525.14	120.50	55.41 b
Cl-5-IP11	South Africa	64.21	4.28	35.10	2.34	17.01 ab	1133.78 ab	0.70 b	12144.58	86.11	143.64 ab
Cl-6-IP12	South Africa	58.25	3.88	37.14	2.47	8.06 b	537.33 b	0.80 ab	5156.73	107.67	64.79 b
GPS	Tanzania	65.40	4.36	39.34	2.62	14.86 ab	990.45 ab	0.75 ab	9794.25	110.72	86.86 ab
GS	Tanzania	69.80	4.65	38.70	2.58	15.32 ab	1021.11 ab	0.83 ab	9214.90	153.06	100.14 ab
PS	Tanzania	70.97	4.73	37.46	2.50	13.15 ab	876.67 ab	0.66 b	8263.11	88.61	188.13 a
Cl-Yambio	Sudan	56.63	3.77	32.19	2.15	14.57 ab	971.11 ab	0.82 ab	10837.18	65.78	143.77 ab
F-test		ns	ns	ns	ns	*	*	*	ns	ns	*
LSD (5%)						10.21	680.85	0.14			90.13
CV(%)		23.35	23.34	20.42	20.46	44.28	44.28	11.48	48.86	42.57	52.38

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Mean separation within the same column at $P < 0.05$ by DMRT.

Determination of cultural requirements for amaranth

Amaranthus constitutes a major group of traditional leafy vegetables in the tropics. These are widely adapted, tolerant to environmental stress, and have short-term, fast-growing characteristics. Amaranthus is usually grown in home gardens, but has attained commercial significance in many parts of tropical Africa and Asia. Amaranthus grows well in both humid and hot, dry climates. The plant prefers temperatures between 25^0C and 30^0C. It is photoperiodic sensitive and most species will flower when day length is shorter than 12 hours.

A study was conducted at Arusha, Tanzania from July to October 2004 to evaluate the yield potential of 33 amaranthus accessions maintained at AVRDC-RCA. The study aimed to develop appropriate cultural practices for production of amaranthus species.

The experiment was laid out in a split-plot design with three replications in plot sizes measuring 1 x 4 m. The seeds were broadcast evenly on the bed or sown at a spacing of 10 x 15 cm and 15 x 15 cm. For each accession 25 g of seeds was used per plot. Two successive experiments were carried out. For the first experiment, no fertilizer was used and seeds were sown on 18 July 2004. For the second experiment, seedbeds were fertilized with 45 t/ha of well-decomposed cow manure mixed with compost at a ratio of 1:1. The manure and compost were well incorporated into the beds before seeds were sown. Seeds were sown on 7th and 8th September 2004. Additional application of NPK and urea fertilizer was carried out on 27th September 2004 at rates of 250 kg/ha and 60 kg N/ha, respectively. For both experiments, after broadcasting the seeds, the seed beds were covered by grass mulch until the seeds germinated before the mulch was removed. In the spacing treatments, seeds were drilled in rows 15 cm apart while the in-row spacing was 10 or 15 cm based on the treatment. A thin layer of sand was applied to cover the seeds after sowing. Furrow irrigation was carried out at one-week intervals and weeding done when necessary. Harvesting was carried out at six weeks after sowing. Whole plants were uprooted, with the exception of the border rows, and weighed. Biological yield (whole plant including roots) and economic yield (leaves) were weighed then recorded. A second experiment using the same treatments was laid out one week after harvesting the first experiment.

Significant differences were observed among tested accessions. Yields varied between the two harvests with the second harvest giving higher yields compared to the first harvest (Table 131 and 132). Since the second harvest was fertilized while the first harvest was not, this shows that amaranth responds well to fertilizer application. The broadcast treatment gave higher biological and leaf yields per hectare compared to drilling; although on a per-plant basis, the broadcast treatment gave lower yields comparatively, probably due to intra-plant competition (Table 131). Accessions AM-IP7, AM-IP5, and AM-IP11 gave the best leaf yields per hectare during the first harvest (Table 132) while accessions AM2-mombo, AM–Red Sud, and AM-IP5 gave the best leaf yields per hectare during the second harvest (Table 132). On the other hand, accessions AM2-mombo, AM-IP11, AM-IP7, and AM-IP5 gave the best biological yields. It is recommended that for higher amaranthus yields, broadcasting is the most efficient method of production, especially when harvests have to be carried out within six weeks. The accessions mentioned above can also be recommended for promotional purposes although the experiment needs to be validated again.

Table 131. The effects of sowing method on the yield of amaranth

Sowing method	Biological yield (t/ha)		Leaf yield (t/ha)		Biological yield (g/plant)		Leaf yield (g/plant)	
	1st harvest	2nd harvest	1st harvest	2nd harvest	1st harvest	2nd harvest	1st harvest	2nd harvest
Broadcast	10.70 a	14.70 a	6.25 a	11.30 a	1.65 c	9.48 b	2.30 a	3.98 b
Drilling (10 x 15 cm)	3.16 b	4.52 b	2.15 b	3.16 b	3.11 b	17.17 ab	1.76 b	10.17 a
Drilling (15 x 15 cm)	2.69 b	3.75 b	1.57 b	2.65 b	4.28 a	23.04 a	1.65 b	11.34 a
LSD (5%)	1.04	0.94	0.68	1.92	0.56	10.76	0.37	1.31
F-test	***	***	***	***	***	*	**	***
CV (%)	39	43	43	38	36	57	30	24

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Mean separation within the same column at $P < 0.05$ by DMRT.

Table 132. Evaluation of amaranthus accessions for leaf yield

Accession	Leaf yield (t/ha)		Leaf yield (g/plant)		Biological yield (g/plant)		Biological yield (t/ha)	
	1st harvest	2nd harvest	1st harvest	2nd harvest	1st harvest	2nd harvest	1st harvest	2nd harvest
AM-2 Mombo	4.62 a-e	14.08	3.37 abc	8.65 abc	4.77 bc	15.14 b	7.88 a-d	10.03 a-d
AM-IP5	6.32 ab	9.50	2.39 a-e	14.59 ab	4.02 bcd	37.48 a	9.84 ab	12.64 a
AM-Red Sud	5.70 a-d	8.94	3.27 a-d	14.98 a	4.39 bcd	28.21 b	8.28 a-d	11.67 ab
AM-Gare	3.04 a-e	8.19	1.64 b-e	7.92 abc	2.94 bcd	14.09 b	5.48 bcd	7.11 b-d
AM-IP6	4.38 a-e	8.09	3.59 ab	12.97 abc	8.09 a	18.28 b	9.79 ab	11.67 ab
AM-IP11	6.18 abc	7.72	1.72 b-e	11.20 abc	4.63 bcd	23.87 b	8.79 abc	11.78 ab
AM-Yambio	3.85 a-e	7.44	2.15 b-e	9.22 abc	3.23 bcd	19.47 b	5.38 bcd	10.06 a-d
AM-42x	1.83 de	6.75	3.66 ab	9.88 abc	1.47 cd	13.49 b	3.72 bcd	8.31 a-d
AM-Zim	4.54 a-e	6.56	1.09 cde	5.41 c	2.65 bcd	10.78 b	7.39 a-d	9.89 a-d
AM-3	3.85 a-e	6.28	1.87 b-e	11.09 abc	4.52 bcd	14.88 b	6.48 a-d	10.36 abc
AM-IP7	6.68 a	5.89	4.15 a	10.02 abc	4.57 bcd	21.49 b	11.62 a	7.44 a-d
AM-IP12	3.64 a-e	5.86	2.60 a-e	7.75 abc	3.36 bcd	14.48 b	5.46 bcd	9.22 a-d
AM-Ex-Mom	3.16 a-e	5.78	1.23 cde	7.15 abc	2.38 cd	10.16 b	5.15 bcd	8.13 a-d
AM-42Q	3.76 a-e	5.08	1.42 b-e	7.77 abc	2.36 cd	11.10 b	5.25 bcd	6.94 bcd
AM-N10	4.21 a-e	5.06	3.09 a-e	6.44 c	4.82 bc	11.02 b	7.89 a-d	6.83 bcd
AM-IP14	1.58 de	4.94	0.99 de	9.20 abc	1.53 cd	15.90 b	2.79 cd	5.97 cd
AM-Kongei	3.13 a-e	4.81	1.51 b-e	7.76 abc	2.98 bcd	14.15 b	6.09 a-d	7.58 a-d
AM-42	4.44 a-e	4.69	3.66 ab	7.80 abc	5.77 b	12.52 b	6.93 a-d	6.53 bcd
AM-Lushot	2.62 a-e	4.67	2.06 b-e	8.76 abc	1.99 cd	15.48 b	5.66 bcd	7.09 bcd
AM-N2	3.53 a-e	4.31	2.06 b-e	5.73 c	2.21 cd	11.32 b	5.92 a-d	8.00 a-d
AM-N21	2.17 b-e	4.22	1.29 cde	8.44 abc	1.71 cd	12.61 b	5.66 bcd	5.81 cd
AM-N31	1.82 de	4.11	1.88 b-e	6.90 bc	1.79 cd	12.82 b	4.73 bcd	5.58 cd
AM-Fune	2.32 b-e	4.01	1.10 cde	6.93 bc	1.97 cd	12.52 b	3.60 bcd	6.67 bcd
AM-SAT2	2.43 b-e	3.97	1.27 cde	6.90 bc	3.73 bcd	11.60 b	3.71 bcd	6.42 bcd
AM-N9	2.02 cde	3.81	1.28 cde	5.70 c	1.96 cd	10.06 b	3.01 cd	6.19 bcd
AM-SAT6	2.48 b-e	3.73	1.68 b-e	10.40 abc	2.09 cd	12.00 b	4.18 bcd	6.19 bcd
AM-IP2	1.84 de	3.56	1.81 b-e	5.97 c	2.44 cd	9.04 b	3.77 bcd	5.11 cd
AM-Cel	1.24 e	3.50	1.17 c-e	7.56 abc	1.13 d	8.01 b	1.74 d	4.58 cd
AM-31	2.47 b-e	3.28	1.88 b-e	8.32 abc	2.43 cd	12.91 b	4.55 bcd	4.58 cd
AM-2	4.00 a-e	2.86	1.08 c-e	5.61 c	2.21 cd	9.00 b	3.48 bcd	5.27 cd
AM-SAT3	1.16 e	2.67	0.74 e	7.34 abc	1.20 d	12.07 b	1.76 d	4.25 d
AM-N6	1.54 de		0.82 e		1.31 cd		2.96 cd	
LSD (5%)	2.26	6.28	1.24	4.29	1.86		3.43	3.06
F-test	*	**	*	***	***	ns	**	***
CV (%)	43	38	30	24	36	57	39	43

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Mean separation within the same column at $P < 0.05$ by DMRT.

Evaluation of onion lines for yield and horticultural characteristics

Onion (*Allium cepa*. L) cultivars exhibit large variations in various characters. Characteristics such as bulb shape, size, diameter, height, flesh color, total soluble solids content, dry matter content, neck thickness, and resistance to diseases are often linked with quality attributes that are desired by specific markets, and are also a basis for developing cultivars for specific consumer preferences. Despite the high potential use of different breeding techniques to develop the desired onion cultivars, there is still a lack of highly performing and adapted onion cultivars in the tropics and subtropics in Africa. Quite often, onion cultivars that are developed or selected for the temperate regions are imported for direct cultivation in the tropics and their performance is sometimes unsatisfactory. Developing high-yielding onion lines is a crucial strategy in onion improvement, especially lines with tolerance to high temperatures and water stress, resistance to major pests and diseases, long bulb storage life, and suitability for growing in the hot–humid tropics and subtropics in Africa because temperature influences bulb initiation and formation, with low temperatures promoting bolting.

A study was conducted at AVRDC–The World Vegetable center, Regional Center for Africa, in Arusha, Tanzania from July to November 2005. Sixteen onion lines/varieties obtained from AVRDC and other sources were evaluated for horticultural and quality characteristics. The experiment was laid out in a RCBD with three replications. The plot size was 1 x 4 m with six rows per bed. The spacing used was 10 cm between plants and 15 cm between rows. Seeds were sown on 9 June 2005 and seedlings transplanted in the open sunken beds on 18 July 2005. Furrow irrigation to field capacity was carried out weekly. NPK (20-10-10) and urea fertilizer were applied as a side-dress at the rate of 250 kg/ha and 50 kg N/ha, respectively, three weeks after transplanting. An additional 50 kg N/ha of urea was applied two weeks thereafter during the onset of bulb formation. Actellic 50 EC insecticide was applied at a concentration of 30 ml/15 l of water and application rate of 1.20 l/ha; while Dithane M45 fungicide was applied at a concentration of 60 mg/15 l of water. Spraying was carried out once a month. Weeding was done regularly to ensure weed-free beds.

The yield and yield components of 16 onion lines are shown in Table 1. The bulb yield ranged from 32.33 t/ha (AC 724 (B)-C-B-C) to 98.1 t/ha (Red Bone). The differences in bulb yield among lines were highly significant (Table 133). Red Bone had the largest bulb size of 142.33 g, followed by Texas Grano 502 with 139.87 g while the lowest was line AC724 (B)-C-B-C with 48.5 g. Mean bulb weight/size was highly and positively correlated to bulb yield ($r = 0.99$). CAL 606 had the highest biological yield of 164.37 t/ha while AC 319-C had the lowest (91.23 t/ha) with differences among lines highly significant. Based on the bulb diameter (neck), the line with the most uniform bulbs was AC319-C while Red Bone had the least uniform bulbs (Table 133). The variety with the thickest neck was Red Bombay (3.77 cm) while TA 377-C had the most narrow neck at 2.57 cm. Red Bone had the tendency to bolt prematurely, at 18.67% followed by Red Bombay at 13.63%.

Lines Texas Grano 502, Red Bone, and CAL 606 showed yields of more than 80.0 t/ha which were significantly higher than the check variety, Red Bombay 5545 and the rest of the test accessions. These lines may therefore be suitable for promotion. However for Red Bone, genetic improvement with respect to bulb uniformity and premature bolting needs further attention.

Table 133. Yield and horticultural characteristics of onions lines

Lines/ Accessions[a]	Bulb color	Bulb shape	Bulb yield (t/ha)	Bulb size (g/bulb)	Bulb diameter (cm)	Bulb length (cm)	Biological yield (t/ha)	Bulb neck thickness (cm)	Bulb[b] uniformity (±SE of bulb length)	Bulb[c] uniformity (±SE of bulb width)	Plant height at maturity (cm)	Number of leaves/ plant	Transplant survival (%)	Bolting (%)
Red Bone	Red	Globe	98.10 a	142.33 a	5.75 b	5.75 b	135.50 abc	2.93 bc	0.20 a	0.21 a	59.07 a-d	9.0 bcd	98.73 a	18.7 a
Red Bombay 5545	Red	Flat	53.83 bc	80.77 bc	7.45 a	7.34 a	135.57 abc	3.77 a	0.13 b-f	0.18 a	66.57 ab	13.3 a	90.60 cd	13.6 a
AC 724 (B) -C-B-C	Red	Globe	32.33 d	48.50 d	5.09 bc	5.05 bc	102.23 cd	2.77 bc	0.11 ef	0.18 a	57.93 a-d	9.6 bc	91.97 bcd	0.0 b
Red Creole (G)-N	Red	Flat	40.73 bcd	61.10 bcd	5.50 bc	5.55 bc	115.40 cd	2.97 bc	0.12 def	0.20 a	59.57 a-d	8.3 bcd	95.97 abc	0.0 b
AC 319-C	Red	Globe	44.23 bcd	66.33 bcd	5.53 bc	5.55 bc	91.23 d	2.93 bc	0.09 f	0.17 a	65.23 ab	8.0 bcd	95.27 abc	0.0 b
267134 Red Creole	Red	Flat globe	50.07 bcd	75.10 bcd	5.70 b	5.78 b	121.87 bcd	2.97 bc	0.14 b-f	0.18 a	62.17 abc	9.7 bc	93.87 bcd	0.0 b
TA 471 (B)-C-C-C	Red	Thick globe	43.27 bcd	64.90 bcd	5.78 b	5.81 b	115.40 cd	3.13 bc	0.20 a	0.24 a	60.93 abc	7.7 cd	91.40 bcd	0.0 b
TA 364ST-D-D-C	Red	Flat	55.57 b	83.23 b	5.60 b	5.60 bc	106.67 cd	3.20 b	0.17 a-e	0.25 a	61.43 abc	10.0 b	87.73 d	0.0 b
AC 727 (A) BST-F-C	Red	Flat globe	36.77 cd	55.17 cd	5.52 bc	5.58 bc	112.03 cd	3.00 bc	0.14 a-f	0.22 a	58.77 a-d	8.3 bcd	88.17 d	0.0 b
OC 286-A A-N	Yellow	Flat globe	58.10 b	87.13 b	5.63 b	5.61 bc	128.93 bc	3.00 bc	0.18 a-d	0.21 a	63.33 abc	9.0 bcd	92.83 bcd	0.0 b
Texas Grano 502 (check)	Yellow	Globe	93.23 a	139.87 a	5.00 bc	4.99 bc	152.17 ab	2.63 bc	0.20 a	0.24 a	68.73 a	9.0 bcd	92.80 bcd	0.0 b
TA 377-C	Yellow	Globe	41.43 bcd	62.13 bcd	4.45 c	4.55 c	106.57 cd	2.57 c	0.19 ab	0.20 a	49.93 d	7.7 cd	93.20 bcd	0.0 b
OC 216(E)-HST-A -N	Yellow	Globe	55.20 b	82.80 b	4.99 bc	4.99 bc	107.00 cd	3.17 bc	0.18 abc	0.24 a	63.13 abc	8.0 bcd	90.63 cd	0.0 b
OC 232-C-A-C	Yellow	Flat top	57.57 b	86.33 b	5.03 bc	5.03 bc	114.13 cd	2.63 bc	0.15 a-e	0.20 a	57.03 bcd	7.3 d	93.03 bcd	0.3 b
CAL 606 (hybrid check)	Yellow	Globe	83.57 a	125.40 a	5.47 bc	5.53 bc	164.37 a	2.93 bc	0.18 abc	0.19 a	68.46 a	8.7 bcd	95.73 abc	0.0 b
AC 853 (B)-A-N	Yellow	High globe	36.43 cd	54.63 cd	4.76 bc	4.84 bc	103.37 cd	2.67 bc	0.12 b-f	0.16 a	54.00 cd	7.7 cd	96.73 ab	0.0 b
LSD (5%)			15.78	23.71	0.95	0.93	28.79	0.51	0.54		9.15	1.8	5.65	0.7
F-test			***	***	***	***	***	**	***	ns	*	***	*	**
CV (%)			17.26	17.29	10.49	10.22	14.44	10.34	20.71	25.69	8.99	12.25	3.64	22.24

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Mean separation within the same column at $P < 0.05$ by DMRT.
[a] Transplanted 18.06.2005 at AVRDC-RCA in Arusha, Tanzania.
[b] Bulb uniformity (±SE) based on bulb neck diameter
[c] Bulb uniformity (±SE) based on bulb equatorial diameter

Influence of spacing and fertilizer on agronomic yield of onion

Onion (*Allium cepa*) is one of the most important vegetables consumed around the world. In sub-Saharan Africa, onion yields are still relatively low and this is partly attributed to poor production practices. To increase production and productivity, there is an urgent need to develop a sustainable production package for farmers. Nitrogen is essential to increase bulb size and yield, but excessively high doses cause delays in bulb maturity. The present study was therefore carried out to find out the best spacing and nitrogen rates that can give optimum bulb yield. A promising Onion line Red Bone was used as a model species.

The trial was conducted in Arusha, Tanzania from July to November 2005. The experiment was laid out in RCBD with three replications. Five levels of plant to plant spacing (5, 7.5, 10, 12.5, and 15 cm) and four urea nitrogen levels (0, 50, 100, and 150 kg N/ha) rates were tested. Urea was applied as a side-dress in two equal splits of equal doses with the first application carried out 17 days after transplanting and the second application 29 days later. Row-to-row spacing was maintained at 15 cm on beds measuring one meter wide and four meters long. Seeds were sown in the nursery on 3 June 2005, and seedlings transplanted in the beds on 11 July 2005. Furrow irrigation was carried out twice a week for three weeks and on a weekly basis thereafter. Weeding and pesticide application were done as needed. Selecron, Actellic 50EC (Syngenta crop protection AG, Basel, Switzerland), and Thionex 35EC (Makhteshim Chemical Worlds Ltd., Israel) were diluted in water at respective doses of 20 ml/15 l, 30 ml/15 l, and 30 ml/15 l and sprayed to control downy mildew, thrips, and other insects, respectively. Ridomil MZ 68 WP (Syngenta crop protection AG, Basel, Switzerland) at the rate of 60 g/15 l and Dithane M45 (Dow Agrosciencies S.A., France) at the rate of 60 g/15 l were sprayed to control other fungal diseases.

Results showed that changes in plant spacing did not affect plant height at maturity, bulb length, and bolting percentage (Table 134). By contrast, bulb yield decreased with increasing plant spacing from 101.4 at 5 x 15 cm spacing to 46.5 t/ha at 15 x 15 cm spacing. However, individual bulb size increased with increasing plant spacing from 76.0 g at 5 x 15 cm to 104.6 g at 15 x 15 cm plant spacing. The same trend was observed with the number of leaves/plant and bulb neck thickness, but for the latter, only the widest spacing (15 x 15 cm) gave significantly thicker bulb than the closest spacing (5 x 15 cm). It was noted that the closer the plant spacing, the earlier the bulb matured and the more uniform the bulb.

The amount of urea applied did not affect bulb size, bulb length, width, neck thickness, bulb uniformity, bolting percentage, and the number of leaves/plant. By contrast, bulb yield as well as biological yield increased with increasing urea application while the bulb maturity was also hastened by the application of urea.

Study on soil treatment methods for seedling stand establishment

Farmers today are using more and more costly hybrid seeds to increase/improve production and alleviate poverty. Seedling production at the nursery is the most common method used by farmers in developing countries for tomato production. A farmer has to start with good healthy seedlings, which can be achieved through disease- and weed-free soil. Weeds compete with seedlings for moisture, nutrients, and light, especially in the nursery. They are also alternative hosts for diseases and pests. At the same time, the soil acts as a reservoir for most disease-causing organisms like fungi, bacteria, nematodes, and viruses. These disease-causing organisms survive in the soil in a dormant state in roots of weeds and plant debris. Hence, soil treatment is required before establishing nurseries. With regard to this, an experiment was carried out at the experimental farm of AVRDC–The World Vegetable Center in Arusha, Tanzania from July to October 2005 to determine the most effective pre-plant soil treatment method (suitable for small-scale farmers) for raising disease-free healthy seedlings in the nursery bed.

The experiment was laid out in RCBD with three replications. Five treatments and two controls were randomly assigned in three replications. Tomato variety Tanya was used as a model crop. Plots of 6 m long and 1 m wide dimensions were marked out with 50 cm interplot spacing and 1.5 m interblock spacing. The soil sterilization treatments used were clear polythene sheet (solarization), heat treatment (burning straw), hot water, Basamid chemical, and ethylene dibromide. For heat treatment, a heap of grass straw and brushwood about 15 cm (6 in) high was burned to ashes on respective plots. After four days, seeds were sown on

Table 134. The influence of plant population on yield characteristics onion, Arusha, Tanzania, July–November 2005

Treatment	Bulb yield (t/ha)	Biological yield (t/ha)	Bulb size (g/bulb)	Plant height at maturity (cm)	Bulb length (cm)	Bulb width (cm)	Bulb neck thickness (cm)	Number of days to maturity	Bulb uniformity (±SE of bulb width)	Number of leaves/ plant	Bolting (%)
Spacing (cm)											
5 x 15	101.36 a	134.38 a	76.02 b	46.17	5.00	5.68 bc	4.37 b	100.83 c	0.17b	15.87	7.89 c
7.5 x 15	70.61 b	90.19 b	79.43 b	48.61	4.83	5.58 c	4.64 ab	102.92 abc	0.18 b	17.07	8.69 bc
10 x 15	59.42 c	81.03 b	89.13 b	46.24	4.90	6.08 a	4.60 ab	101.75 bc	0.18 b	14.6	9.45 ab
12.5 x 15	47.22 d	65.00 c	88.53 b	46.99	4.99	5.83 abc	4.94 ab	104.42 a	0.19 ab	15.41	9.77 a
15 x 15	46.50 d	64.01 c	104.62 a	47.27	5.12	6.01 ab	5.17 a	103.33 ab	0.22 a	15.70	10.18 a
LSD (5%)	9.98	13.02	14.83			0.35	0.57	2.1	0.03		1.03
F-test	***	***	**	ns	ns	*	*	*	*	ns	***
Urea(kg)											
0	57.81 b	75.71 c	78.41	44.92 b	4.89	5.68	4.72	104.67 a	0.18	18.96	9.01
50	65.72 ab	89.05 ab	92.16	46.23 ab	5.06	5.97	4.76	101.47 b	0.18	15.22	9.04
100	66.75 ab	84.58 bc	90.56	48.40 a	4.93	5.87	4.50	101.93 b	0.20	119.99	9.41
150	69.80 a	98.39 a	89.05	48.66 a	4.92	5.83	4.99	102.53 b	0.20	13.60	9.32
LSD (5%)	8.93	11.64		2.61				1.88			
F-test	*	**	ns	*	ns	ns	ns	**	ns	ns	ns
CV (%)	18.57	18.12	20.49	7.51	7.66	7.28	14.57	2.47	22.46	19.46	13.58

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Mean separation within the column at $P < 0.05$ by DMRT.

the plots. For hot water treatment, water was boiled in a drum using firewood. The boiling water was then applied on the plot to a depth of 10 cm (4 in). After four days, the seeds were sown on the bed. For Basamid treatment, granules were broadcast on the beds at the rate of 50 g/m^2 and then incorporated into the soil using a hand hoe. The plots were watered and covered with a clear polythene sheet for 10 days, before being uncovered and seeds sown on the plots. For ethylene dibromide treatments, a 45% w/v mixture was applied at the rate of 30 ml/m^2 using soil fumigant injector; to a depth of 15 cm (6 in). The plots were covered with a clear polythene sheet for 10 days, then uncovered before seeds were sown. For solarization, two treatments were carried out. In the first solarization treatment, the prepared plots were covered with a clear polythene sheet (no chemical used) for two weeks. These were then uncovered, the soil loosened, and the seeds sown on the bed. In the second solarization treatment, clear polythene was placed on the prepared plots for a period of seven weeks. The polythene was then removed, the soil loosened, and the seeds sown on the bed. After implementation of all the treatments, watering was done regularly until the seedlings emerged.

Results of the experiment are shown in Table 135. There was a significant difference between treated and untreated plots in all parameters. Ethylene dibromide and Basamid showed greater impact in controlling broadleaved weeds. There was a significant difference in number of annual narrow-leaved weeds between the treatments. Basamid, ethylene dibromide, and solarization for seven weeks showed best results (Table 135). There was a high incidence of plants infected by nematodes in the control treatment when compared with other treatments. All the treatments worked well in controlling weeds, nematodes, and diseases. It is recommended that farmers put into practical use Basamid and ethylene dibromide (whenever they can afford it) or otherwise the use of heat treatment by hot water and fire would be appropriate.

Table 135. The effect of soil sterilization methods on weed and disease control, Arusha, Tanzania, July–October 2005

Soil sterilization method	Annual broad leaved weeds	Annual narrow leaved weeds	Perennial narrow leaved weeds	Number of nematode infected plants	Number of diseased plants
No treatment (control)	80 a	17.0 c	0.00 c	26.7 a	28.00 b
Heat treatment (burning straw)	60 b	9.6 d	0.33 bc	5.0 cd	8.00 d
Heat treatment (hot water)	57 b	24.0 b	4.33 a	14.3 b	20.33 bc
Solarization 1 (2 weeks)	54 b	45.0 a	1.66 b	3.0 d	14.33 cd
Solarization 2 (7 weeks)	27 c	1.3 e	0.00 c	5.3 cd	28.33 b
Basamid	15 d	0 .0 e	0.00 c	3.3 d	38.66 a
Ethylene dibromide	13 d	0.6 e	0.00 c	8.6 c	19.00 bc
LSD (5%)	8.35	4.08	0.93	4.88	9.49
F-test	***	***	***	***	***
CV (%)	10.65	24.95	88.07	28.96	23.85

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$).
Means followed by the same letter are not significantly different at 5% level based on DMRT.

Effect of insecticide and irrigation scheduling on onion thrips control

Bulb onion (*Allium cepa*) is a crop that tolerates several growing environments including high temperatures. However, pests such as thrips lead to low bulb yield. *Thrips tabaci* Lindermann is a polyphagous and cosmopolitan damaging insect that occurs during relatively cooler and drier periods of the year. Onion remains tolerant to this pest during flowering stages but it is susceptible during early bulb formation stages and especially a few weeks before harvest. Damage of the pest is due to feeding of larvae and semi-adults on leaves; white spots, silvery streaks, and blotches can result in low quality and quantity of bulb yield. Life cycle can be completed in two weeks when temperatures are warm. Development of infestation is influenced by seasonal conditions. The pest breeds most rapidly when there is a mild, dry winter followed by a hot, dry spring. Several methods can be implemented to reduce or totally eliminate thrips on onion: increased soil moisture (rainfall, irrigation); cultural control (intercropping, crop rotation); trapping (use of colourful sticky traps); pesticides (Selecron, Avermectin B1, and so on), biological control (use of thrips predators such as anthocorid bugs and phytoseiid mites) and use of thrips-tolerant varieties. Since the insects feed between leaves near the base of the plant, which are hard to reach with insecticide, insecticides should be applied with sufficient water to ensure thorough coverage. Recent studies conducted in Taiwan have shown that effective control of thrips populations can be achieved by adjusting or scheduling the irrigation water quantity or the insecticide application. This study aims to evaluate the effect of insecticide application and irrigation scheduling on the control of thrips in East Africa.

Two separate distinct trials were conducted at AVRDC-RCA from July to October 2005. Both experiments were laid out in RBCD with three replications. Six-week-old seedlings of the onion line Red Bone were transplanted in these two trials. During the first eight weeks, all plots were sufficiently furrow-irrigated twice a week and weeding was done when necessary. Gap filling was carried out one week after transplanting and NPK (20-10-10) and urea fertilizer were applied in two splits as a side-dress at the rate of 150 kg/ha and 45 kg N/ha respectively, on 29 July 2005. One month later, another 45 kg N/ha of urea was applied. Plants were scored weekly for thrip leaf damage based on visual evaluation using a 0–5 scale where 0 = no damage, 1 = 1–20% leaf area damaged, 2 = 21–40% leaf area damaged, 3 = 41–60% leaf area damaged, 4 = 61–80% leaf area damaged, and 5 = 81–100% leaf area damaged. Scoring for thrips was done on a 1-m-long section in middle rows of each plot. Treatments were initiated on 9 September 2005 for the irrigation trial. Selecron (or Profenofos) was used at 20 ml/15 l of water in the insecticide trial and seedlings were transplanted for this trial on 15 July 2005. The plot size was 3 x 1 m, beds were separated by 1.5 m, and 6 m was the distance between blocks. Spacings were 15 cm between rows, and 10 cm between plants. Insecticide treatments were carried out at 0, 4, 6, 8, 9, 10, and 11 weeks after transplanting. For irrigation experiments, seedlings were transplanted on 16 July 2005 in plot sizes measuring 2 x 1.5 m. The beds were separated by 2 m while blocks were separated by 6 m. Plant spacings were the same as in the insecticide trial. The water treatments tested were: 100 l/week until harvest; 2) 100 l every two weeks, 60 l every week; 4) 60 l every two weeks; 5) 20 l every week, 20 l every two weeks, and the control (no water except rainfall). Fertilizer application was the same as in the insecticide trial. Thrip rating was done as described in the previous trial.

Results showed that thrips were controlled by the scheduling of the insecticide application, with four weeks after transplanting giving the best protection (Table 136). The mean thrips infestation score was 1.1 for 4 WAT, while it was 3.6 for both 11 and 12 WAT. Biological yield and bulb size (diameter and length) were significantly affected by insecticide spraying, with 4 WAT giving the best results as compared to other treatments. The current results are in agreement with previous results obtained at AVRDC-RCA (AVRDC 2004) showing that bulb yields were markedly increased when Selecron application is started at 4 WAT.

The irrigation treatment significantly affected bulb yield and size (Table 137). Irrigation rate of 100 l gave significantly higher bulb yields compared with other irrigation levels, but only if applied once a week. Applying the same amount every two weeks did not have the same effect. For biological yield, irrigation rates of 100 l and 60 l applied once a week and 100 l applied every two weeks gave comparable yields which are significantly higher than 20 l (one week or two weeks) and 60 l when applied once every two weeks.

Table 136. Effect of insecticide scheduling on yield and onion thrip control, Arusha, Tanzania, July–October 2005

Spraying schedule (WAT)	Bulb yield (g/plant)	Bulb yield (t/ha)	Biological yield (t/ha)	Biological yield (g/plant)	Bulb length (cm)	Bulb width (cm)	Thrips infestation[a]
4	112.17	74.78	103.27 a	154.91 a	4.17 a	6.71 a	1.07 f
6	83.83	55.89	91.33 ab	136.99 ab	4.6a b	5.98 ab	1.63 e
8	89.25	59.50	74.26 ab	118.97 ab	4.34 b	5.70 b	2.43 d
9	101.18	67.45	92.61 ab	138.92 ab	4.38 ab	5.60 b	2.67 c
10	89.97	59.98	73.15 b	109.73 b	4.47 ab	5.91 ab	3.00 b
11	97.07	64.72	79.31 ab	111.38 ab	4.42 ab	6.16 ab	3.63 a
Control	95.26	63.51	77.46 ab	116.19 ab	4.46 ab	6.26 ab	3.57 a
LSD (5%)			26.86	40.29	0.32	0.75	0.21
F-test	ns	ns	*	*	*	*	***
CV (%)	19.99	19.99	17.87	17.87	4.07	7.01	4.53

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$)
Mean separation within the same column at $P < 0.05$ by DMRT.
[a] Using a 0–5 scale where 0 = no damage, 1 = 1–20% leaf area damaged, 2 = 21–40% leaf area damaged, 3 = 41–60% leaf area damaged, 4 = 61–80% leaf area damaged, and 5 = 81–100% leaf area damaged.

Table 137. Effect of irrigation scheduling on yield and onion thrips control, Arusha, Tanzania, July–October 2005

Amount of water applied (l)	Bulb yield (g/plant)	Bulb yield (t/ha)	Biological yield (t/ha)	Biological yield (g/plant)	Bulb length (cm)	Bulb width (cm)	Thrips infestation[a]
100 l/week	44.92 a	29.95 a	32.88 a	49.32 a	4.54 ab	4.88 a	2.83 c
100 l/2 weeks	28.79 bc	19.19 bc	28.98 ab	43.48 ab	4.23 abc	4.86 a	3.67 b
60 l/ week	40.36 ab	26.91 ab	34.73 a	52.09 a	4.59 a	4.94 a	3.82 ab
60 l/2 weeks	30.73 bc	20.49 bc	23.66 bc	35.49 bc	4.15 bc	4.35 ab	4.12 ab
20 l/ week	28.55 bc	19.03 bc	21.79 bc	32.68 bc	4.14 bc	4.35 ab	4.10 ab
20 l/2 weeks	27.69 bc	18.46 bc	20.33 bc	30.50 bc	3.90 c	4.86 a	4.40 a
Normal irrigation (control)	25.93 c	17.29 c	19.53 c	29.31 c	4.10 c	4.11 b	3.75 b
LSD (5%)	13.00	8.67	8.04	12.07	0.38	0.59	0.55
F-test	*	*	**	**	*	*	**
CV (%)	22.54	22.54	17.40	17.40	5.04	7.43	8.15

ns: not significant; * significant ($P < 0.05$); ** highly significant ($P < 0.01$); *** highly significant ($P < 0.001$)
Mean separation within the same column at $P < 0.05$ by DMRT.
[a] Using a 0–5 scale where 0 = no damage, 1 = 1–20% leaf area damaged, 2 = 21–40% leaf area damaged, 3 = 41–60% leaf area damaged, 4 = 61–80% leaf area damaged, and 5 = 81–100% leaf area damaged.

Results from these studies show that insecticide application for control of thrips infestation in onion should be started four weeks after transplanting and 100 l of irrigation water should be supplied once a week to effectively control onion thrips. These findings should be adopted as part of the standard cultural practices in onion production.

Training

Regional Vegetable Crops Production and Research Training Course

As part of the RCA's continuous program in capacity building of NARES, NGO, and private sector personnel in sub-Saharan Africa on Vegetable Research and Development, the RCA conducted the 12th Regional Vegetable Production and Research Training Course from 4 July to 4 November 2005. Twenty-four participants (12 female and 12 male) from NARES in 17 countries namely Tanzania, Malawi, Zambia, Zimbabwe, Ghana, Botswana, Lesotho, Kenya, Cameroon, Sudan, Uganda, Ethiopia, Seychelles, Benin, Namibia, South Africa, and Mauritius attended the training course. The training participants found the lectures and research practical, useful, and helpful in that their knowledge and practical skills were improved. In addition, the training enhanced their capacity to conduct quality research, training, and extension duties upon returning to work.

Training courses in nursery management, vegetable production, IPM techniques, vegetable processing and utilization

Twenty 2- to 3-day training courses were conducted at AVRDC-RCA in Arusha, Tanzania for self-help women groups and small-scale farmers in the Arusha region in Northern Tanzania. Four hundred and thirty people were trained with 90% of them being women. The training courses offered topics on marketing, seedling nursery management, vegetable production and IPM techniques, as well as vegetable processing, preservation, and utilization techniques. The aim of the courses was to help equip the farmers with production and processing knowledge and techniques necessary to improve productivity, reduce micronutrient loss, improve postharvest handling techniques and marketing of indigenous and select exotic vegetables.

Farmers' Field Day

A Farmers' Field Day was held at AVRDC-RCA, in Arusha, Tanzania on 7 October 2005. The event featured technology demonstrations for applied vegetable production and a display of vegetable varieties. One hundred and fifty farmers, research scientists and personnel from NARES, the private sector, and NGOs attended the field day. Demonstrations were followed by a question-and-answer panel session with the aim of addressing the farmers' problems.

Planning Workshop on Technology Transfer of Promising Vegetable Lines Through Sustainable Seed Production in East Africa

A planning workshop for a Rockefeller-funded project on 'Technology Transfer of Promising Vegetable Lines Through Sustainable Seed Production in East Africa' was held at AVRDC-RCA during September 19–20, 2005. The purpose of the project is to promote quality vegetable seed production and marketing for better livelihood, socio-economic base and nutrition status of rural farmers. Twenty-five participants from Tanzania, Kenya, and Uganda attended the workshop. The participants were from East African seed companies and AVRDC. The objective of the meeting was to conceptualize a three-year workplan to help implement the project activities.

Contact: Detlef Virchow

Central Asia and Caucasus

Characterization of asparagus lines in Azerbaijan and Uzbekistan

Asparagus is a nontraditional crop in the Central Asia and Caucasus (CAC) region. AVRDC introduced four lines of asparagus in Azerbaijan and Uzbekistan for the first time in 2005. Research to study the crop was conducted at the Research Institute of Genetic Resources in Azerbaijan (IGR) and the Uzbek Research Institute of Plant Industry (UzRIPI). Seeds of the four lines were sown in March 2005. For both countries, cultural practices included furrow irrigation, hoeing, and fertilization. By autumn, shoot height of asparagus plants ranged from 35 to 59 cm in IGR and from 20 to 61 cm in UzRIPI. In spring 2006, the asparagus roots will be transplanted to special beds to study productivity and for seed multiplication.

Studies of non-heading Chinese cabbage in Uzbekistan and Azerbaijan

Non-heading Chinese cabbage or pai-tsai (*Brassica rapa* cv. group pak-choi) is a non-traditional crop for the CAC region. There is a need to select varieties that are well-adapted to the ecological conditions of the CAC region. Trials of ten cultivars and hybrids were conducted at UzRIPI, Uzbekistan and IGR, Azerbaijan with four replications. Seeds were sown in a greenhouse and then seedlings were transplanted to the field in April 2005.

The soil at UzRIPI is a sierozem. Seedlings were planted on 70 cm raised beds, in double rows with 20 cm between rows and 10 cm between plants in the rows. The plot was furrow irrigated four times. Plants were fertilized with a total application of 50 kg N, 40 kg P, and 30 kg K each per hectare. Hoeing of the soil was done twice. No diseases occurred during the growing season.

The results at UzRIPI showed that marketable plants were produced 18–27 days after mass germination and the growing period from germination to potential harvest for most pai-tsai accessions was 22–29 days (Table 138). The fastest maturing lines were harvestable at 18 and 22 days. These included RY0610 Show-Jean (F_1), KY1389, Fun Jen (F_1), KY0606 Ching-Chiang, KY1307 Brisk Green (F_1), and FN0231 Butter. KY0603 Gracious was the latest-maturing at 27 days. The per plant weight ranged from 16 to 49 g. KY0610 Show-Jean (F_1) gave the heaviest plants (49 g). The plants of RN0123 Semi-Heading (F_1) and KY0591 San-Feng (F_1) were medium-sized and weighed 31 and 36 g, respectively. KY1389 Fun Jen (F_1), KY0606 Ching-Chiang and KY0603 Gracious had smaller plants (20–25 g). The hybrids RY0610 Show-Jean (F_1) and KY0591 San-Feng (F_1) gave the highest yields of 1.47 and 1.08 kg/m^2 at UzRIPI, respectively; while 0.4 and 0.29 are yields at IGR, respectively. RN0123 Semi-Heading (F_1) and KY0606 Ching-Chiang accessions were characterized with average yields of 0.93 and 0.75 kg/m^2 at UzRIPI, respectively; while 0.26 and 0.4 are yields at IGR, respectively. The yields of other accessions ranged from 0.48 to 0.66 kg/m^2.

Chemical analysis showed that RN0123 Semi-Heading (F_1), KY1307 Brisk Green (F_1), and FN0231 Butter accessions had the highest dry matter (8.49.2%). KY0606 Ching-Chiang, KY0603 Gracious, and KY1900 Rich Green (F_1) gave the highest sugar content (1.45–1.84%). KY1307 Brisk Green (F_1), KY0603 Gracious, and FN0231 Butter had the highest ascorbic acid content (130–149 mg/100 g). RN0123 Semi-Heading (F_1), KY1307 Brisk Green (F_1), and FN0231 Butter accessions were revealed with carotene content (4.6-5.4 mg/100 g). KY1307 Brisk Green (F_1), FN0231 Butter, and KY0603 Gracious gave significantly higher content for most of the chemical components. Among the studied accessions, only the medium-ripening RN0123 Semi-Heading (F_1) hybrid had a combined average yield and high dry matter and carotene content.

In Azerbaijan, the experiment was conducted on brown soil. The climate was characterized by strong winds, which affected plant development. Seedlings were planted on 60 cm wide raised beds, in double rows with 20 cm between rows and between plants within rows. Plots were furrow-irrigated and mellowed two times. Fertilizer application was 30-20-20 NPK kg/ha.

Table 138. The vegetation period, yield, and chemical composition of pai-tsai, UzRIPI, Uzbekistan

Entry	Accession name	First real leaf (day)	Days after emergence		Yield (kg/m²)	Plant weight (g/plant)	Dry matter (%)	Sugar content (%)	Ascorbic acid (mg/100 g)	Carotene (g/100 g)
			Marketability	Vegetation						
RY0610	Show-Jean (F_1)	5	18	22	1.47	49.0	6.80	0.91	67.2	2.79
KY0591	San-Feng (F_1)	7	23	27	1.08	36.0	7.32	1.07	76.8	3.04
KY1389	Fun Jen (F_1)	5	22	24	0.66	22.0	7.72	1.02	38.4	2.95
RN0123	Semi-Heading i (F_1)	7	23	27	0.93	31.0	9.20	0.86	48.0	5.40
KY0606	Ching-Chiang	5	22	24	0.75	25.0	7.08	1.45	57.6	2.48
KY1307	Brisk Green i (F_1)	5	22	24	0.50	16.8	9.20	1.29	148.8	4.63
KY0603	Gracious	10	27	29	0.60	20.0	7.28	1.84	129.6	3.83
FN0231	Butter	5	22	24	0.48	16.0	8.40	1.29	129.6	4.95
KY1900	Rich Green (F_1)	10	23	27	0.49	16.4	6.80	1.67	67.2	3.33
LSD (5%)		0	0.13	0.9	0.00	0.0	0.00	0.00	0.67	0.00

Results showed that plants started to become marketable at 17–23 days after emergence (Table 139). The hybrids that showed the earliest signs of marketability were ÊY0610 Show-Jean (F_1) hybrids, GN0102 Nylon, and KY0591 hybrid San-Feng (F_1) at 17–19 days after emergence. Plant weight ranged from 29 to 47 g. The entries ÊY0610 Show-Jean (F_1), KY1389 Fun Jen (F_1), KY1307 Brisk Green (F_1), and KY0606 Ching-Chiang had the largest plant weights (45–48 g). ÊY0610 Show-Jean (F1), KY1389 Fun Jen (F_1), and KY0606 Ching-Chiang had the highest yields (0.40 kg/m²). The entries KY1307 Brisk Green (F_1) and GN0102 Nylon had yields equal to 0.34 and 0.38 kg/m², respectively. Other accessions had less yields ranging from 0.26 to 0.29 kg/m².

Results from Azerbaijan and Uzbekistan revealed that ÊY0610 Show-Jean (F_1) hybrid and KY0606 Ching-Chiang are promising crops, which warrant further evaluations.

Table 139. The vegetation period and yield of pai-tsai, IGR, Azerbaijan

Entry	Accession name	First real leaf (day)	Mass marketability (day)	Yield (kg/m²)	Average weight (g/plant)
ÊY0610	Show-Jean (F_1)	3	18	0.40	47
GN0102	Nylon	2	17	0.34	31
KY0591	San-Feng (F_1)	2	19	0.29	34
KY1389	Fun Jen (F_1)	2	20	0.41	48
RN0123	Semi-Heading (F_1)	2	20	0.26	31
KY0606	Ching-Chiang	2	20	0.40	47
KY1307	Brisk Green (F_1)	2	20	0.38	45
KY0603	Gracious	2	19	0.27	32
FN0231	Butter	2	23	0.25	29
KY1900	Rich Green (F_1)	2	23	0.24	29
LSD (5%)		0.0	0.97	0.00	0.0

Reproductive growth of non-heading Chinese cabbage under the climatic conditions of Azerbaijan and Uzbekistan

Non-heading Chinese cabbage or pai-tsai (*Brassica rapa* cv. group Pakchoi) is a non-traditional crop in the CAC region. This study was conducted to examine the ability of this crop to develop seeds under CAC climatic conditions. Ten pai-tsai accessions were grown at UzRIPI and IGR with four replications Seedlings were transplanted to the field in late April 2005.

Soil at UzRIPI is sierozem. Spacing was 70 cm between rows, and 30 cm between plants in each row. The plot was furrow-irrigated six times. A total of 50 kg N, 40 kg P, and 30 kg K per hectare was applied. Hoeing was carried out twice. During the growing season, plants were damaged by downy mildew. Plants of pai-tsai were in rosette stage for a short time. When the temperature went up in the middle of May and one week after the beginning of the plants' marketable stage, the stems emerged fast, and the plants started to flower. Plant height ranged from 40 to 79 cm and diameter from 11 up to 32 cm, with Show-Jean giving significantly taller plants. All entries formed four stem branches except Rich Green (F_1) and Semi-heading (F_1) which formed five and six stem branches, respectively. Stems emerged starting on the 28th until the 33rd day after germination. Seventy-five percent of flowering was from 35 to 68 days germination. Plants of KY1307 Brisk Green (F_1) hybrid remained in rosette stage and did not develop any stem. KY0606 Ching-Chiang and KY1900 Rich Green (F_1) flowered but seeds did not set. Milky ripening of seeds occurred at 74 days after germination for all entries, except two; while gold ripening occurred on the 78th and 84th day after germination. The full seed ripening occurred 82 days after germination for Show-Jean (F_1) and Butter, and six days later for the rest of the entries (Table 140). Seeds per plant weighed 0.6–1.5 g. The entries KY0603 Gracious, FN0231 Butter, and Semi-heading have shown potential for high seed productivity.

A study of pai-tsai accessions was conducted in brown soil in Azerbaijan. Spacing was 60 cm between rows, and 20 cm between plants in each row. The cultural practices carried out included furrow irrigation done five times, fertilization with 30 kg N, 20 kg P, and 20 kg K per hectare, and hoeing.

Plant height was 47–78 cm while diameter was 22–25 cm. About four to five stem branches were formed. Stems emerged at 15–21 days. Mass flowering (75%) was at 48–55 days. Plants of KY0606 Ching-Chiang, KY1389 Fun Jen (F_1), and KY1307 Brisk Green (F_1) remained at the rosette stage and did not form stems. GN0102 Nylon flowered, but seeds did not set. A large variation was observed on days to milky ripening of seeds, which occurred at 52–79 days after germination while gold ripening was at 75–88 days. Full ripeness was reached from 81 to 91 days after germination (Table 141). Each plant produced 0.3–1.3 g of seeds. The variety FN0231 Butter was comparable with the hybrid Semi-heading (F_1) in terms of seed productivity per plant.

Table 140. Characteristics of pai-tsai seeds plants, UzRIPI, Uzbekistan

Entry	Accession name	Days after stem formation	Flowering (day) 50%	Flowering (day) 75%	Ripening (day) Milk 50%	Milk 75%	Gold 50%	Gold 75%	100% Ripening (day)	Seed weight (g/plant)	Plant height (cm)	Plant diameter (cm)	Number of stem branches
KY0610	Show-Jean (F_1)	28	31	35	66	68	74	78	82	0.8	79	23	4
KY0591	San-Feng (F_1)	33	36	40	72	74	80	84	88	0.6	40	24	4
KY1389	Fun Jen (F_1)	28	45	49	72	74	80	84	88	0.7	50	32	4
RN0123	Semi-Heading (F_1)	33	36	40	72	74	80	84	88	1.5	66	25	6
KY0606	Ching-Chiang	28	60	68	-	-	-	-	-	-	63	32	4
KY1307	Brisk Green (F_1)	Left in rosette stage	-	-	-	-	-	-		-	-	-	-
KY0603	Gracious	33	36	40	72	74	80	84	88	1.1	59	24	4
FN0231	Butter	28	31	35	66	68	74	78	82	1.3	64	22	4
KY1900	Rich Green (F1)	33	50	54						-	55	11	5
LSD (5%)		0.10	0.10	0.10	0.10	0.13	0.10	0.17	0.10	0.1	0.10	0.10	0.24

Table 141. Characteristics of pai-tsai seeds plants, IGR, Azerbaijan

Entry	Accession name	Days after stem formation	Flowering day		Ripening (day)				100% Ripening (day)	Seed weight (g/plant)	Plant height (cm)	Plant diameter (cm)	Number of stem branches
					Milk		Gold						
			50%	75%	50%	75%	50%	75%					
KY0610	Show-Jean (F_1)	15	42	51	59	79	62	75	81	0.7	78	25	4
GN0102	Nylon	17	42	49	-	-	-	-	-	-	-	-	-
KY0591	San-Feng (F_1)	16	41	48	39	79	74	81	84	0.6	52	23	4
KY1389	Fun Jen (F_1)	No	stalks		-	-	-	-	-		-	-	-
RN0123	Semi-Heading (F_1)	21	46	53	44	52	79	86	89	1.3	60	23	5
KY0606	Ching-Chiang	No	stalks		-	-	-	-	-	-	-	-	-
KY1307	Brisk Green (F_1)	No	stalks	-	-	-	-	-	-	-	-	-	-
KY0603	Gracious	19	49	55	48	57	85	88	91	0.5	52	23	4
FN0231	Butter	20	44	49	43	54	81	83	85	1.0	50	23	4
KY1900	Rich Green (F_1)	19	48	55	48	59	86	88	91	0.3	47	22	4
LSD (5%)		0.10	0.56	0.10	0.10	0.10	0.10	0.14	0.84	0.2	0.95	0.1	0.47

Results showed that some of accessions did not form stems while others did not flower. Across locations, only FN0231 Butter and Semi-heading (F_1) showed promising seed productivity.

Yield trials of cucumber accessions in Azerbaijan and Uzbekistan

There is a need to select varieties that are well-adapted to the ecological conditions of the CAC region. A study of 10 cucumber accessions was conducted at UzRIPI and IGR. Non-replicated plots were used and due to the limited amount of seeds available only 20 plants per plot were used.

The soil type used at UzRIPI was a sierozem. A row spacing of 140 cm was used, sowing on both sides of the furrow and the spacing between plants in a row was 30 cm. The cultural practices used included 10 furrow irrigations, four hoeings for weed control, and a total fertilization of 140 kg N and 80 kg P per hectare. Downy mildew was observed at flowering and to arrest the development of the disease, sulphur powder was applied.

Seeds were sown on 30 May 2005 and mass seedlings emerged six to eight days after sowing. Male flowers emerged from 28 to 32 DAS. The female flowers emerged from 35 to 43 DAS. Fruit development to marketable stage took 46 to 56 DAS, and to biological ripeness from 59 to 69 DAS (Table 142).

There were differences in yield between accessions, but the level of significance cannot be assessed as the trials were not replicated. Plants of TOT1972, TOT1070, and TOT1973 did not survive the high temperatures and dry air of summer. The fruits of TOT1110, TOT1403, and TOT1074 developed into the marketable stage significantly earlier than the rest of the entries (46 DAS). They were also characterized by early fruit ripening. The productivity per plant ranged from 0.06 to 1.26 kg, and the average plant weight ranged from 14 to 55 g. TOT1110 and TOT1403 had the highest productivity per plant; 1.26 kg and 0.98 kg, respectively. Their average fruit weights were 31 and 40 g, respectively. These accessions were the best based on a number of crop trait indices, with the exception of fruit weight, as the standard variety had larger fruits (55 g). The harsh climactic conditions under which the cucumber trial was grown in Uzbekistan affected crop growth and resulted in low yields.

In Azerbaijan, the experiment was conducted on brown soil. The row spacing was 120 cm with sowing on both sides of the furrow; and a spacing of 60 cm between plants in a row. The cultural practices included 12 furrow irrigations, six hoeings for weed control and a total fertilization of 100 kg N and 60 kg P per hectare. Seeds were sown in April 2005, but the seeds of TOT1974 did not germinate. Male flowers emerged starting at 47 to 66 DAS, while female flowers emerged from 59 to 81 DAS.

Fruits became marketable starting at 74 DAS and ripened from 96 to 108 DAS (Table 143). TOT1404 produced the earliest marketable fruits (74 DAS) and was characterized by early fruit ripening (96 days). The productivity per plant ranged from 0.18 to 1.46 kg. No entries gave a productivity higher than the standard. Only TOT1180 (1.24 kg/plant) came close to the standard's productivity and this was the highest among the test entries. The average weight of fruit ranged from 30 to 85 g and TOT1406 had the best crop trait indices. The weather in Azerbaijan was harsh when the cucumber trial was being conducted and strong winds affected both the yield and quality of fruits.

Characterization of AVRDC mungbean lines in Uzbekistan

Mungbean is a popular crop in CAC countries. This study of 10 mungbean lines was conducted at UzRIPI with four replications. Spacing was 70 cm between furrows, with a single row between furrows, and the spacing was 25 cm between plants in a row. The cultural practices included weeding, hoeing, furrow irrigation, and fertilization (80 kg N and 60 kg P per hectare). Bean weevil *(Bruchus pisorum)* and bacteriosis (Bacterial black rot) were observed. Seeds were sown on 28 April 2005.

Table 142. Selected horticultural characteristics of cucumber, UzRIPI, Uzbekistan

Entry	75% Flowering		75% Ripeness		Productivity (kg/plant)	Average weight of fruit (g)
	Male flower (day)	Female flowers (day)	Market suitability (day)	Biological (day)		
Uzbekskiy-140-st	32	35	49	65	0.68	55
TOT1107	32	35	49	65	0.61	46
TOT1110	28	35	46	61	1.26	31
TOT1180	28	43	49	65	0.06	40
TOT1403	32	35	46	61	0.98	40
TOT1406	28	43	56	69	0.5	40
TOT1972	46	dead				-
TOT1070	35	dead				-
TOT1404	28	43	56	69	0.2	14
TOT1973	dead					-
TOT1974	32	35	46	59	0.2	14

Table 143. Selected horticultural characteristics of cucumber, IGR, Azerbaijan

Entry	75% Flowering		75% Ripeness		Productivity (kg/plant)	Average weight of fruit (g)
	Male flower (day)	Female flowers (day)	Market suitability (day)	Biological (day)		
Fenix-st	66	81	97	114	1.46	85
TOT1107	64	72	93	108	0.76	51
TOT1110	65	78	96	108	0.61	41
TOT1180	66	78	92	107	1.24	50
TOT1403	64	76	89	103	0.12	30
TOT1406	59	71	90	104	0.99	80
TOT1972	54	76	94	109	0.47	72
.TOT1070	60	74	91	111	0.29	52
TOT1404	47	59	74	96	0.28	34
TOT1973	58	78	97	111	0.18	60
TOT1974	-	-	-	-	-	-

Mass seedlings emerged within nine days. Table 144 presents the characteristics and yield of mungbean lines. Days from mass seedlings to first flower ranged from 41 to 51; and ripening of the first pod from 52 to 72 days. VC1178A line was the earliest to ripen. The vegetation period of most lines was the same as that of the standard variety. VC6493-41 and VC6493-42 ripened more than 10 days later than the standard. Height of plant ranged from 24 to 86 cm. The number of pods per plant ranged from 8 to 23 while the number of seeds in a pod, from 8 to 11. The seeds per plant weighed, on the average, 5.7 to 27.0 g. VC6492-59, VC6493-41, VC6493-42, and VC6506-127 had the largest seeds (81–86 g/1000 seeds). Total yield of lines was from 0.32 to 1.54 tons per hectare. Yields at 1st harvest ranged from 159.6 up to 798.0 kg/ha and at 2nd harvest, from 74.1 to 741.0 kg/ha. The highest yields in both harvests were given by VC6493-47 for a total yield of 1.54 t/ha. The entries VC1973A, VC6510-151, and VC6492-59 also had high yields at both harvests giving total yields from 0.97 to 0.99 t/ha. VC6492-55, VC6493-41, VC6493-42, and VC6493-44 lines had lower yields (0.76–0.85 t/ha) than above-mentioned entries but higher than the yield of the standard entry. The high yields of the promising lines were mainly due to their large seeds per plant (16–27 g/plant). VC1973A, VC6493-47, VC6492-59, VC6493-41, and VC6510-151 lines were considered promising based on the observed crop traits. An important characteristic of mungbean is lodging. The promising lines were observed to have no or only slight lodging.

Table 144. Characteristics and yield of mungbean lines, UzRIPI, Uzbekistan

Entry	Days to first flower	Days to ripening 1^{st} pod	Plant height (cm)	Number of pods per plant	Number of seeds per pod	Weight of 1000 seeds (g)	Lodging	Yield of two harvests (kg/ha)		Total yield (t/ha)	Seed weight g/plant
								1st	2nd		
Pobeda 104, st	51	61	42	19	9	68.51	slight	524.4	-	0.52	9,2
VC1178A	41	52	24	16	11	71.63	none	250.8	74.1	0.32	5,7
VC1973A	44	61	57	23	10	72.12	none	558.6	416.1	0.97	17,1
VC6493-47	44	61	82	14	11	77.23	slight	798.0	741.0	1.54	27,0
VC6492-55	49	61	54	15	11	73.20	none	558.6	199.5	0.76	13,3
VC6492-59	51	61	60	12	10	85.68	a little	587.1	410.4	0.99	17,5
VC6493-41	51	72	86	9	9	84.23	a little	367.4	478.8	0.85	14,8
VC6493-42	44	72	67	13	9	80.05	a little	478.8	279.3	0.76	13,3
VC6493-44	51	69	48	8	8	73.10	none	456.0	393.3	0.85	14,9
VC6506-127	51	61	55	9	10	81.32	a little	159.6	387.6	0.55	9,6
VC6510-151	51	63	52	10	8	77.65	a little	570.0	336.3	0.91	15,9
LSD (5%)	0.13	0.27	0.87	0	0	0.24		0.56	0.0	0.00	0.23

Evaluation trial of AVRDC vegetable soybean lines in Azerbaijan and Uzbekistan

Vegetable soybean is a nontraditional crop in the CAC region. Eight lines and varieties of vegetable soybean were introduced from AVRDC. Research studies were conducted at IGR and at UzRIPI. The experiments were conducted from April to October 2005. Trials were conducted with four replications. No check varieties were used to serve as standards in either countries.

At IGR in Azerbaijan, the experiment was conducted on brown soil. Seeds were sown in double rows with 60 cm between rows and 20 cm between plants within rows. Each row had 10 plants representing one replication. The cultural practices included 10 times of furrow irrigation, four times hoeing, weeding and fertilization using a total amount of 60 kg N, 40 kg P, and 20 kg K per hectare. Diseases and pests were not observed in the vegetation period. Seeds were sown on 13 April 2005. Mass seedlings emerged in 20–24 days.

Results showed highly significant differences between accessions. Days to first flower seed emergence ranged from 20 to 24, days to marketability of seeds, from 70 to 95, and days to ripening of seeds, from 119 to 160 days (Table 145). G 12917-Natsunoka and AGS 329-Shironomai were the earliest to ripen (70 days). Biological ripeness of these accessions was at 119 days. Other accessions had long vegetation periods. Plant height at initial flowering ranged from 20 to 73 cm and at ripening, from 33 up to 81 cm. Number of stem nodes ranged from 3 to 7. The total number of pods from 10 plants seeds ranged from 193 to 296, while total weight was from 0.15 to 0.25 kg. More than 90% of the pods had more than two seeds per pod. The number of pods that comprised 500 g ranged from 738 to 929. The weight of 100 green seeds was from 26.3 to 33.7 g. Based on desirable trait indicators set by farmers, two accessions—early-ripening G 12917-Natsunoka and medium-ripening G 10134-Ryokkoh—were considered promising.

Research was also conducted in Uzbekistan. Soil is a typical sierozem. Seeds were sown in double rows with 70 cm between rows and 15 cm between plants within rows. Each row had 10 plants, representing one replication. The cultural practices included eight times of furrow irrigation; two times hoeing, weeding, and fertilization. Mineral fertilizers were applied using a total amount of 80 kg N and 60 kg P per hectare. Diseases and pests were not observed in the vegetation period. Seeds were sown on 27 April 2005. Mass seedlings emerged in 14 days. Seeds of G 9053 and G 10134 did not germinate. Days to first flower ranged from 27 to 45, days to marketability of seeds ranged from 46 to 61, days to biological ripeness of seeds from 95 to 107 (Table 146). G 12917 Natsunoka was the earliest to ripen. G42 Mikawashima and G 12926-Sakata ripened the latest. Other accessions had long vegetation periods (95–110 days). Height of plant at first flower ranged from 18 to 29 cm and at ripening, from 28 to 52 cm. The differences in yield between lines were significant. The number of stem nodes ranged from 3 to 10, while the total number of pods from 10 plants ranged from 182 to 280 and weighed from 0.15 up to 0. 25 kg. The number of pods that weighed 500 g ranged from 757 to 926. The weight of 100 green seeds ranged from 27 to 33 g. Across the two locations, G42 Mikawashima and Misono-green showed promising character traits desired by farmers.

Table 145. Characteristics and yield of vegetable soybean, IGR, Azerbaijan, 2005

Entry	Days to			Heigth of plant at		Number of nodes on the main stem of plant	Yield of 10 plants)			No. of pods in 500 g (> 2 seeds)	Weight of 100 green seeds
	1st Flower	Market suitability	Biological ripeness of seeds	1st Flower (cm)	Ripening (cm)		Total pods	Pods with > 2 seeds	Total weight (kg)		
G42, Mikawashima	22	-	-	-	-	-	-	-	-	-	-
G 12917,Natsunoka	21	70	119	26	55	7	272	253	0.19	929	26.3
G 12926, Sakata Kairvo Mikawashima	23	-	-	-	-	-	-	-	-	-	-
Misono-green	20	78	126	20	36	5	208	196	0.24	830	30.9
G 9053, Tzuzunoko	24	95	160	73	81	7	296	281	0.25	792	32.1
G 10134, Ryokkoh	23	76	124	68	76	6	279	260	0.25	804	31.6
AGS 292, Taisho Shigore	20	75	119	29	51	4	221	203	0.19	738	33.7
AGS 329, Shironomai	21	70	119	22	33	3	193	180	0.15	743	33.2
LSD (5%)	0.59	0.79	0.24	0.0	0.13	0.36	0.28	0.0	0.00	0.22	0.64

Table 146. Characteristics and yield of vegetable soybean, UzRIPI, Uzbekistan, 2005

Entry	Days to			Height of plant at		Number of nodes at main stem of plant	Length of pods with > 2 seeds (cm)	Width of pods with > 2 seeds (cm)	Yield of 10 plants			Number of pods in 500 g (> 2 seeds)	Weight of 100 green seeds
	1st Flower	Market suitability	Biological ripeness of seeds	1st Flower (cm)	Ripening (cm)				Total pods	Pods with > 2 seeds	Total weight (kg)		
G42, Mikawashima	45	61	100	22	50	10	4.8	1.2	280	270	0.20	833	30
G 12917,Natsunoka	27	46	95	28	52	6	5.0	1.1	218	210	0.15	926	27
G 12926, Sakata Kairvo Mikawashima	45	61	107	29	50	7	4.7	1.2	268	260	0.23	757	33
Misono-green	30	49	100	18	28	4	5.0	1.2	204	294	0.25	812	31
G 9053, Tzuzunoko	-	-		-	-	-	-	-	-	-	-	-	-
G 10134, Ryokkoh	-	-		-	-	-	-	-	-	-	-	-	-
AGS 292, Taisho Shigore	30	49	110	25	48	4	5.0	1.2	242	230	0.19	757	33
AGS 329, Shironomai	29	49	106	20	35	3	4.9	1.2	182	172	0.14	758	33
LSD (5%)	0.7	0.0	0.0	0.0	0.9	0.14	0.10	0.0	0.41	0.84	0.0	0.14	0.35

Yield and horticultural characteristics of AVRDC tomato lines in Azerbaijan and Uzbekistan

Tomato is one of the most important and widely grown vegetables in the CAC countries. The study of 10 tomato lines from AVRDC was conducted at UzRIPI and the IGR with two replications as the amount of seeds was limited.

The soil at UzRIPI is a sierozem. Seeds were sown on a nursery bed in the greenhouse and transplanted in beds with a spacing of 140 cm between rows. Planting was on both sides of the furrow and the spacing between seedlings was 30 cm. The cultural practice included 10 furrow irrigations, three weedings via hoeing, and a total application of 140 kg N and 100 kg P per hectare.

The results at UzRIPI showed that the days to mass flowering ranged from 46 to 58 and the days to mass fruit ripening ranged from 96 to 118 (Table 147). The earliest mass ripening of tomato fruits occurred from 96–99 days for CLN 1555 A, CH 15446, and CLN 2026 D. In the hot dry summer conditions of Central Asia, the plants of some tomato lines were distressed and this affected yields. The check varieties gave the largest fruits (152–250 g). Among the lines evaluated, two late ripening lines which matured at 112–115 days, namely CL 5915 – 206 D4 and CLN 8498 E had average yields of 0.7 kg/plant and a fruit weight of 69–78 g. Two small fruited tomato lines (27-28 g) CLN 1555 A and CLN 1762 A had average yield of 0.5 kg/plant. CLN 2026 D was early ripening (97 days) with yield of 0.48 kg/plant and fruit weight of 74 g.

In Azerbaijan, the experiment was conducted on brown soil. The spacing was 60 cm between furrows and 20 cm between plants in a row. The cultural practices included weeding, four hoeings, and a total application of 120 kg N, 80 kg P, and 40 kg K per hectare. The furrows were irrigated once every week.

The results showed that days to mass flowering ranged from 63 to 73, and days to mass ripening from 116 to 129 (Table 148). The earliest mass fruit ripening (116 days) was for line CL 5915 – 206 D4 line. Lines PT4664 B and CLN 8498 E yielded 0.7 kg/plant or more.

Table 147. The vegetation period and yield of tomato, UzRIPI, Uzbekistan

Entry	75% Flowering (day)	75% Ripening (day)	Yield of 10 plants (kg)			Yield (kg/plant)	Average fruit weight (g)
			1st harvest	2nd harvest	Total yield		
Avitsena, st 1	57	115	4.5	-	4.5	0.45	250
TMK-22, st 2	57	115	2.6	-	2.6	0.26	152
CL 5915 – 206 D4	55	112	5.5	2.3	7.8	0.78	69
CLN 8498 E	57	115	5.7	1.5	7.2	0.72	78
CLN 1466 P	52	109	3.0	1.3	4.3	0.43	61
CLN 1555 A	52	99	3.5	1.6	5.1	0.51	27
CH 15446	46	96	0.8	0.8	1.6	0.16	6
PT 4719 A	48	105	2.1	0.7	2.8	0.28	77
CLN 2026 D	50	97	4.0	0.6	4.6	0.46	74
CLN 1762 A	58	118	2.0	3.3	5.3	0.53	28
PT 4664 B	48	105	0.8	1.3	2.1	0.21	15
LSD (5%)	0.14	0.0	0.1	0.1	0.1	0.10	0.38

Table 148. The vegetation period and yield of tomato, IGR, Azerbaijan

Entry	75% Flowering (day)	75% Ripening (day)	Yield of 10 plants (kg)			Yield (kg/plant)	Average fruit weight (g)
			1st harvest	2nd harvest	Total yield (kg)		
Elnur-standard	64	118	2.43	3.21	5.64	0.56	230
CL 5915 – 206 D4	63	116	2.95	3.21	6.16	0.62	75
CLN 8498 E	67	120	3.23	4.32	7.55	0.76	90
CLN 1466 P	69	122	2.63	2.10	4.73	0.47	72
CLN 1555 A	70	121	2.83	2.26	5.09	0.51	30
CH 154	66	123	0.91	0.93	1.84	0.18	12
PT 4719 A	64	124	3.56	2.45	6.01	0.60	82
CLN 2026 D	65	125	1.46	1.53	2.99	0.30	84
CLN 1762 A	71	127	2.83	4.05	6.88	0.69	34
PT 4664 B	73	129	2.79	4.55	7.34	0.73	27
LSD (5%)	0.	0.17	0.91	0.00	0.67	0.10	0.53

Contact: Ravza Malavyona

Afghanistan

Vegetable research on Model Research Plot

With the start of RALF-0104 Project by Relief International (RI), AVRDC, IDE, and Nangarhar University (NU) in late 2004, a Model Research Plot of just a little more than one jerib (2000 m^2) was created at NU ARF to be used for vegetable research in eastern Afghanistan (Figure 35). In the middle of 2005, the research site was expanded to about one hectare (10,000 m^2) to have more area under research trials. An assured source of irrigation has been created and properly maintained. A range of research trials on various crops mentioned under the project have been conducted.

Figure 35. Model research plot established by RALF-0104 Project on NU ARF, Afghanistan.

Carrot seed rates trial

Based on the survey of a number of farmers, it was decided that the famous carrot variety, Manzilianow, which has been imported several years ago and has shown good adaptation to the region, should be tested for its seed rates at NU ARF. The survey showed that most of the farmers use seeds at the rate of 9 kg/ha. It was proposed to test for lower and higher rates of seeds than those used by the farmers.

Four seed rates at 6 kg, 8 kg, 10 kg, and 12 kg/ha, urea at 250 kg, and DAP at 200 kg were applied in each hectare. The experiment was conducted in the form of RCBD with three replications. Statistical analysis of the data is shown in Table 149.

Statistical analysis showed that the lowest amount of seed rate, 6.0 kg/ha gave the highest yield and it looks like even lower seed rates might be useful. On the basis of LSD at 5%, the seed rates of 6 and 8 kg/ha were not significantly different from each other, but 6 kg seed in comparison to 10 and 12 kg/ha were significantly different.

Table 149. Effect of seeding rates on yield of carrots in Nangarhar, Afghanistan

Seeding rate (kg/ha)	Average yield of plot (kg/4.2 m^2)	Yield (t/ha)
6	17.1	40.6 a
8	16.1	38.4 ab
10	13.5	32.1 bc
12	12.1	28.9 c
LSD (5%)		3.5

The same carrot variety was tested under higher levels of fertilizers, urea at 300 kg, and DAP at 250 kg/ha. These rates have adversely affected carrots. As a result of a lot of carbohydrates and water accumulation in the roots, a very thick crown region, misshaped carrots, and large cracking in the roots reduced the market value and storability of the carrots tremendously. Because of that, without doing any statistical analysis, this component of the research was totally taken out from the above experiment.

The experiment is being repeated for the second time with the seed rates of 4, 6, 8, and 10 kg/ha.

Garlic variety performance trial

Four garlic varieties, China Kabuli, China Pakistani, Red Garlic, and Watani Local were planted with farmers level of fertilizer, urea at 200 kg/ha, and DAP at 150 kg/ha in RCBD with three replications.

The above four garlic varieties were chosen in consultation with farmers in Nangarhar Province to be tested for comparative performance at NU ARF. Statistical analysis showed that the two garlic varieties, China Pakistani and China Kabuli, both gave higher yields compared to Red Garlic and Local Watani garlic varieties. There was no significant difference between China Pakistani and China Kabuli as both were giving higher yields than the local variety. The analysis did not show any significant difference between the Red Garlic and Watani local varieties (Table 150).

Table 150. Yield performance of four garlic cultivars at Nangarhar University, Nangarhar, Afghanistan

Cultivar ($kg/4.2\ m^2$)	Average plot yield	Yield (t/ha)
China Pakistani	8.76	17.5 a
China Kabuli	8.16	16.3 a
Red garlic	4.33	8.7 b
Watani (local)	4.16	8.3 b
LSD (5%)		2.2

Based on this study, China Pakistani and China Kabuli varieties are recommended for eastern Afghanistan. Based on the recommendations from last year's results, a comparative variety trial of the Elephant Garlic variety brought from UC Davis, China Kabuli, China Pakistani, and local garlic varieties were planted on 5 October 2005 using RCBD in three replications. Results of the two years will be compared and recommendations will be made based on the statistical analysis of the yield.

Onion variety performance trial

A total number of six onion varieties (Red Local Mazina, Supreme Stone Commercial, Super Swat 1 Commercial, Nasik Red Commercial, Red Brown F 1 Commercial, and N-53 Commercial) collected from local and Pakistani sources and one variety (CAL 606) from AVRDC in Taiwan were first planted and grown in nursery and then transplanted at the beginning of April 2005.

Results showed that CAL 606 from AVRDC, Taiwan was superior to all other varieties which produced significantly higher yields. Red Local Mazina proved to be the second-highest yielding variety followed by Super Stone and then Super Swat 1 (Table 151).

Table 151. Yield performance of seven onion cultivars in Jalalabad, Afghanistan

Cultivar ($kg/4.2m^2$)	Average plot yield	Yield (t/ha)
CAL 606	24.3	40.6 a
Red Local Mazina	17.7	29.4 b
Super Stone	13.4	22.3 bc
Super Swat	11.3	18.9 cd
Red Brown F1 Hybrid	9.5	15.8 cd
Nasik Red	7.3	12.1 d
N-53 Commercial	6.7	11.2 d
LSD (5%)		4.83

In addition to higher yield, CAL 606 appears to be faster or earlier maturing. If it is transplanted in early spring or even late winter, it will perform better and can make it to the market one to two months earlier where prices might be much higher compared to the regular growing season's crop. CAL 606 onion variety has white colour; fleshy, succulent, and tasty leaves with very little or almost no pungency.

On the other hand, CAL 606 onions have a narrow and weaker neck region and thus are intolerant to very windy conditions, hence, this variety will not be recommended to areas with strong winds. Because of the succulent nature of its leaves, this variety needs to be brought to market immediately as it will have short storage period after harvest.

Red Local Mazina came as the second highest yielding onion variety. This variety has been widely cultivated in most parts of Nangarhar Province. The color of its bulb is reddish, leaves are thinner than CAL 606, tastes a little harder, and with good storability and transportability. Cultivation and improvement of this variety is also recommended, especially, for the regular season's crop in most of the areas in eastern Afghanistan (Table 151).

Based on the study, CAL 606 is recommended for early season while Red Local Mazina is the variety for common or regular growing season. Red Local Mazina has good storability and with higher dry matter content, making it better for drying purposes.

Tomato variety performance trial

Twelve out of the seventeen tomato varieties collected from markets in Jalalabad and Peshawar, Pakistan germinated and produced successful seedlings in nursery. These seedlings were transplanted into the field to study their adaptation, performance, and production. The experiment was conducted in RCBD with three replications (Table 152).

Harvest of tomato fruits started in late June 2005 and continued until the end of July 2005. ISI Sementi (Spedra) gave significantly highest yield among the 12 cultivars followed by DN 2498E and then by Roma. Based on this study, ISI Sementi (Spedra) obtained the highest position, DN 2498E the second, and Roma the third; all three can be easily recommended for cultivation in eastern Afghanistan. The performance of the remaining nine tomato cultivars seems to be in need of more research in eastern Afghanistan.

Table 152. Yield performance of 12 tomato cultivars on NU ARF, Jalalabad, Afghanistan

Cultivar (kg/20 m^2)	Average plot yield	Yield (t/ha)
ISI Sementi (Spedra)	58.02	29.0 a
DN 2498E	42.83	21.4 b
Roma	32.30	16.2 c
Jeo7 F1	30.03	15.0 cd
UC 204A	28.03	14.0 cd
Super Roma (1-vf)	23.70	11.9 cd
Gala	22.47	11.4 d
P 74664 B	21.00	10.5 de
Ps (Peto seed)	18.57	9.3 de
S.DT	18.37	9.2 de
Carioon	14.87	7.4 e
Red Jumbo	13.70	6.9 e
LSD (5%)		9.14

Eggplant variety performance trial

Eleven out of the twelve eggplant varieties collected from markets in Jalalabad and Peshawar, Pakistan produced successful seedlings in the nursery. These seedlings were transplanted into field to study their adaptation, performance, and production. The experiment was conducted in RCBD with three replications.

Harvest of eggplant fruits started in the beginning of July 2005 and continued until early August 2005. Hybrid Gogee gave the highest yield followed by Superlong Black, Round Black, Black beauty (Round), and then Super Black (Table 153).

Table 153. Yield performance of 11 eggplant cultivars on NU ARF, Jalalabad, Afghanistan

Cultivar (kg/7 m^2)	Average plot yield	Yield (t/ha)
Hybrid Gogee	20.47	29.2 a
Superlong Black	17.34	24.8 ab
Round Black	16.30	23.3 ab
Black Beauty (Round)	14.23	20.3 b
Super Black	13.57	19.4 b
Be-706 Nanhams	13.20	18.9 bc
Black Ball	13.04	18.6 bc
Long Purple Black	13.04	18.6 bc
Long Black	12.50	18.0 bc
Black Beauty (Long)	11.77	16.8 bc
Purple Early	08.97	12.8 c
LSD (5%)		4.48

Pepper variety performance trial

Eleven out of the 14 pepper cultivars collected from markets in Jalalabad and Peshawar, Pakistan germinated and produced seedlings. These seedlings were transplanted into the field to study their adaptation, performance, and production in eastern Afghanistan. The experiment was conducted using RCBD with three replications.

Most of these pepper cultivars grew successfully until the flowering period, after which, most of the plants showed sudden and aggressive wilting, usually followed by the death of the whole plant. There was no successful harvest and not enough yield data for complete statistical analysis.

According to various literature, there are a number of diseases such as Verticillium wilt, Fusarium wilt, Rhizoctonia wilt, collar rot, and Pythium damping-off diseases that cause different kinds of wilting and death of pepper plants. One or more of the above diseases might have been the cause of severe damage to these pepper plants. This matter needs extensive study.

The above problem was discussed with the scientists in AVRDC Headquarters in Taiwan. It was decided that ten pepper varieties have shown resistance to most of these wilts: ICPN 15 #1, #2, #3, #4, #5, #6, #7, #8, #9, and #10. The varieties that survived and showed signs of promising yield will be tested for variety performance and adaptation in 2006 on NU ARF.

Mungbean variety performance trial

Five mungbean cultivars (NM 92, NM 94, Nayab 92, Qunduzi (improved) and Watani (local) were planted in RCBD with three replications for variety performance and production testing in eastern Afghanistan. The first two varieties, NM 92 and NM 94 were brought from AVRDC in Taiwan, Nayab 92 from the International Center for Agricultural Research in the Dry Areas (ICARDA) and Qunduzi (locally known as 'Zeraaty' or 'Improved mungbean') and Watani cultivars were collected from the local market in Jalalabad, Afghanistan.

Statistical analysis at LSD 5% showed that all the five mungbean varieties were significantly different from each other and performed consequently as Nayab 92, NM 94, NM 92, Watani (local) and Watani Zeraati or Kunduzi (Table 154).

A similar trial has been conducted on eight collaborating sites in the districts where each collaborating farmer is treated as one replication.

Table 154. Yield performance of five mungbean cultivars at NU ARF, Jalalabad, Afghanistan

Cultivar (kg/15 m^2)	Average plot yield	Yield (t/ha)
Nayab 92	1.833	1.222 a
Nm 94	1.540	1.028 b
Nm 92	1.370	0.915 c
Watani (Local)	1.300	0.868 d
Watani (Kunduzi)	0.950	0.637 e
LSD (5%)		0.019

Vegetable demonstration/research in districts

Twenty-three farmers were selected to demonstrate and/or research carrots, onions, garlic, tomato, eggplant, pepper, cucumber, okra, mungbean, green bean and peanut cultivars as alternatives to opium poppy cultivation, processing and marketing in 10 districts in Nangarhar Province. The 10 districts are Behsud, Rodat, Kot, Chaprahar, Ghani Khel, Achin, Surkhrud, Torghar, Khugiani and Sherzad (Table 155).

Seven of the selected farms are equipped with 260 square meters green houses. A low cost drip irrigation system previously installed in four greenhouses will be repaired and rehabilitated in the above greenhouses (Table 155). It is planned to complete the installation of this low cost drip irrigation system in all the seven greenhouses repaired and rehabilitated by RALF program in the month of January, 2006.

The vegetable varieties used are either local or have been imported throughout the years, mostly from Peshawar, Pakistan and have shown adaptation to most of the eastern parts of Afghanistan.

Carrot, garlic, onion, tomato, eggplant, pepper, cucumber, okra, mungbean and peanut planted in 2005 were harvested and the data was taken. Distributions of green beans and green peas and winter vegetables (different kinds of radishes, garlic and cilantro and onion seeds for onion transplants production) was done in the months of October and November 2005.

Table 155. Distribution of vegetable demonstration trials in 10 target districts, Afghanistan

	Districts										
Vegetable	Behsud	Rodat	Kot	Chaprahar	Ghani-Khel	Achin	Surrud	Torghar	Khugiani	Sherzad	Total
Carrots	0	0	0	0	0	0	1	0	0	0	1
Garlic	2	7	4	2	3	1	2	2	3	0	26
Onion	2	6	3	2	2	1	1	2	2	2	23
Tomato	2	2	2	2	2	1	1	1	2	0	15
Eggplant	1	2	2	2	2	1	0	1	2	0	13
Pepper	1	2	2	1	2	1	0	1	2	0	12
Cucumber	4	1	1	0	1	0	0	2	1	0	10
Okra	3	3	3	2	2	1	3	2	2	0	21
Mung bean	4	6	3	5	2	1	0	2	2	0	25
Green peas	2	7	4	2	3	1	2	2	3	0	26
Peanut	0	0	0	0	0	0	0	0	2	0	2
Total number of trials	21	36	24	18	19	8	10	15	21	2	174

The protocol with the selected farmers is that the farmers provide between 1000 and 2000 square meters of good agricultural land, irrigation water, do all kinds of agricultural work set forth for the trial, protect their farms from animals, children, flooding and inform the RALF program of any disease and pest attacks. The responsibility of RALF program is to provide good quality seeds and seedlings, simple agricultural tools, chemical fertilizers, and in case of diseases and pests, identifying the problem and providing control measures as needed. Teaching modern vegetable production technology to the collaborating farmers is also the program's responsibility. The goal is to change the common and low-value agriculture into a modern, high-value horticulture/vegetable production system to earn more money from each unit of land and to reduce and eventually eradicate the dependency of the collaborating farmers on poppy cultivation, processing and marketing in eastern Afghanistan.

Seven previously installed greenhouses were inherited from the program of Creating Restoring Alternative Livelihood Sources (CRALS) of Relief International. These greenhouses were repaired and rehabilitated and used for winter vegetable production in the off-season with a low-cost drip irrigation system installed under the guidance of IDE (Table 156).

In the spring of 2005, the RALF program proposed to distribute 500 g of tomato seeds, 300 g of eggplant seeds and 200 g of chili pepper seeds as well as seeds of leafy vegetables such as cilantro to each of the collaborating farmers. These seeds were planted in seedbeds in the greenhouses or under plastic covers in the open field to produce transplants.

Haji Hashmatullah, the selected farmer in Rodat District, planted 100 m^2 of his greenhouse area with tomato, eggplant and pepper. He was able to sell an equivalent of 12,000 Afs worth of transplants from the above 100 m^2 area. These were extra ordinary high-value vegetable transplants crop in addition to the regular tomato, eggplant, and cucumber crops from his greenhouse. These kinds of nurseries were planned as intercrop in the empty edges, corners and strips in the middle of the regular crop rows of the greenhouses. The transplants became a third high-value crop in addition to the two crops growing during the regular season.

Onion production on collaborating farms

Onion is an important vegetable grown in most parts of Nangarhar Province. Unfortunately this year, more than 90% of the onions in Nangarhar Province were attacked by downy mildew disease, *Peronospora destructor* and one of the thrips, *Thrips tabaci*. These problems were identified by RALF program and a special prescription, a chemical control measure, was recommended to the farmers. The recommended control measure consisted of using a fungicide, Mancozeb, for controlling the downy mildew and a semi-systemic insecticide, Cypermethrine, for controlling the thrips. The technical assistants of the program helped and instructed the farmers in the implementation of the control measure. The measure worked very well and the RALF program was able to save the onion crop of the collaborating and many other neighboring farmers from almost a total loss.

The farmers who have planted onions under the RALF program were able to produce about 24.22% more yield than that of the neighboring farmers who were not supervised by the RALF Program. The program provided good seeds of the wanted variety, fertilizers, disease and pest control measures and training in vegetable production technology to the collaborating and the neighboring farmers.

Most of the farmers in these districts regularly plant onions on broadcast/scattered pattern, not in rows. The program proposed a fixed plant-to-plant and row-to-row distance (20 cm x 10 cm) to be able to plant a total number of 50 onions per square meter (500,000 plants/ha). Our collaborating farmers were able to produce 8.20 kg onions/m^2 (82,000 kg/ha) from planting in rows, 8.50 kg/m^2 (85,000 kg/ha) if planted in a broadcast or scattered system under RALF program, and 6.56 kg/m^2 (65,600 kg/ha) when planted in broadcast system not supported by the RALF program.

Table 156. Seven greenhouses repaired and rehabilitated in four districts, Afghanistan

Districts	Behsud	Rodat	Kot	Chaprahar	Ghani-Kheyle	Achin	Surrud	Torghar	Khugiani	Sherzad	Total
Number of greenhouses	1	1	2	0	3	0	0	0	0	0	7

The collaborating farmers were able not only to fill but surpass the average yield value of the opium poppy crop from each unit of land planted with onions (Table 157). This calculation has been done on the basis of Afs. 3.56/kg onions on 7 May 2005 at farm gate sale on the ground. Prices can go up or come down as the harvest season advances. These farmers were able to produce almost six times of the value of the wheat crop and a little bit higher than the value of the opium poppy. This result looks promising and most of the collaborating farmers think if they are provided with good seeds of the good crop varieties, fertilizers, agricultural tools and equipment, diseases and pest management, and training in vegetable production and protection technology they might be able to fill most, if not all of the gap of the crop value between wheat and opium poppy.

Tomato production on collaborating farms

Tomato is another crop widely planted by vegetable growers in Nangarhar Province and planted by our collaborating farmers under the RALF program. A collaborating farmer in Behsud District, Haji Ansarullah, was able to produce off-season inside the greenhouse 9.75 kg tomatoes in each m^2 and sold the produce at 10.50 Afs/kg compared to 4.20 Afs/kg in the regular growing season. This is 2.5 times more than the regular growing season.

Our collaborating farmers are growing tomatoes in the open field during the regular growing season as well. The yields of these collaborating farmers were compared with the yields of the neighboring farmers who were not receiving any assistance from the RALF program.

Tomato fruitworm, *Heliocoverpa (Heliothis) zea*, was widespread as a pest on tomatoes in 2005 in most areas of Nangarhar Province. The program did not anticipate that the pest would be that serious and did not plan for a successful integrated pest management program for the current growing season. After identifying the pest, all the collaborating farmers and a number of other lead farmers have been trained how to identify and manage the pest in tomatoes in 2006.

Patches of eggs of the pest can be recognized with the naked eye on the lower surfaces of the tomato leaves in the early flowering time. This is the time to plan and practice reliable control measures. The control measures practiced should be based on IPM principles. For example, if the infestation is very light, a few egg patches on the leaves can be discarded mechanically and should not call for a wide chemical application. On the other hand, a heavy infestation can not be managed efficiently without a timely application of an effective chemical. Hail was another problem that hit most of the vegetables in the month of June 2005. Tomatoes with their heavy clusters of fruits in Ghani Kheyl and Achin districts were among the heavily damaged fields.

Eggplant production on collaborating farms

Eggplant is the other vegetable variety grown in eastern Afghanistan and as such is part of our project and has been planted by the collaborating farmers under the RALF program. The comparative analysis of the yields of the crops under the RALF program and the common neighboring farmers with no technical support is presented in Table 157.

Pepper production on collaborating farms

Chili pepper varieties have a considerable consumption in Afghanistan in general and in eastern Afghanistan in particular. Most of the chili peppers used to be imported from different parts of Pakistan. According to our baseline socioeconomic survey now a considerable amount of green chili pepper consumed in Afghanistan is produced around the city of Jalalabad, Behsud District and Lalpura District in Nanagarhar Province.

Table 157. Yield comparison of vegetables grown under RALF supervision with non–RALF farmers in each hectare, Afghanistan

No.	Field	Onion	Okra	Tomato	Eggplant	Pepper	Peanut
1	RALF	61,633	23,700	30,000	24,000	11,520	1,100
2	Non-RALF	47,778	18,900	23,800	15,000	8,760	960
3	Difference in yield	13,855	4,800	9,200	9,000	2,760	140
4	Difference in %	22.48	20.25	20.66	37.50	24.53	12.72

As pointed out earlier pepper plants are being attacked by numerous types of diseases, thus affecting the pepper production industry in eastern Afghanistan.

Impact of RALF-0104 project on vegetable yield

Onion, tomato, eggplant, pepper, okra, and peanut grown on the collaborating farms gave between 12.72 and 37.50% more yield than the same crops that are not supported by the RALF program (Table 157).

Mungbean performance and production on collaborating farms

The same five varieties of mungbean, tested in NU ARF, were distributed to eight collaborating farmers in the districts and planted for variety performance under field conditions. Each of the collaborating farmers was considered as a separate replication for the statistical analysis (Table 158). Five mungbean cultivars (NM 94, NM 92, Nayab 92, Qunduzi [Zeraaty/ Improved] and Watani) were tested for variety performance and production on the collaborating farms in eastern Afghanistan (Figure 36). The first two varieties, NM 94 and NM 92 were brought from AVRDC in Taiwan, Nayab 92 from ICARDA, and Qunduzi and Watani cultivars from the local markets in Jalalabad, Afghanistan.

The results of trials from the field closely match with that of NU ARF. The experiment will be repeated at the end of 2006 and on the basis of the results of both years, trials, logical recommendations can be made on the higher yielding varieties to the farmers in eastern Afghanistan (Table 158).

Figure 36. Five mungbean variety performance trial in Rodat District, Afghanistan.

Peanut production on collaborating farms

Peanut grows in Chaprahar, Torghar, Khugiani, and Sherzad districts of Nangarhar Province. A peanut variety called Improved or Zeraaty which has been used by growers for the last several years was distributed to two collaborating farmers in Khugiani District. The theme was to demonstrate to the growers the technology of row planting, uniform spacing, and shallow irrigation furrows, and at the end to compare the value of the crop with that of the regular peanut farms and eventually with the opium poppy crop value (Table 158). It is hypothesized that the peanuts grown with collaboration of the RALF Program will prove to be one of the suitable alternatives to poppy cultivation in eastern Afghanistan.

Table 158. Mungbean yield comparison on eight collaborating farms, Afghanistan

No.	Farmer name	NM-94	NM-92	Nayab-92	Watany	Kundozi
1	Haji Sher Mohd	1,040.00	812.50	1,045.00	476.15	690.00
2	Haji Multan	1,445.00	1,630.00	1,445.00	865.00	595.00
3	Naser Khan	1,035.00	970.00	945.00	890.00	840.00
4	Sharafdin	1,015.00	I,100.00	1,100.00	960.00	750.00
5	Fazuldin	1,210.00	1,480.00	1,430.00	1,325.00	805.00
6	Qader Khan	657.50	895.00	460.00	710.00	428.50
7	Nurulhodah	1,200.00	1,165.00	1,080.00	915.00	1,000.00
8	Said Nabi	1,150.00	695.00	720.00	835.00	335.00
Total		8,752.50	8,747.50	8,225.00	6,976.10	5,443.50
Average		1,094.06	1,093.44	1,028.12	872.10	680.40

Drip irrigation technology in vegetable production

Because of the continuous drought and difficulty in getting irrigation water in southern districts of Nangarhar Province, it was decided to include a low-cost drip irrigation component in this RALF project.

International Development Enterprise, one of the four co-implementing institutions is taking care of the drip irrigation installation on the selected farms. IDE's representative, Mr. Sudarshan, has come two times for the duration of one week each time. His second trip to Jalalabad, Afghanistan was in early March of 2005. Both of the technical assistants of RALF Program, Engr. Mohd. Jalil Niazi and Engr. Amin Yar Anwary as well as the program coordinator Ehsanullah Ehsan obtained training in the installation of the low-cost drip irrigation system. Following the training, low-cost drip irrigation systems were installed on NU ARF, four greenhouses and a number of kitchen gardening kits around the houses. These low-cost gravitational flow drip irrigation systems have come in the covering capacities of 260, 200, and 20 m^2 area.

RALF Program repaired and rehabilitated seven greenhouses inherited from the finishing CRALS Program of Relief International in the month of December 2005. The program has invited the representative of IDE, Mr. Sudarshan, to travel to Jalalabad, Afghanistan and help in the installation and improvement of the low-cost drip irrigation system in all the greenhouses repaired and rehabilitated in the districts.

Provision of clean irrigation water for the drip irrigation system is the outstanding limitation in this technology. From one side the irrigation water from the streams is not clean and causes the blockage of the pipes after a while. It is usually costly and sometimes impractical for the farmers to fill the irrigation reservoir (Beryl) manually. This problem was solved by one of the greenhouse owners, Mr. Hashmatullah, in Rodat District. It was decided to construct a stage for the Beryl inside the housing compound next to the drinking water well and extend the water distribution pipes to the greenhouse. Women and children of the household will fill and feed the Beryl from the well as needed. In this case the drip irrigation technology will be successfully implemented and managed by the women and children of the household.

Testing imported vegetable varieties

Three varieties of watermelon, one variety of cucumber and two varieties of okra from the Known-You Seed Company in Taiwan; two mungbean varieties and very small amounts of seeds of 10 chili pepper varieties from AVRDC, Taiwan; and one garlic variety (elephant garlic) from UC Davis, California were brought to be tested for survival, adaptation, performance and production in Nangarhar Province.

The cucumber variety, Fountain F_1 hybrid, from the Known-You Seed Company in Taiwan has very good survival, adaptation, performance in vegetative growth, heavy flowering, and successful fruit set. The fruits are up to 33 cm long with a diameter from 1.75 to 4.00 cm in its tender stage, are dark green in colour, and are tasty and crispy. Diameter of the fruit is consistently uniform from one end to the other end. If harvested while the diameter of the fruit is within the range of 1.75 and 3 cm, it will give good quality and high yield. It has been decided that this cucumber variety will be used for winter cucumber production in the greenhouses.

The okra varieties have shown very aggressive vegetative growth and good flowering. The fruit is light green and tasty but thicker when compared to their pictures in the catalogue, as well as to the other okra varieties common in Nangarhar. It is apparently tolerant to powdery mildews. Unfortunately the thickness of the fruit discredits the variety in the market.

The watermelon varieties seem to be intolerant of the high heat, for example over 40°C for many days and weeks in the flowering and fruit-set time. It is recommended to plant these varieties in early spring so that they will produce fruit just before the hard and long hot summer.

The 10 chili pepper varieties brought from AVRDC, Taiwan, were planted first in pots to produce transplants and then transplanted in the Shisham Bagh Research Farm of the Department of Agriculture of Nangarhar Province in Jalalabad. Most of these varieties survived and showed adaptation in the beginning and grew almost successfully up to the flowering and even the fruit-set stage. These pepper varieties were planted to produce as much seeds as possible for next year's pepper variety performance trial. This was a variety survival and seed multiplication project to be used in variety adaptation, performance, and production trials for the year 2006. Unfortunately because of the lack of irrigation water and some other problems, these could not be grown up to the seed production stage. Hence, not enough seeds of each variety for the variety performance trial of 2006 were produced.

Because pepper plants were attacked by a number of plant diseases in Nangarhar Province, there is a need to look for productive and tolerant varieties for economical pepper production. These 10 pepper varieties, which have shown disease resistance of different levels in Taiwan, were brought for the second time. It is planned that these pepper varieties be tested with a number of successful local chili pepper varieties under the supervision of NU ARF.

The elephant garlic brought from the University of California (UC) Davis survived and performed well and produced good bulbs and cloves. The seed cloves of the above garlic variety were kept to be used in the second garlic variety performance trial with other successful garlic varieties in 2006.

Training collaborating and lead farmers in vegetable production technology

The program has been working in training vegetable farmers in production and protection technologies in 10 target districts. These training programs have been conducted in RI training centers in the districts and the City of Jalalabad. In addition to the group training there has been one-on-one training for a number of selected farms in different districts. A total number of 124 farmers got training in district centers or other places in five different training sessions and about the same number or even more farmers have benefited from our practical one-on-one and small-group training on site. Some of these farmers have benefited from both kinds of the training programs. The last training was in Vegetable Nursery Management in late December in the Faculty of Education of Nangarhar University in the City of Jalalabad.

In addition to training farmers the program has been involved in the training of agricultural extension agents of the Department of Agriculture of Nangarhar Province. The program has been helping to train the agricultural engineers of RI as well. Special training has been offered to the RI engineers while studying and identifying diseased samples brought by the RI engineers or the collaborating farmers from fields. Training agricultural engineers of the Department of Agriculture and that of RI is part of the capacity building strategy of the RALF program in Nangarhar, Afghanistan.

Socioeconomic baseline survey

To assess the socioeconomic status of the Afghan farming households and find out the cropping patterns and how and where the agricultural products are used in the farming communities, a baseline survey consisting of production and consumption surveys was designed and prepared by Dr. Mubarik Ali, the agricultural economist from AVRDC. Dr. Mubarik Ali took two trips to Jalalabad and trained the surveyors in three teams. The production survey team consisted of six NU instructors, the consumption survey team consisted of two senior female high school teachers, and a data entry team consisted of two NU instructors.

The production survey team has completed surveying 240 farmers for information in agricultural production processes (Figure 37) and the consumption survey team has completed surveying female heads for information about consumption of agricultural products in 230 households. The questionnaires are entered in the computers for detailed socioeconomic analysis.

Figure 37. Six professors of NU working while production survey team are surveying farmers for information in agricultural production processes, Afghanistan.

Role of the RALF-0104 Project on capacity building

Impact on Nangarhar University capacity building

Agriculture as an applied science can be taught efficiently if the theoretical knowledge is demonstrated and researched in the laboratories or on the research farm.

There are a few empty laboratory rooms in the Faculty of Agriculture at NU. Changing these empty rooms in to active agricultural or biological labs call for lots of funds and expertise and can be achieved step-by-step through continuous effort and long-term planning.

An agricultural area of about one hectare was selected, fenced and improved into an agriculture research farm on Nangarhar University Campus. A water pump was also installed to irrigate the plots while the Nangarhar Irrigation Canal is turned off for cleaning and repair services. In addition to that a low-cost drip irrigation system covering 200 m^2 and 20 m^2 area have been installed. As a result, NU instructors were assigned to start comparative variety performance trials on several onions, garlic, tomato, eggplant, pepper and mung bean varieties and different seed rates on a famous carrot variety, Manzilianow.

In general, the RALF-0104 Project has been creating impact on the capacity-building skills of the Faculty of Agriculture at NU. Twelve senior and junior professors have been trained in research project design, implementation and recording basic data for statistical analysis. Six instructors have been trained in conducting a socio economic baseline survey. Two junior instructors have been trained in entering data of the socioeconomic survey in the computers. Three junior instructors have learnt sampling, harvesting, measuring yields, taking data, and recording the comparative performance of varieties throughout the growing/ production season. Three junior instructors have taken research projects that will be conducted on NU ARF in 2006 for their academic promotion. This, in general, has created a convenient situation for junior instructors and some of the talented senior students to assist the researchers in the implementation of the research projects and get a chance to benefit academically and in some cases financially.

About 180 senior and junior students from the departments of Agronomy, Horticulture and Plant Protection have been working in weeding, irrigation, spraying for disease and pest control and watching or learning methods of sampling, harvesting, measuring yield and taking data for statistical analysis.

The research farm is able to produce clean and fresh agricultural products that can be sold at reasonable prices to the university academic and common staff which will create a cash flow for maintenance and further improvement of the farm. It will also help in the introduction of improved crop varieties to the surrounding communities or even the entire eastern Afghanistan. A research farm at this kind of stage has the potential to attract the attention of several other donors for further expansion and improvement.

The Faculty of Agriculture of NU with the above kind of research facility is developing the capacity to train agricultural extension agents of Nangarhar, Laghman, Kunar and Nuristan provinces.

Moreover, possibilities have been created for 15 wheat variety performance trial conducted by ICARDA with the collaboration of the Department of Agronomy at Faculty of Agriculture.

Impact on the economic development of farming community

The RALF-0104 Project has been working with 25 collaborating farmers in 10 southern districts in Nangarhar Province. These districts were among the highest poppy cultivating areas in the province. In 2003 and 2004, about 85% of the good agricultural land of these districts was cultivated with opium poppy. In 2005, most of the above land was cultivated with wheat. The reduction in poppy cultivation was mostly due to law enforcement, which banned poppy cultivation. All the 25 collaborating farmers of the RALF-0104 Project and a good number of other farmers in these areas have expressed repeatedly that if the international community and the government of Afghanistan continue their efforts in the alternative livelihood programs they will not only reduce poppy cultivation and trading but will be ready to stop it at once.

The RALF program is affecting the farming community through empowering the farmers to use the lessons learnt under the RALF program in finding suitable alternatives for opium poppy cultivation, processing, and trading in eastern Afghanistan. The results of a number of our vegetable research and demonstration projects have shown that there is a very good possibility that some of the vegetables, especially if combined with some of the improved vegetable growing technology, have the potential of becoming a good alternative to poppy cultivation in eastern Afghanistan (Table 159).

As a result of the socioeconomic baseline survey and asking shopkeepers, merchants and individual farmers, the crop value of opium poppy from each unit of land was estimated and compared with a number of vegetables, fruits, and cereal crop values. It was found that the value of the wheat crop was only one-sixth of the opium value of each unit of land.

The above economic gap is forcing farmers, especially smallholders, to go after illegal crops and businesses such as poppy cultivation, processing, and trading in eastern Afghanistan.

Under the supervision of the RALF-0104 Project, the collaborating farmers as well as a number of regular farmers in these areas were able to obtain economic value from some of the vegetable varieties.

Over 150 farmers were trained in vegetable production technology in six training sessions in the RI Training Centers in Rodat and Khugiani districts and in the Faculty of Education of Nangarhar University in the city of Jalalabad. About 170 farmers obtained practical vegetable production technology training in their fields individually or in small groups.

Table 159. Comparison of opium poppy crop value with a number of vegetables, fruits, cereals, and vegetable nursery crops from one-fifth of a hectare (2000 m^2) land in Afghanistan, 2005

Number	Crop	Yield value	Remarks
1	Opium poppy	60,000	
2	Onion	57,250	
3	Okra	54,320	Usually both seasons
4	Garlic	52,000	
5	Spinach	50,000	Haji Naser Khan
6	Tomatoes	44,100	
7	Eggplants	37,800	
8	Sour orange	32,000	
9	Santa Rosa plums	28,000	
10	Barley	15,000	
11	Wheat	10,000	
12	Vegetable nursery	120,000	Estimated on small scale nurseries with RALF collaborating farmers

Contact: Ehsanullah Ehsan

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

Dr. Paul M.H. Sun, Chair
Taiwan/R.O.C.

Dr. Gilles Saint-Martin, Vice-Chair
France

Mr. Robert Havener[16]
USA

Mr. Hiroto Hirakoba[16]
Japan

Dr. Mark Holderness[17]
United Kingdom

Dr. Tzu-Bin Huang
Taiwan/R.O.C.

Dr. Yu-Tsai Huang[17]
Taiwan/R.O.C.

Dr. Viroch Impithuksa
Thailand

Mr. Koichi Ito[17]
Japan

Dr. Romano M. Kiome
Kenya

Dr. Stephan Krall
Germany

Dr. Il-Gin Mok[17]
Republic of Korea

Ms. Nicole Senécal[17]
Canada

Professor Sally Smith
Australia

Dr. Ichiji Yamashita
Japan

Dr. Thomas A. Lumpkin (ex-officio)
Director General, AVRDC

Contact: Adrienne Mak

[16] Left in 2005
[17] Arrived in 2005

Staff

Administration

Dr. Thomas A. Lumpkin, Director General, <lumpkin@avrdc.org>

Comptroller's Office

Ms. Shaw-wei Chai, Comptroller, <nancy@avrdc.org>
Ms. Ya-ting Yang[17], Internal Auditor

Grant Development Office

Dr. Friedemann Markus Kaiser, Grant and Gift Development Coordinator, <kaiser@avrdc.org>
Dr. Gregory C. Luther, Consultant/IPM/Development Program, <gcluther@avrdc.org>

International Cooperation Office

Dr. George Kuo, Head, <gkuo@avrdc.org>
Ms. Li-ju Lin, Principal Research Assistant, <mandy@avrdc.org>
Ms. Yun-yin Hsiao, Principal Research Assistant, <ruby@avrdc.org>

Office of the Deputy Director General (Administration and Services)

Dr. Yin-fu Chang,[17] Deputy Director General (Adminstration and Services) <yfchang@avrdc.org>

Communications and Training Office

Dr. Thomas Kalb, Information and Training Officer and Head, <kalb@avrdc.org>
Mr. Yi-ming Chen, Principal Research Assistant, <ymchen@avrdc.org>

Computer Services Unit

Mr. Hsien-yang Tien, Assistant Specialist, <tien@avrdc.org>
Ms. Yuh-ling Chen, Research Assistant, <shirley@avrdc.org>

Library Services Unit

Ms. Fang-chin Chen, Officer/Chief Officer, <fcchen@avrdc.org>

Food and Dormitory Services Unit

Ms. Sui-fang Wu, Superintendent, Food and Dormitory Services Unit, <lydia@avrdc.org>

Technical Services Office

Mr. Yun-sen Wang, Superintendent, Technical Services Office, <ysw@avrdc.org>

Office of the Deputy Director General (Research)

Dr. S. Shanmugasundaram,[16] Deputy Director General (Research)
Dr. Jacqueline Hughes,[17] Deputy Director General (Research) <j.hughes@avrdc.org>
Ms. Dolores R. Ledesma, Specialist for Statistics and Database Development, <didit@avrdc.org>

Bulb Allium Unit

Dr. Paul A. Gniffke, Plant Breeder, <gniffke@avrdc.org>
Dr. Leonidas Fereol,[16] Allium Biotechnology Specialist, <lfereol@avrdc.org> (Seconded Scientist from France)
Ms. Shin-jiun Cherng, Principal Research Assistant, <sjcherng@avrdc.org>
Ms. Swee-suak Ko,[16] Principal Research Assistant, <rachelko@avrdc.org>

Legume Unit

Dr. S. Shanmugasundaram,[16] Plant Breeder, <sundar@avrdc.org>
Mr. Motoki Takahashi, Associate Plant Breeder (Legume), <mtaka@avrdc.org>(Seconded Scientist from Japan)
Miao-rong Yan, Principal Research Assistant, <yanmr@avrdc.org>

Pepper Unit

Dr. Paul A. Gniffke, Plant Breeder, <gniffke@avrdc.org>
Dr. Do-Ham Pae,[16] Plant Breeder (Pepper), <pdoham@avrdc.org> (Seconded Scientist from Korea)
Dr. Jong-Gyu Woo,[17] Plant Breeder, <woojgyu@avrdc.org> (Seconded Scientist from Korea)
Ms. Sheue-chin Shieh, Principal Research Assistant, <jin@avrdc.org>
Ms. Shih-wen Lin, Research Assistant, <susan@avrdc.org>

Mycology Unit

Dr. Tien-chen Wang,[18] Specialist, <tcwang@avrdc.org>
Mr. Zong-ming Sheu, Principal Research Assistant, <zmsheu@avrdc.org>
Mr. Chien-hua Chen, Principal Research Assistant, <wallace@avrdc.org>

Virology Unit

Dr. Sylvia K. Green, Plant Pathologist, <skg@avrdc.org>
Mr. Wen-shi Tsai, Principal Research Assistant, <wenshi@avrdc.org>
Ms. Su-ling Shih, Principal Research Assistant, <suling@avrdc.org>
Ms. Yi-chien Huang, Principal Research Assistant (Project), <yichien@avrdc.org>

Biotechnology/Plant Physiology Unit

Dr. C. George Kuo, Plant Physiologist, <gkuo@avrdc.org> (Plant Physiology Unit)
Dr. Chien-an Liu, Assistant Scientist–Molecular Biology, <liuchien@avrdc.org> (Biotechnology Unit)
Dr. Teng-yung Feng,[17] Sabbatical Scientist, <nature@avrdc.org>
Dr. Sengoda Venkatesan,[17] Post-Doctoral Fellow in Plant Virology and Molecular Genetics <venkat@avrdc.org>
Ms. Huei-mei Chen, Associate Specialist, <hmchen@avrdc.org>
Ms. Jean-yu Lin, Principal Research Assistant (Project), <jean@avrdc.org>
Ms. Yen-wei Wang, Research Assistant (Project), <vivian@avrdc.org>
Ms. Ching-ling Lee,[17] Principal Research Assistant (Project), <cllee@avrdc.org>
Ms. Shih-yi Pan,[17] Principal Research Assistant (Project)
Ms. Ching-mei Chien,[17] Research Assistant (Project), <shruka@avrdc.org.tw>

Tomato Unit

Dr. Peter H. Hanson, Plant Breeder, <hansp@avrdc.org>
Dr. Elaine B. Graham, Post-Doctoral Fellow in Molecular Plant Breeding, <graham@avrdc.org>
Mr. Jen-tzu Chen, Associate Specialist, <jtchen@avrdc.org>
Ms. Shu-fen Lu, Research Assistant, <lsf@avrdc.org>
Ms. Shu-mei Huang, Research Assistant, <shumei@avrdc.org>

Crop and Ecosystem Management Unit

Dr. Manuel C. Palada, Vegetable Production/Ecosystems Specialist, <mpalada@avrdc.org>
Dr. Peter Juroszek,[17] Post-Doctoral Fellow in Organic Vegetable Production, <juroszek@avrdc.org>
Dr. Chin-hua Ma, Associate Specialist, <mach@avrdc.org>
Ms. Heidi Lumpkin, Research Consultant on Organic Agriculture, <heidi@avrdc.org>
Mr. Deng-lin Wu, Principal Research Assistant, <dlwu@avrdc.org>
Ms. Shao-wen Chiang,[16] Research Assistant (Project), <sylviach@avrdc.org
Ms. Chia-chien Lin,[17] Research Assistant (Project)

Entomology Unit

Dr. N. S. Talekar,[16] Entomologist, <talekar@avrdc.org>
Dr. Ramasamy Srinivasan, Post-Doctoral Fellow in Entomology, <amrasca@avrdc.org>
Ms. Mei-ying Lin, Principal Research Assistant, <turtle@avrdc.org>
Mr. Fu-cheng Su, Principal Research Assistant, <sufc@avrdc.org>
Ms. Yun-che Hsu,[17] Principal Research Assistant (Project), <ychsu@avrdc.org>

Nutrition and Analytical Laboratory

Ms. Ray-yu Yang, Assistant Specialist, <ryy074@avrdc.org>
Ms. Wan-jen Wu, Research Assistant, <janewu@avrdc.org>

---

[18] Promoted in 2005

Crucifer Unit

Dr. Peter Hanson, Plant Breeder, <hansp@avrdc.org>
Mr. Lien-chung Chang, Associate Specialist, <lcchang@avrdc.org>

Bacteriology Unit

Dr. Jaw-fen Wang, Associate Plant Pathologist, <jfw@avrdc.org>
Dr. Elbaz Mounira,[16] Post-Doctoral Fellow in Plant Pathology, <elbaz@avrdc.org>
Mr. Chih-hung Lin, Principal Research Assistant, <chlin@avrdc.org>
Ms. Fang-I Ho, Principal Research Assistant, <fangi@avrdc.org>

Socio-Economics-I Unit

Dr. Mubarik Ali, Agricultural Economist, <mubarik@avrdc.org>
Ms. Mei-huey Wu, Principal Research Assistant, <mhwug@avrdc.org>

Socio-Economics-II Unit

Dr. Katinka Weinberger, Assistant Scientist–Socio-Economist, <weinberg@avrdc.org>
Mr. Christian Angeles Genova II,[17] Research Assistant, <cagenova@avrdc.org>
Dr. Tim Ekin,[16, 17] Project Manager of ADB RETA-6208 (May-October

Genetic Resources and Seed Unit

Dr. Liwayway M. Engle, Geneticist and Head, <lmengle@avrdc.org>
Dr. Hidekazu Sasaki,[16] Associate Vegetable Physiologist, <hsasaki@avrdc.org>
Dr. Flordeliza C. Faustino, Project Manager, ADB RETA 6067, <florcf@avrdc.org>
Mr. Yung-kuang Huang, Principal Research Assistant, <ykhuang@avrdc.org>
Ms. Jia-chain Shieh, Research Assistant, <jcshieh@avrdc.org>
Ms. Ching-huan Chang, Research Assistant, <jessica@avrdc.org>
Ms. Min-mei Su, Research Assistant (Project), <kasumi@avrdc.org>

Regional Programs

Asian Regional Center, Bangkok, Thailand

Dr. Masaaki Suzuki,[16] Director, <arc_wvc@ksc.th.com>
Dr. Peter Ooi,[17] Director, <Peterooi.arcwvc@gmail.com>
Mr. Efren Altoveros, Training and Information Officer, <ealtoveros@yahoo.com>

Regional Center for Africa, SADC-AVRDC-CONVERDS, Arusha, Tanzania

Dr. Madan Mohan Lal Chadha, Director, <avrdc-arp@cybernet.co.tz>
Dr. Mel O. Oluoch, Training Specialist at AVRDC-RCA, <avrdc-arp@cybernet.co.tz>
Dr. Drissa Silue, Associate Plant Pathologist at AVRDC-RCA, <avrdc-arp@cybernet.co.tz>

AVRDC/Program Facilitation Unit of the CGIAR Program for Central Asia and the Caucasus, Tashkent, Uzbekistan

Dr. Ravza F. Mavlyanova, AVRDC's Regional Coordinator for Central Asia and the Caucasus, <mravza@yandex.ru>

Afghanistan Program, Jalalabad, Afghanistan

Mr. Ehsanullah Ehsan, Country Coordinator for the RI-RALF/CLVEA Project, <ehsanullaha@yahoo.com>

AVRDC/CIRAD Peri-urban Project, Hanoi, Vietnam

Mr. Boun-tieng Ly, Coordinator of SUSPER Project, <bountiengly@pmail.vnn.vn>

AVRDC/WARDA "Collaboration on Promotion of Superior Vegetable Cultivars" Project, Bamako, Mali

Dr. Virginie Levasseur, Associate Scientist in Crop Production, <v.levasseur@cgiar.org>
Dr. Issoufou Abdourhamane,[17] Project Coordinator of ABGP-II WA Project, <i.abdourhamane@icrisatml.org>
Mr. Sean Winter,[17] Administrative Assistant for AVRDC's activities in West Africa

Contact: Yin-fu Chang

Trainees

Bacteriology

Elbaz, Mounira. Tunisia. 8 April 2004 to 1 October 2005. Plant pathology (bacteria and fungi).

Lin, Huey-wen. Taiwan. 4 July to 31 August 2005. Subtractive hybridization—test the subtracted fragments' specifictiy to the tester strain.

Tsai, Yi-chen. Taiwan. 4 July to 31 August 2005. Characterization of suppressive subtraction hybridization clones of *Ralstonia solanacearum* according to their size.

Biotechnology

Feng, Teng-yung. Taiwan. 10 May 2004 to 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.

Venkatesan, S. India. 30 September 2005 to 30 September 2006. Virology and biotechnology.

Lee, Tzu-hui. Taiwan. 27 June to 22 July 2005. RFLP analysis of mungbean parental lines for bruchid resistance.

Liao, Hsiu-ting. Taiwan. 4 July to 31 August 2005. Detection of Ty-2 gene in tomato by RFLP analysis.

Pang, Kai-yun. Taiwan. 4 July to 5 August 2005. AFLP: DNA fingerprinting, genetic diversity between *Vigna radiata* ssp. Sublobata and *Vigna radiata* ssp. Radiate.

Reyes, Melquiades Emmanuel C. Philippines. 8 December 2004 to 27 February 2005. Research internship on the development of multiple virus resistant (MVR) tomato.

Santoso, Tri Joko. Indonesia. 1 December 2004 to 38 February 2005. Initial hybridization for development of Indonesia multiple viruses resistant tomato.

Crop and Ecosystem Management

Amphant, Jumphol. Thailand. 4 July to 30 July 2005. Innovative techniques in crop and germplasm management.

Ke, Te-sheng. Taiwan. 1 March to 31 May 2005. Grafted tomato and sweet pepper seedlings production practices at AVRDC; application of AVRDC-grafting technology for increasing tomato and sweet pepper transplants production.

Keovichit, Khamsavath. Lao PDR. 2 March to 30 May 2005. Evaluation of the mulching practice and water requirement through drip irrigation to improve efficient for growing tomato production; and application of AVRDC-grafting technology for increasing tomato and sweet pepper transplants production.

Chanthaleauxay, Sinlakone. Lao PDR. 2 March to 30 May 2005. Evaluation of seedlings production for tomato and sweet pepper vegetables with AVRDC's grafting technology; evaluation of the mulching practice and water requirement through drip irrigation to improve efficiency of tomato production.

Rungsamer, Channarong. Thailand. 1 December 2004 to 30 March 2005. Use of grafting technology for vegetable seedlings' production; effect of grafted sweet pepper, hot pepper, and tomato plants grown under varied soil moisture for seed production in open field.

Vispo, Naireen Aiza. Philippines. 3 April to 30 May 2005. Evaluation of *Brassica rapa* evg. pak-choi varieties under low-input organic conditions.

Chen, Chien-lung. Taiwan. 4 July to 31 August 2005. Effects of organic solution application and planting method on the growth of organic pak-choi.

Communications and Training

Acosta, Charito G. Philippines. 15 May to 16 May 2005. Educational tour.

Akimaliev, Dzhamin. Kazakhstan. 11 November to 15 November 2005. Visit Dr. Lumpkin and learn of AVRDC activities.

Chawda, Hema. India. 8 May to 11 May 2005. Genetic improvement and crop management technologies for major vegetable crops.

Chawda, Vimal. India. 8 May to 11 May 2005. Genetic improvement and crop management technologies for major vegetable crops.
Dale, Steve. Singapore. 10 May to 10 May 2005. Reestablishment of contacts at AVRDC; learn more on fungal disease control and emerging pest and disease problems; seeks collaborative research opportunities.
Garcia, Michael Q. Philippines. 5 May to 11 May 2005. Vegetable breeding.
Hidayati, Nurul. Indonesia. 17 April to 20 April 2005. Meet with AVRDC scientists to discuss shared interest in plant breeding and possible collaborative activities for the future.
Laguna Gonzalez, Tomas J. Nicaragua. 20 June to 30 June 2005. Molecular technologies in tomato and pepper breeding.
Lambalk, Johannes J. Netherlands. 17 April to 19 April 2005. Meet with AVRDC scientists to discuss shared interest in plant breeding and possible collaborative activities for the future.
Lutken, Peter K. USA. 25 August to 27 August 2005. Discuss future collaboration between AVRDC and a development project in Mynamar.
Mulyantoro. Indonesia. 15 March to 15 March 2005. Preliminary discussion on BISI seed researcher and training opportunities at AVRDC; discussion on vegetable germplasm evaluation, collaboration, and usage germplasm for BISI seed variety development.
Natividad, Rodolfo A. Philippines. 15 May to 16 May 2005. Educational tour.
Nelson, Jerry. USA. 31 May to 31 May 2005. Learn about AVRDC, with special attention to legumes and legume genomics.
Nicetic, Oleg. Australia. 30 November to 3 December 2005. Sharing of information related to an ACIAR-funded project in Central Vietnam which focuses on controlling Tomato yellow leaf curl virus through integrated crop management approaches.
Oizumi, Futaba. Japan. 19 June to 30 June 2005. Molecular technologies in tomato and pepper breeding.
Pascual, Carlos M. Philippines. 15 May to 16 May 2005. Learning visit of facilities, researches on indigenous vegetables, training opportunities, and partnerships on R&D and training.
Rodenburg, Rien. Indonesia. 17 April to 20 April 2005. Meet with AVRDC scientists to discuss shared interest in plant breeding and possible collaborative activities for the future.
Rojas Solis, Aldo F. Nicaragua. 20 June to 30 June 2005. Molecular technologies in tomato and pepper breeding.
Runge, Edward C.A. USA. 25 August to 27 August 2005. Discuss future collaboration between AVRDC and a development project in Mynamar.
Shapiro, Barry I. India. 7 June 2005 to 9 June 2005. Learn about AVRDC and discuss opportunities for collaboration with ICRISAT.
Spooner-Hart, Robert N. Australia. 30 November to 3 December 2005. Information sharing related to an ACIAR-funded project in Central Vietnam which focuses on controlling Tomato yellow leaf curl virus through integrated crop management approaches.
Tambo, Sat Q. Philippines. 5 May to 11 May 2005. Vegetable breeding.
Uy, Alan B. Philippines. 5 May to 11 May 2005. Vegetable breeding.
Welbaum, Gregory E. USA. 8 June to 11 June 2005. Discuss collaboration with AVRDC.

Crucifer

Ledesma, Lance Gerard R. Taiwan. 1 December 2005 to 30 June 2007. Evaluation of crucifer lines.

Entomology

Kwon, Min. Korea. 14 May to 12 August 2005. Methods of parasite release into field and evaluation of control efficiency.
Huang, Yin-hsuan. Taiwan. 4 July to 31 August 2005. In vivo production of *Maruca vitrata* nuclear polyhedrosis virus and its safety to selected non-target pests and silkworm .
Penjore, Karma. Bhutan. 29 December 2005 to 30 January 2006. Training on pest and disease management in selected vegetables .
Sison, Maria Luz J. Philippines. 1 August to 27 September 2005. Evaluation of Bt toxins against the bean podborer, *Maruca vitrata* (Fabricius) (Pyralidae:Lepidoptera) .
Chou, Chun-ting. Taiwan. 4 July to 31 August 2005. Studies on the influence of selected n-alkanes on the reproductive behavior of tomato fruitworm (TFW), *Helicoverpa armigera* (Hubner) (Lepidoptera:Noctuidae).

Genetic Resources and Seeds

Alcantara, Victor P. Philippines. 14 November 2004 to 14 November 2005. Design improvement of AVGRIS and online dissemination of GRSU activities and publications.

Chae, Young. Korea. 27 December 2005 to 27 March 2006. Multiplication and characterization of vegetable germplasm: evaluation of resistance against late blight, early blight, and Fusarium wilt in tomato.

Chen, Bo-jen. Taiwan. 4 July to 31 August 2005. Germination of stored seeds of *Moringa oleifera*.

Chiang, Hsu-liang. Taiwan. 4 July to 31 August 2005. Effect of storage on germination of *Momordica charantia* seeds.

Islam, Md. Tariqul. Bangladesh. 1 December 2005 to 30 March 2006. Molecular characterization of hyacinth bean and pumpkin accessions collected through the ADB project in Bangladesh.

Ko, Ho Cheol. Korea. 24 November 2005 to 15 February 2006. Characterization and documentation of *Brassica rapa* cvg Chinese cabbage.

Kumar, Nanjundaiah N. India. 3 December 2005 to 1 January 2006. Seed processing, characterization of tomato, eggplant, and hot pepper.

Li, Wai-ting. Taiwan. 4 July to 31 August 2005. Drying behavior of moringa (*Moringa oleifera*) and spider flower (*Cleome gynandra*) seeds.

Lozada, Jed P. Philippines. 3 March to 22 May 2005. Database management.

Nanjappa, Sathish M. India. 3 December 2005 to 1 January 2006. Seed processing, characterization of tomato, eggplant, and hot pepper.

Ngi, Samnang. Cambodia. 23 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties (2005); characterization, evaluation, documentation, and conservation of indigenous vegetables collected through the ADB project (2006).

Palada, Michael Roy B. Philippines. 1 August 2005 to 30 April 2006. Computer designs and layouts; improvement and maintenance of GRSU database, designs, lay-out, and publications .

Palada, Michael Roy B. Philippines. 3 March to 27 May 2005. Computer designs and layouts; improvement and maintenance of GRSU database, designs, layout, and publications .

Park, Kwonseo. Korea. 1 December 2004 to 28 February 2005. Characterization and evaluation of tomato germplasm derived from *Lycopersicon eculentum* x *L. pimpinelliflium* cross.

Phengvong, Khamla. Lao PDR. 2 November 2004 to 30 January 2005. Characterization, regeneration, and documentation of indigenous vegetables collected through the ADB project.

Taridno, Patcharin. Thailand. 15 May 2005 to 31 May 2006. Genetic diversity morphological in selected indigenous vegetable species; seed drying and germination behavior in selected indigenous vegetable species.

Tsai, Yuen-jen. Taiwan. 4 July to 31 August 2005. Drying curve of *Cajanus cajan* and *Corchorus capsularis*.

Vu, Quang H. Vietnam. 4 November 2004 to 31 January 2005. Microsoft access for vegetable germplasm management and documentation.

Yu, Ming-yi. China. 18 April to 13 May 2005. Sampling of representative seeds for testing of moisture content and germination.

International Cooperation

Amirov, Bakhytbek M. Kazakhstan. 23 September to 10 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Bazarradnaa, Enkhtuya. Mongolia. 25 September to 7 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Buctuanon, Eugenia M. Philippines. 25 September to 9 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Choodee, Kraising. Thailand. 25 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Gaswanto, Redy. Indonesia. 25 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Handayani, Tri. Indonesia. 25 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Jalbiidandariin, Suvdaa. Mongolia. 25 September to 7 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Jose, Divina C. Philippines. 25 September to 9 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Kang, Thae Sok. DPR Korea. 23 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Lapoot, Carmelito R. Philippines. 25 September to 9 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Le, Van T.H. Vietnam. 25 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Liu, Ei-Chang. Taiwan. 26 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Malikov, Tofig G. Azerbaijan. 23 September to 10 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Mong, Vanndy. Cambodia. 23 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Pak, Yong Gun. DPR Korea. 23 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Pham, Dung V. Vietnam. 25 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Philavong, Bouathong. Lao PDR. 23 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Pirnazarov, Djurabek R. Uzbekistan. 23 September to 10 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Poh, Bee Ling. Singapore. 25 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Samadi, Ghulam R. Afghanistan. 26 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Sandoval, Digna L. Philippines. 25 September to 9 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Seyidov, Bayrammurad G. Turkmenistan. 26 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Sommany, Xayasinh. Lao PDR. 23 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Tai, Shun-Fa. Taiwan. 26 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Tan, Huai Lin. Singapore. 25 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Wang, Hsiao-Hua. Taiwan. 26 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Yuldashev, Firuz M. Uzbekistan. 23 September to 10 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Zeynalov, Hajiaga Y. Azerbaijan. 23 September to 10 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Insung, Laddawan. Thailand. 25 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties.

Ngi, Samnang. Cambodia. 23 September to 8 October 2005. Training workshop on conducting trials of promising vegetable varieties (2005); characterization, evaluation, documentation, and conservation of indigenous vegetables collected through the ADB project (2006).

Shen, Meng-ni. Taiwan. 4 July to 31 August 2005. Evaluation of heat and flooding tolerance of promising indigenous vegetables.

Legume

Han, Won-Young. Korea. 16 February to 15 July 2005. Generation advance and seed multiplicatin of Korean soybean breeding lines.

Ismail, Suboh B. Malaysia. 26 April to 29 April 2005. Gather information on new technology, agronomic practices, and mechanization of soybean and mungbean.

Jelani, Abdul Razak B. Malaysia. 26 April to 29 April 2005. Gather information on new technology, agronomic practices, and mechanization of soybean and mungbean.

Mycology

Acosta, Joseph Jasper. Philippines. 3 April to 30 May 2005. Race determination and intergenic spacer (IGS), haplotype analysis of tomato Fusarium wilt pathogen in Taiwan.

Bunyanupappong, Kuakoon. Thailand. 4 July to 30 July 2005. Screening of major vegetable diseases.

Chae, Young. Korea. 27 December 2005 to 27 March 2006. Multiplication and characterization of vegetable germplasm: evaluation of resistance against late blight, early blight, and Fusarium wilt in tomato.

Elbaz, Mounira. Tunisia. 8 April 2004 to 1 October 2005. Plant pathology (bacteria and fungi).

Tsai, Yu-chung. Taiwan. 4 July to 31 August 2005. Mating type determination and metalaxyl sensitivity assessment of Phytophthora infestans isolates collected in Taiwan 2005.

Nutrition

Green, Jasper Karim. Taiwan. 15 September 2004 to 14 September 2005. Organic vegetable crop production practices.

Jones, Carl M. USA. 24 May to 22 June 2005. Collaboration with Elaine Graham and Ray Yu Yang on characterization of *L. pimpinellifollium* RIL's for ascorbic acid and phenolic levels.

Kraikruan, Wilawan. Thailand. 15 May to 31 August 2005. Correlation between anthracnose resistance and fruit characteristics of different varieties and different fruit ages of pepper.

Ledesma, Lance Gerard R. Taiwan. 1 December 2005 to 30 June 2007. Evaluation of crucifer lines.

Wang, Ju-chieh. Taiwan. 4 July to 31 August 2005. Comparison of capsaicinoids, oil, and pigment contents among chili pepper accessions and sugar contents among sweet pepper lines.

Pepper

Huang, Yu-lun. Taiwan. 4 July to 31 August 2005. Evaluation and performance of heterosis and combining ability for chilli hybrids.

Kraikruan, Wilawan. Thailand. 15 May to 31 August 2005. Correlation between anthracnose resistance and fruit characteristics of different varieties and different fruit ages of pepper.

Liu, Wing Yee (Winnie). Hong Kong. 12 June 2005 to 16 June 2005. Application of molecular markers in plant breeding.

Reano, Ian Mari. Philippines. 3 April to 30 May 2005. Identify correlation between anthracnose resistance and fruit characteristics of different varieties in pepper.

Socioeconomics

Honicke, Mireille. Germany. 9 June to 21 July 2005. Role of indigenous vegetables for micronutrient consumption in Southeast Asia.

Bramberger, Maria A. Germany. 18 October to 29 December 2005. Indigenous vegetables and their contribution to micronutrient consumption in Vientiane municipality, Lao PDR.

Ecker, Olivier. Germany. 9 June to 28 June 2005. Socioeconomic aspects of micronutrient malnutrition.

Technology Promotion and Services

Esguerra, Manuel Q. Philippines. 15 February 2004 to 30 June 2005. Environmental adaptability, growth, and yield components in relation to yield performance and clientele acceptance of promising indigenous vegetables.

Ledesma, Lance Gerard R. Philippines. 15 February 2004 to 30 June 2005. Environmental adaptability, growth, and yield components in relation to yield performance and clientele acceptance of promising indigenous vegetables.

Tomato

Arimoto, Ryohei. Japan. 12 June to 16 June 2005. Application of molecular markers in plant breeding.
Asavasena, Sumitra. Thailand. 12 June to 16 June 2005. Application of molecular markers in plant breeding.
Azanes, Mia Desiree. Philippines. 3 April to 30 May 2005. Quantitative trait loci (QTL) analysis and mapping of female and male fertility genes in an interspecific cross of tomato (*Lycopersicon esculentum* Mill. x *Lycopersicon pimpinellifolium* (Jusl.) Mill.).
Bulasag, Abriel S. Philippines. 3 April to 30 May 2005. Characterization of 50 *Solanum* accessions from the *S. nigrum* complex.
Chao, I-Lan. Taiwan. 13 June to 15 June 2005. Application of molecular markers in plant breeding.
Kaith, Puneet. India. 12 June to 17 June 2005. Application of molecular markers in plant breeding.
Malabanan, Katrina B. Philippines. 3 April to 30 May 2005. Screening for introgressions contributing to Tomato yellow leaf curl virus resistance in tomato, *Lycopersicon esculentum* Mill.
Piamjit, Phatralada. Thailand. 13 June to 15 June 2005. Application of molecular markers in plant breeding.
Rotsianglum, Kanya. Thailand. 1 December 2004 to 30 March 2005. Breeding for high yielding tomato hybrids with geminivirus resistance and good quality traits .
Wang, Hsiu-Wen. Taiwan. 13 June to 15 June 2005. Application of molecular markers in plant breeding.
Wo, Chun Yin (Jimmy). Hong Kong. 12 June to 16 June 2005. Application of molecular markers in plant breeding.
Liu, Wing Yee (Winnie). Hong Kong. 12 June to 16 June 2005. Application of molecular markers in plant breeding.
Reyes, Melquiades Emmanuel C. Philippines. 8 December 2004 to 27 February 2005. Research internship on the development of multiple virus resistant (MVR) tomato.
Santoso, Tri Joko. Indonesia. 1 December 2004 to 38 February 2005. Initial hybridization for development of Indonesia multiple viruses resistant tomato.
Jones, Carl M. USA. 24 May to 22 June 2005. Collaboration with Elaine Graham and Ray Yu Yang on characterization of *L. pimpinellifollium* RIL's for ascorbic acid and phenolic levels.

Virology

Schwer, Carolin Susanne. Germany. 26 February to 1 May 2005. Disease screening techniques including molecular-based technologies.
Venkatesan, S. India. 30 September 2005 to 30 September 2006. Virology and biotechnology.

Contact: Thomas Kalb

Regional Center for Africa

Training for graduate students

Mwai, Gideone. January to July 2005. Ph.D. work on African nightshade.

Training for undergraduate students on vegetable crops production

Grace, Kabate. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Preygod, Shedrack. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Ntuli, Swila. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
George, Tryphone M. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Muro, Lightness. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Omari, Rehema. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Mngale, A. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Mlwale, A. W. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.

Matutu, W. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Kassim, Jumanne. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Buberwa, Kafanabo. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Emmanuel, Daniel. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Yohana, Daniel. Tanzania. 30 May to 2 July 2005. Department of Agronomy, Sokoine University of Agriculture.
Ally, Ally H. Tanzania. 24 January to 18 February 2005. Ministry of Agriculture Training Institute.
Makungu, Mwanaenzi. Tanzania. 24 January to 18 February 2005. Ministry of Agriculture Training Institute.
Omar, Haji A. Tanzania. 24 January to 18 February 2005. Ministry of Agriculture Training Institute.
Minja, Benson J. Tanzania. 24 January to 18 February 2005. Ministry of Agriculture Training Institute.

Special training on advanced vegetable crops production

Chiwosi, George. Malawi. 2 October to 3 November 2005. Ministry of Agriculture.
Chinamale, Kauma Mathias. Malawi. 2 October to 3 November 2005. Ministry of Agriculture.
Nkhoma, Mathias. Malawi. 2 October to 3 November 2005. Ministry of Agriculture.
Kamanga, Smart. Malawi. 2 October to 3 November 2005. Ministry of Agriculture.
Kumwenda, Victor. Malawi. 2 October to 3 November 2005. Ministry of Agriculture.

Special training on vegetable crops production and research

Ntsane, Salminah. Lesotho. 4 July to 4 November 2005. Lesotho Agricultural College.
Chipanthenga, Margaret. Malawi. 4 July to 4 November 2005. Kasinthula Research Station.
Nambela, Jane. Zambia. 4 July to 4 November 2005. Seed Control and Certification Institute.
Mwiyare, Jesca Shadrack. Tanzania. 4 July to 4 November 2005. Ministry of Agriculture.
Osei, Michael Kwabena. Ghana. 4 July to 4 November 2005. Crops Research Institute.
Elmostafa, Khalid Abdelraheem Abdelgadir. Sudan. 4 July to 4 November 2005. Food Processing Research Center.
Neema, Irene Leonard. Tanzania. 4 July to 4 November 2005. Ministry of Agriculture.
Oumer, Ali Mohammed. Ethiopia. 4 July to 4 November 2005. Ethiopian Agricultural Research Organization.
Larue, Antoine Serge. Seychelles. 4 July to 4 November 2005. Ministry of Environment and Natural Resources, The Vegetable Evaluation Research Section Victoria.
Nalwanga, Edith. Uganda. 4 July to 4 November 2005. Ministry of Agriculture.
Mtei, Kelvin Mark. Tanzania. 4 July to 4 November 2005. Mikocheni Agricultural Research Institute.
Samwel, Tumwesigye. Uganda. 4 July to 4 November 2005. Victoria Seeds Limited.
Nowbotsing, Maya. Mauritius. 4 July to 4 November 2005. Agricultural Research and Extension Unit.
Shivolo, Ottilie Michele. Namibia. 4 July to 4 November 2005. Ogongo Agricultural College.
Muenyi, Paul Mbonjo. Cameroon. 4 July to 4 November 2005. Institute of Agricultural Research for Development.
Mirisawu, Peter. Zimbabwe. 4 July to 4 November 2005. Agricultural Research and Extension Services.
Assenga, Emerenciana Joachim. 4 July to 4 November 2005. Horticultural Research Institute.
Tjalle, Sidwell Sindy. South Africa. 4 July to 4 November 2005. Agricultural Research Council-Roodeplaat.
Kgotladintsi, Nonofo. Botswana. 4 July to 4 November 2005. Ministry of Agriculture.
Suweid, Said Abdalla. Tanzania. 4 July to 4 November 2005. Ministry of Agriculture.
Azagba, Joel Armand. Benin. 4 July to 4 November 2005. Benin National Institute of Agricultural Research.
Makungu, Mwanaenzi Juma. Tanzania. 4 July to 4 November 2005. Commission for Agriculture Research and Extension.
Mbugua, Jane Muthoni. Kenya. 4 July to 4 November 2005. National Genebank of Kenya.
Urassa, Boniface Rogath. Tanzania. 4 July to 4 November 2005. Ministry of Agriculture Training Institute.

Contact: Mel Oluoch

Staff publications

Ali, M., de Bon, H., Moustier, P. 2005. Promoting the multifunctionality of urban and periurban agriculture in Hanoi. *Urban Agriculture Magazine* 15:11–13.

Arai, M., Hayashi, M., **Takahashi, M.**, Shimada, S., Harada, K. 2005. Expression and sequence analysis of systemic regulation gene for symbiosis, NTS1/ GmNARK in supernodulating soybean cultivar, Sakukei 4. *Breeding Science* 55(2):147–152.

[AVRDC] AVRDC-The World Vegetable Center. 2005. *Medium-term plan 2005-2007: World Vegetable Center*. Tainan, Shanhua: AVRDC-The World Vegetable Center. 28 p.

Basim, H., Minsavage, G.V., Stall, R.E., **Wang, J.F.**, Shanker, S., Jones, J.B. 2005. Characterization of a unique chromosomal copper resistance gene cluster from *Xanthomonas campestris* pv. vesicatoria. *Applied and Environmental Microbiology* 71(12):8284–8291.

Burleigh, J.R., Black, L.L., Mateo, L.G., Cacho, D., Aganon, C.P., Boncato, T., Arida, I.A., Ulrichs, C., **Ledesma, D.R.** 2005. Performance of grafted tomato in Central Luzon, Philippines: a case study on the introduction of a new technology among resource-limited farmers. *Crop Management* July:1–9.

Chen, C.H., **Wang, T.C.** 2005. Race identification of *Phytophthora infestans* isolates collected from Taiwan from 2004 to 2005. *Plant Pathology Bulletin* 14(4):283.

Chen, G.H., Hsu, M.P., Tan, C.H., Sung, H.Y., **Kuo, C.G.**, Fan, M.J., **Chen, H.M.**, Chen, S., Chen, C.S. 2005. Cloning and characterization of a plant defensein VaD1 from azuki bean. *Journal of Agricultural and Food Chemistry* 53(4):982–988.

Cho, K.S., Hong, S.Y., Kwon, Y.S., **Woo, J.G.**, Moon, J.Y., Ryu, S.Y., Park, H.G. 2005. Selection of maintainer line in open-pollinated onion (*Allium cepa* L. cv. “Manchuhwang”) using SCAR marker linked to cytoplasmic male sterile factor. *Korean Journal of Breeding* 37(3):133–137.

Cork, A., Alam, S.N., Talelar, K., **Talekar, N.S.** 2005. Development and commercialization of mass trapping for control of eggplant borer, *Leucinodes orbonalis* in South Asia. In: *Recent advances in integrated management of brinjal shoot and fruit borer: extended summary*. Varanasi: Indian Institute of Vegetable Research. p. 29–33.

Cork, A., Alam, S.N., Rouf, F.M.A., **Talekar, N.S.** 2005. Development of mass trapping technique for control of brinjal shoot and fruit borer, *Leucinodes orbonalis* (Lepidoptera: Pyralidae). *Bulletin of Entomological Research* 95(6):589–596.

Cork, A., Alam, S.N., Srinivasan, K., Das, C.S., Ghosh, G.C., **Talekar, N.S.** 2005. Development of a pheromone trap system for eggplant borer, *Leucinodes orbonalis* in South Asia. In: *Recent advances in integrated management of brinjal shoot and fruit borer: extended summary*. Varanasi: Indian Institute of Vegetable Research. p. 25–28.

Crossman, S., **Palada, M.C.** 2005. Production constraints to agricultural development. In: *Proceedings of the first U.S. Virgin Islands agricultural forum: prospects for sustainable agriculture in the V.I., April 22-23, 2003*. Kingshill, VI: University of the Virgin Islands Cooperative Extension Service. p. 24–27.

Diongue, Aliou, Lai, P.Y., **Chang, Y.F.**, Lin, C. 2005. Effects of *Solanum viarum* cuticular leaf extracts and its fractions on the oviposition of *Helicoverpa armigera* (Hubner) (Lepidoptera: Noctuidae). *Formosan Entomologist* 25(1):23–32.

Fereol, L., Chovelon, V., Causse, S., Kalumvueziko, M.L., Kahane, R. 2005. Embryogenic cell suspension cultures of garlic (*Allium sativum* L.) as method for mass propagation and potential material for genetic improvement. *Acta Horticulturae* 688:65–74.

Fereol, L., Chovelon, V., Causse, S., Triaire, D., Arnault, I., Auger, J., Kahane, R. 2005. Establishment of embryogenic cell suspension cultures of garlic (*Allium sativum* L.), plant regeneration and biochemical analyses. *Plant Cell Reports* 24:319–325.

Fereol, L. 2005. *Set up of techniques for onion breeding and garlic dissemination*. Shanhua, Tainan: AVRDC-The World Vegetable Center. 65 p.

Gniffke, P.A., Green, S.K., Wang, J.F., Wang, T.C. 2005. Improving chili peppers for developing countries. *Hortscience* 40(4):980.

Graham, E., **Wang, T.C., Hanson, P.** 2005. Preliminary evaluation of LA1777 introgression lines for early blight resistance. In: *Report of the Tomato Genetics Cooperative, number 55*. Wimauma, FL: University of Florida. p. 15–18.

Green, S.K., Tsai, S.L., **Shih, S.L.**, Huang, Y.C., **Lee, L.M.** 2005. Diversity of begomoviruses of tomato and weeds in Asia. In: *Proceedings of the international seminar on whitefly management and control strategy*. Taichung: Agricultural Research Institute, Council of Agriculture. p. 19–66.

Han, J.S., Oh, D.G., **Woo, J.G.**, Kim, J.H., Kim, C.K. 2005. Ectopic expression of an Arabidopsis H+/Ca_2+ antiporter gene in bottle gourd (*Lagenaria siceraria*). *Korean Society for Horticultural Science Journal* 46(4):250–254.

Hanson, P.M., Yang, R.Y., Tsou, S.C.S., Lee, T.C. 2005. Evaluation of antioxidant activity levels among Solanaceae germplasm. In: *Symposium on Taiwan-America agricultural cooperative projects: contributed papers*. Taichung Hsien: Agricultural Research Institute, COA. p. 61–68.

Jhala, R.C., Patel, J.R., Patel, B.H., Bharpoda, T.M., Patel, N.C., Patel, M.G., Chavda, A.J., Patel, Y.C., **Talekar, N.S.** 2005. Evaluation of eco-friendly integrated pest management components to combat eggplant shoot and fruit borer (*Leucinodes orbonalis* Guenee) in Gujarat. In: *Recent advances in integrated management of brinjal shoot and fruit borer: extended summary*. Varanasi: Indian Institute of Vegetable Research. p. 39–43.

Jhala, R.C., Chavda, A.J., Patel, M.G., **Talekar, N.S.**, Cork, A. 2005. Evaluation of various modified traps for their trapping efficiency against Leucinodes male moths. In: *Recent advances in integrated management of brinjal shoot and fruit borer: extended summary*. Varanasi: Indian Institute of Vegetable Research. p. 154–156.

Kafle, L., Lai, P.Y., **Chang, Y.F.**, Yang, J.T. 2005. Host searching behavior of *Ganaspidium utilis* (Beardsley) (Hymenoptera:Eucoilidae) on *Liriomyza trifolii* (Burgess) (Diptera:Agromyzidae).*Formosan Entomologist* 26(4):399–406.

Kafle, L., Lai, P.Y., **Chang, Y.F.** 2005. Life History of *Ganaspidium utilis* (Beardsley) (Hymenoptera: Eucoilidae) in Taiwan. *Formosan Entomologist* 25(2):87–94.

Kalb, T. 2005. *Proceedings of the APSA-AVRDC workshop on collaborative vegetable research*. Shanhua, Tainan: AVRDC-The World Vegetable Center. 25 p.

Kalb, T. 2005. *Saving your own vegetable seeds: a guide for farmers*. Shanhua, Tainan: AVRDC-The World Vegetable Center. 25 p.

Kalb, T.J., Mavlyanova, R.F. 2005. *Vegetable production in Central Asia*. Shanhua, Tainan: AVRDC-The World Vegetable Center. v, 151 p.

Kawabata, S., **Sasaki, H.**, Sakiyama, R. 2005. Role of transpiration from fruits in phloem transport and fruit growth in tomato fruits. *Physiologia Plantarum* 124(3):371–380.

Kim, K.S., **Wang, T.C.**, Yang, X.B. 2005. Simulation of apparent infection rate to predict severity of soybean rust using a fuzzy logic system. *Phytopathology* 95(10):1122–1131.

Komatsu, K., Okuda, S., **Takahashi, M.**, Matsunaga, R., Nakazawa, Y. 2005. QTL mapping of antibiosis resistance to common cutworm (*Spodoptera litura* Fabricius) in soybean. *Crop Science* 45(5):2044–2048.

Lin, S.W., Shieh, S.C., **Sheu, Z.M., Wang, T.C.**, Hong, C.H., **Gniffke, P.A.** 2005. Genetic study of resistance to anthracnose in pepper. *Chinese Society for Horticultural Science Journal* 51(4):422.

Lumpkin, H.M. 2005. *A comparison of lycopene and other phytochemicals in tomatoes grown under conventional and organic management systems*. Shanhua, Tainan: AVRDC-The World Vegetable Center. iv, 48 p.

Lumpkin, T.A., Ali, M., Farooq, U. 2005. Vegetable research and development in Central Asia: a guideline for setting priorities under data scarcity. In: *Vegetable production in Central Asia: status and perspectives*. Proceedings. Shanhua, Tainan: AVRDC-The World Vegetable Center. p. 1–23

Lumpkin, T.A., Weinberger, K., Moore, S. 2005. Increasing income through fruit and vegetable production: opportunities and challenges. In: *CGIAR priorities: science for the poor*. Marrakech: 10 p.

Ma, C.H., Palada, M., Chen, L.H., Tien, H.Y. 2005. Development of a farm-based system for composting and organic vegetable production with application to developing countries. In: Kopke, U., Niggli, U., Neuhoff, D., Cornish, P., Lockeretz, W., Willer, H., eds. *Researching sustainable systems*. Proceedings. Bonn: ISOFAR. p. 70–73

Mavlyanova, R.F. 2005. Evaluation of global sources of root crops for breeding and cultivation in Uzbekistan. In: *Vegetable production in Central Asia*. Shanhua, Tainan: AVRDC-The World Vegetable Center. p. 138–145

Mavlyanova, R.F., Abdullaev, F.K., Khodjiev, P., Zaurov, D.E., Molnar, T.J., Goffreda, J.C., Orton, T.J., Funk, C.R. 2005. Plant genetic resources and scientific activities of the Uzbek Research Institute of Plant Industry. *Hortscience* 40(1):10–14.

Njukeng, A.P., Atiri, G.I., **Hughes, J.** 2005. Comparison of TAS-ELISA, dot and tissue blot, ISEM and immunocapture RT-PCR assays for the detection of Yam mosaic virus in yam tissues. *Crop Protection* 24(6):513–519.

Norton, G.W., Heinrichs, E.A., **Luther, G.C.**, Irwin, M.E. 2005. *Globalizing integrated pest management: a participatory research process*. Ames, IA: Blackwell Publishing. xxiv, 338 p.

Ogundiwin, E.A., Berke, T.F., Massoudi, M., **Black, L.L.**, Huestis, G., Choi, D., Lee, S., Prince, J.P. 2005. Construction of two intraspecific linkage maps and identification of resistance QTLs for *Phytophthora capsici* root-rot and foliar-blight diseases of pepper (*Capsicum annuum* L.). *Genome* 48(4):698–711.

Oluoch, O.M., Chadha, M.L., Silue, D. 2005. Effect of plant population and nitrogen rates on leaf and seed yield of jute mallow. In: *African crop science conference proceedings, vol.7*. Kampala: African Crop Science Society. p. 83–88.

Oluoch, O.M., Megessa, J.M., **Chadha, M.L., Silue, D.** 2005. Evaluation of vegetable soybean lines for seed yield characteristics. In: *African crop science conference proceedings, vol.7*. Kampala: African Crop Science Society. p.55–58.

Orton, T., Zaurov, D., Remmers, P., Ballister-Howells, P., Buriev, K., Zuev, V., **Mavlyanova, R.**, Hakimov, R. 2005. Reciprocal exchange and testing of vegetable varieties in Uzbekistan and the USA. In: *Increasing market-oriented vegetable production in Central Asia and the Caucasus through collaborative research and development*. Workshop proceedings. Shanhua, Tainan: AVRDC-The World Vegetable Center. p. 208–219.

Pae, D.H. 2005. *Breeding pepper cultivars for resistance to anthracnose and Phytophthora blight and with good horticultural traits*. Shanhua, Tainan: AVRDC-The World Vegetable Center. 151 p.

Pae, D.H., Chae, Y., **Wang, T.C., Engle, L.M., Shanmugasundaram, S.** 2005. Selection of new breeding materials with resistance to anthracnose in Capsicum annuum. *Korean Society For Horticultural Science Journal* 46(1):10–12.

Pajot, E., **Silue, D.** 2005. Evidence that DL-3-aminobutyric acid and acibenzolar-S-methyl induce resistance against bacterial head rot disease of broccoli. *Pest Management Science* 61:1110–1114.

Palada, M. , Ma, C.H. , Chen, L.H. 2005. Development of starter solution technology for organic chili pepper production in the tropics. In: *15th IFOAM organic world congress: shaping sustainable systems*. Adelaide: IFOAM. p. 126.

Palada, M.C., Mitchell, J.M., Beaker, B.N., Nair, P.K.R. 2005. The integration of medicinal plants and culinary herbs in agroforestry systems for the Caribbean: a study in the U.S. Virgin Islands. *Acta Horticulturae* 676:147–153.

Pateña, L.F., Dolores, L.M., Bariring, A.L., Alcachupas, A.L., Laude, N.P., Barg, E., **Green, S.K.**, Barba, R.C. 2005. Improved technique for virus elimination in and production of certified planting materials of garlic (*Allium sativum* L.). *Acta Horticulturae* 694:271–276.

Prom, L.K., Waniska, R.D., **Abdourhamane, I.K.** 2005. Role of chitinase and sormatin accumulation in the resistance of sorghum cultivars to grain mold. *Journal of Agricultural and Food Chemistry* 53(14):5565–5570.

Rakocy, J., Godfrey, R., **Palada, M.**, Zimmerman, T. 2005. Agricultural research at the University of the Virgin Islands. In: *Proceedings of the first U.S. Virgin Islands agricultural forum: prospects for sustainable agriculture in the V.I., April 22-23, 2003*. Kingshill, VI: University of the Virgin Islands Cooperative Extension Service. p. 39–47.

Sasaki, H., Yano, T., Yamasaki, A. 2005. Reduction of high temperature inhibition in tomato fruit set by plant growth regulators. *Japan Agricultural Research Quarterly* 39(2):135–138.

Saxena, S. 2005. *Sustainable development in Darjeeling Hills, India: ecological and socioeconomic aspects for small-scale farmers with supportive observations from Kanagawa, Japan*. Mainz: Johannes Gutenberg-University Mainz. 206 p.

Scott, J.W., **Wang, J.F., Hanson, P.M.** 2005. Breeding tomatoes for resistance to bacterial wilt: a global view. *Acta Horticulturae* 695:161–172.

Sheu, Z.M., Wang, T.C. 2005. Characterization of Taiwan isolates of *Fusarium oxysporum* f. sp. *lycopersici* based on race determination, vegetative compatibility and DNA IGS-RFLP haplotyping. *Plant Pathology Bulletin* 14(4):282–283.

Sheu, Z.M., Wang, T.C. 2005. Evaluation of phenotypic and molecular criteria for the identification of *Colletotrichum* species causing pepper anthracnose in Taiwan. In: *The second Asian conference on plant pathology 2005*. Singapore: Faculty of Science, National University of Singapore. p. 26–27

Sheu, Z.M., Wang, T.C. 2005. Physiological races and IGS-RFLP haplotypes identification of *Fusarium oxysporum* f. sp. *lycopersici* isolates in Taiwan. *Phytopathology* 95(6):S95.

Shieh, S.C., Lin, S.W., Sheu, Z.M., Wang, J.F., Green, S.K., Gniffke, P.A. 2005. Development of a heat-tolerant and disease-resistant sweet pepper variety. *Chinese Society for Horticultural Science Journal* 54(4):421.

Shivalingaswamy, T.M., Satpathy, S., Tripathi, U.K., Monohar, R., **Talekar, N.S.** 2005. Dimensions of insecticide use for eggplant shoot and fruit borer management in Eastern U.P.—a case study. In: *Recent advances in integrated management of brinjal shoot and fruit borer: extended summary*. Varanasi: Indian Institute of Vegetable Research. p. 48–50

Sorajjapinun, W., Rewthongchum, S., Koizumin, M., **Srinives, P.** 2005. Quantitative inheritance of resistance to powdery mildew disease in mungbean (*Vigna radiata* (L.) Wilczek). *Sabrao Journal of Breeding and Genetics* 37(2):91–96.

Srinivasan, R., Huang, C.C., **Talekar, N.S.** 2005. Characterization of resistance in eggplant to eggplant shoot and fruit borer. In: *Recent advances in integrated management of brinjal shoot and fruit borer: extended summary*. Varanasi: Indian Institute of Vegetable Research. p. 90–93

Srinivasan, R., Uthamasamy, S. 2005. Does host plant chemistry influence feeding and ovipositional behavior of fruitborer in tomato?. *Journal of Vegetable Science* 11(1):97–115.

Srinivasan, R., Uthamasamy, S. 2005. Effect of tomato leaf cuticular wax extracts on egg hatchability and neonate mortality of *Helicoverpa armigera* Hub. (Lepidoptera: Noctuidae). *Insect Environment* 10(4):186–187.

Srinivasan, R., Talekar, N.S., Uthamasamy, S. 2005. Feeding stimulants in *Solanum viarum* Dunal for tomato fruit borer (*Helicoverpa armigera* Hubner). *Formosan Entomologist* v.25:95–102.

Srinivasan, R., Uthamasamy, S. 2005. Studies to elucidate antibiosis resistance in selected tomato accessions against the fruitworm *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae). *Resistant Pest Management Newsletter* 14(2):24–26.

Srinivasan, R. 2005. Transgenic plants with dual Bt gene—an innovative initiative for sustainable management of *Brassica* insect pests. *Current Science* 88(12):1878–1879.

Srinivasan, R., Uthamasamy, S. 2005. Trichome density and antibiosis affect resistance of tomato to fruitborer and whitefly under laboratory conditions. *Journal of Vegetable Science* 11(2):3–17.

Talekar, N.S. 2005. Development of IPM strategy for eggplant shoot and fruit borer. In: *Recent advances in integrated management of brinjal shoot and fruit borer: extended summary*. Varanasi: Indian Institute of Vegetable Research. p. 34–38

Talekar, N.S. 2005. Sources of resistance to shoot and fruit borer in eggplant. In: *Recent advances in integrated management of brinjal shoot and fruit borer: extended summary*. Varanasi: Indian Institute of Vegetable Research. p. 12–14

Tsai, W.S., Jan, J.F., Huang, Y.C., **Green, S.K.** 2005. Molecular characterization of five strains of Chili veinal mottle virus (ChiVMV) in Taiwan. *Plant Protection Bulletin* [TW] 47(4):429–430.

Wang, J.F., Lin, C.H. 2005. Colonization capacity of *Ralstonia solanacearum* tomato strains differing in aggressiveness on tomatoes and weeds. In: Allen, C., Prior, P., Hayward, A.C., eds. *Bacterial wilt disease and the Ralstonia solanacearum species complex*. St. Paul, MN: The American Phytopathological Society. p. 73–79.

Wang, J.F., Lin, C.H. 2005. *Integrated management of tomato bacterial wilt*. Shanhua, Tainan: AVRDC-The World Vegetable Center. 12 p.

Wang, T.C.,Yang, X.B. 2005. Simulation of apparent infection rate to predict soybean rust severity using a fuzzy logic system. *Phytopathology* 95(6):S53.

Wang, T.C., Chen, C.H. 2005. The variation of race composition of *Phytophthora infestans* in Taiwan during 1991–2004. *Phytopathology* 95(6):S109.

Weinberger, K. 2005. Assessment of the nutritional impact of agricultural research: the case of mungbean in Pakistan. *Food and Nutrition Bulletin* 26(3):287–294.

Weinberger, K., Lumpkin, T.A. 2005. *Horticulture for poverty alleviation*. Shanhua, Tainan: AVRDC-The World Vegetable Center. ii, 20 p.

Weinberger, K., Genova, C.A. 2005. *Vegetable production in Bangladesh: commercialization and rural livelihoods*. Shanhua, Tainan: AVRDC-The World Vegetable Center. iv, 51 p.

Yang, R.Y. 2005. *Obesity and overweight in developing countries*. Bonn: GTZ GmbH. 5 p.

Yang, R.Y., Tsou, S.C.S., Lee, T.C., **Hanson, P.M.**, Lai, P.Y. 2005. Antioxidant capacities and daily antioxidant intake from vegetables consumed in Taiwan. In: *Symposium on Taiwan-America agricultural cooperative projects*. Contributed papers. Taichung Hsien: Agriculturel Research Institute. p. 69–77.

Contact: Thomas Kalb

Financial information

Summary financial statement, 2005

(USD 000)

	Core		Project		Total	
Revenues						
Grant	5,018		5,561		10,579	
Other revenues and support	674		0		674	
Total revenues	5,692	51%	5,561	49%	11,253	100%
Expenditures						
Object Expenditures						
Personnel						
Internationally recruited staff (IRS)	1,430		760		2,190	20%
Nationally recruited staff (NRS)	3,272		249		3,521	35%
Operating expenses						
Field labor	487		183		670	7%
Supplies	206		933		1,138	10%
Travel	111		253		363	2%
Training and workshop	21		795		816	8%
General expenses	494		560		1,054	8%
Contract outreach research	0		978		978	7%
Equipment, facilities & renovations	0		851		851	3%
Total	6,020	52%	5,561	48%	11,581	100%
Strategic Themes						
1. Germplasm conservation, evaluation, and gene discovery	1,317		1,395		2,712	23%
2. Genetic enhancement, varietal development, and selection of indigenous lines	930		985		1,914	17%
3. Nutrition security, diet diversification, and human health	620		656		1,276	11%
4. Seed and safe vegetable production systems	542		574		1,117	10%
5. Postharvest management, market opportunities and income generation	465		492		957	8%
Administration and Services	2,146		1,459		3,605	31%
Total expenses	6,020	52%	5,561	48%	11,581	100%
Allocate to working capital funds	(100)		0		(100)	
Translation adjustment	86				86	
Changes in net assets	(328)				(328)	
Net assets beginning of the year	524		0		524	
Net assets at the end of the year[a]	182		0		182	

[a] Excludes working capital fund of $1,000,000 as end of 2005.

Contact: Nancy Chai

Meteorological information

Data (monthly mean) collected at the AVRDC weather station, Shanhua Taiwan, 2005

Month	Daily average humidity (%)	Daily air temp. max (°C)	Daily air temp. min (°C)	Daily soil temperature 10 cm max (°C)	10 cm min (°C)	30 cm max (°C)	30 cm min (°C)	Daily avg. wind velocity (m/s)	Daily avg. solar radiation (W-hour/m²)	Monthly precipitation (mm)	Daily average evaporation (mm)
January	61	22.0	13.3	20.9	18.6	20.7	20.0	2.62	3132	3	2.8
February	59	23.2	14.5	22.7	20.0	22.1	21.2	2.39	3065	76	3.0
March	52	23.5	14.3	22.2	19.3	21.3	20.4	2.40	3664	62	3.2
April	71	28.8	20.6	27.6	24.3	25.7	24.8	1.73	4679	32	4.6
May	69	31.4	23.9	30.7	27.5	28.8	28.0	1.67	5032	228	5.3
June	74	30.8	24.8	29.7	27.4	28.7	28.0	2.16	3576	1679	4.8
July	66	32.8	24.9	31.3	28.3	29.8	29.0	2.13	4825	656	5.4
August	71	31.6	24.7	30.4	28.3	29.5	28.9	2.37	3931	406	4.3
September	63	32.8	25.2	30.9	28.7	30.0	29.3	1.91	4671	288	4.8
October	64	30.3	22.0	29.3	27.1	28.7	28.0	1.89	4099	94	3.8
November	61	28.7	19.5	26.9	24.6	26.5	25.9	1.58	3600	8	3.4
December	59	21.9	13.8	22.3	20.0	22.5	21.8	2.64	3081	10	3.3

Data (monthly mean) collected at the Tengeru meteorological weather station, Tengeru, Arusha, Tanzania, 2005

Month	Daily temperatures (°C) min	Daily temperatures (°C) max	Monthly precipitation (mm)
January	19.85	30.10	73.5
February	19.44	30.10	42.5
March	19.70	29.27	228.0
April	18.76	26.31	189.5
May	18.20	25.80	88
June	16.60	23.30	20.5
July	18.10	23.35	5.5
August	15.50	23.50	18.4
September	18.13	26.03	9.4
October	16.90	35.67	17.9
November	20.50	21.30	71.9
December	23.48	32.14	10.9

AVRDC

The World Vegetable Center