Project 9: Collaborative research and networks for vegetable production

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

The following reports summarize the work of AVRDC's collaborative programs in Bangladesh, Korea, Philippines, the Republic of China, and the Collaborative Vegetable Research and Development Network for Central America, Panama and the Dominican Republic. The activities of the South Asia Vegetable Research Network (SAVERNET) are reported as part of Program I.

AVRDC–USAID Bangladesh project

The AVRDC project entitled *Technology development and transfer for sustainable vegetable production and enhanced nutritional status in Bangladesh*, funded by the United States Agency for International Development (USAID), has been in operation, in collaboration with the Bangladesh Agricultural Research Institute (BARI) and Bangladesh Agricultural Research Council (BARC), since June 1993. The project has been providing valuable advanced breeding lines/varieties of different vegetable crops to various agriculture research institutions. Such collaboration has enabled BARI and other research organizations to develop and release several promising high yielding vegetable varieties, which will increase the productivity and consumption of vegetables in Bangladesh, and enhance food and nutritional security. In cooperation with non-governmental organizations (NGOs), the project has also been active in technology transfer, in the form of on-farm demonstrations, assistance with establishing home gardens, and training of farmers, trainers, and scientists on various aspects of vegetable production.

Contact: D P Singh

Introduction of germplasm

In 1999, about 216 germplasm accessions of 16 vegetables from AVRDC and other sources were provided to BARI and the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) for evaluation and utilization.

Tomato

Twenty-nine lines of tomato were evaluated at BARI, Joydebpur, during winter 1998–99. TM0999 produced the maximum number of fruit per plant. The yield range was 31.4–91.2 t/ha, the highest being from TM0972. Total soluble solids (TSS) content was high in TM0993, TM0994, TM0995, and TM0997 (6.06–6.37°brix). In terms of yield, TM0968, TM0971, TM0972, TM0974, TM0975, TM0977, TM0978, and TM0979 are the most promising lines.

Beta-carotene and cherry tomato

Yield trials of high beta-carotene (ß-gene) tomato entries were successfully carried at two Bangladesh locations: BARI at Gazipur (north of Dhaka) and with the Mennonite Central Committee (MCC) near Maijdi in Noahkhali district. Both trials were conducted in the peak vegetable season from November 1998–April 1999. Entries, selected fruit characters, and yields are given in Table 100. Mean entry yields were large in both trials, indicating that many of the entries are adapted to peak season conditions at the two locations. The mean yield at MCC was slightly lower, possibly because the trial was conducted in a farmer's field rather than at a research station. Several fresh market entries performed well at both locations, including CLN1314B, CLN1314E, and CLN1314G. The cherry tomato entries as a group yielded less than the fresh market entries, but that was expected. These entries will be evaluated in demonstration trials and on-farm in Bangladesh during 1999–2000. At the same time, large-scale seed multiplication of the entries is being carried out at AVRDC for international distribution.

Garlic

Fifteen virus-free garlic lines were evaluated at BARI's Spices Research Centre (SRC) during rabi (winter, December–February, cool/dry) 1998–99. The yield of GC0014, at 6.9 t/ha, was superior to that of any other line.

Muskmelon

Twenty-five muskmelon lines were evaluated during summer 1999 at BARI, Joydebpur. The highest yield per plant was obtained from MM104 (8.6 kg), followed by MM117 (7.9 kg), MM118 (7.7 kg), and MM107 (6.4 kg).

Watermelon

Twenty-eight varieties of watermelon were evaluated during summer 1999 at BARI. The highest yield was obtained from WM146 (31.4 t/ha); WM140, WM125 and WM142 all yielded more than 23 t/ha. WM132 was best for TSS content (11°brix) followed by WM125 (10.1°brix).

Research trials

Regional yield trials of promising tomato lines during winter 1998–1999

Six promising tomato lines (and Ratan as the check) were tested at BARI, Joydebpur, and its four regional stations. TM0944, TM0945, and TM0949 were promising at Joydebpur and Hathazari; TM0854-2-2 and TM0854-2-3 were best at Jessore and Ishurdi; and TM0949 was best at Jamalpur. Further testing is needed to confirm the results.

Two promising processing tomato lines (TM0928 and TM0931) were evaluated along with Lalima at five locations. Lalima was the best at Joydebpur, but the poorest at Jessore and Hathazari. TM0928 was better at Hathazari and Jessore, but was the poorest at Joydebpur. The evaluation needs to be repeated.

Four promising cherry tomato lines were evaluated at BARI and its four regional stations. The yield of HTM006 was higher (but not significantly) than that of the other lines. The trial needs to be repeated.

Three beta-carotene-rich tomato lines (along with TM0835 [Apurba] as check) were evaluated at Joydebpur, Hathazari, Ishurdi, and Akbarpur. TM0922 produced the highest yield at Ishurdi and Hathazari (72.2–72.4 t/ha), and TM0835 (check) was best at Akbarpur and Joydebpur (54.1–58.9 t/ha).

Regional yield trial of advanced early garden pea lines

Two promising lines of garden pea (GP006 and GP018) were evaluated (along with BARI Motor Shuti-1 as check) during rabi 1998–99. GP018 was early with reasonable yield at all the locations. This promising line is ready for release for early pea cultivation.

Table 100. *Characteristics of selected high beta-carotene tomato lines in Bangladesh*

Entry	Beta-carotene (mg/100g)[1]	Fruit size (g)	Disease resistance[2]	BARI yield (t/ha)	MCC yield (t/ha)
CLN1314G	6.59	182	BW, TMV, I	85.7a-c	71.0ab
CLN1314A	4.16	177	BW, TMV, I	63.2f-g	67.0a-c
CLN1314E	4.60	211	BW, TMV, I	78.5b-d	60.5a-e
CLN2070A	7.07	58	BW, TMV, I	47.2hi	58.0a-e
CLN2071C (ck)	4.33	44	BW, TMV, I	35.8j	43.9c-g
CaroRed (ck)	3.60	82		NT	39.6d-g
CLN1466D (ck)	1.18		BW, TMV, I, GLS	88.2 ef	80.1a
Trial mean	5.75	65		64.4	49.0

Means followed by the same letter within columns are not significantly different according to Duncan's Multiple Range Test (P=0.05).

[1] Beta-carotene contents for entries were determined at AVRDC.

[2] Disease resistance: BW = bacterial wilt tolerance, TMV = resistance to tobacco mosaic virus (conditioned by the *Tm2*^{2} allele), I = Fusarium wilt race 1 resistance, GLS = gray leaf spot.

NT = not tested; BARI = Bangladesh Agricultural Research Institute; MCC = Mennonite Central Committee (NGO).

Seed multiplication for screening against excess-moisture and drought in mungbean

AVRDC provided 500 mungbean accessions to BSMRAU during 1998 for screening for drought and excess moisture tolerance. The first step was to multiply seed. The germplasm was planted out in kharif I (March–May), and 316 plants produced flowers and seeds. Seed yield per plant ranged between less than 1 g and almost 60 g. Of the 316 plants, 59 yielded more than 30 g and nine produced more than 40 g of seeds.

Effect of grafting in watermelon

Agricultural Research Station Pahartali conducted a trial from August to December 1998 to determine whether grafting watermelon (variety Top Yield) onto bottle gourd rootstock can improve the growth and yield of the watermelon. Compared with nongrafted plants, the grafted watermelons had longer vines and more lateral branches, they produced both male and female flowers on higher nodes, and they flowered earlier: but none of these differences was significant. However, grafting did result in significant ($P<0.05$) increases in number of fruit per plant, TSS content, yield (56.9 t/ha from grafted plants, 3.5 times the yield of the nongrafted plants) and tolerance to fusarium wilt (43% of nongrafted plants died, compared with only about 3% of grafted plants).

Bacterial wilt resistance screening under field conditions

Twelve tomato lines supplied by AVRDC were evaluated at BARI, Joydebpur, during late rabi (winter) season, 1998–99. BL986 and BL1004 had no bacterial wilt infection. Slightly infected were L180 (4.16%), SX7611 (4.35%), and BL985 (4.35%). The highest yield was obtained from SX7610 (64.6 t/ha), followed by BL1004 (60.0 t/ha) and BL986 (59.4 t/ha).

Twelve eggplant varieties received from AVRDC, along with one local variety (Dohazari), were evaluated at Agricultural Research Station Pahartali during December 1998 to April 1999. All the lines showed resistance to bacterial wilt in the field (natural infection). After artificial inoculation, EG195 showed no wilting up to 28 days after inoculation, and only 20% of EG193 plants wilted, but the wilting rates of the other entries ranged from 55 to 100%.

Tomato yellow leaf curl virus resistance screening

Tomato yellow leaf curl virus (TYLCV) is a serious disease of tomato in Bangladesh. In rabi 1998–99, 14 *Lycopersicon* accessions were screened for resistance to this virus. The susceptible check (ATY13) showed the highest disease incidence, with 75% of plants showing symptoms. Five other entries (ATY1, 5, 7, 15, and 21) also showed some susceptibility (17–27%). ATY 10, 11, 14, 16, 17, 18, 22, and 23 showed no visual symptoms.

Thirteen pepper lines from AVRDC were also screened for resistance to TYLCV. Entries were planted in a screenhouse and in the field. Virus-like symptoms were seen on most of the accessions, but only one (PTY4) showed a positive reaction in a DNA hybridization test with a Bangladesh probe. In another trial, of five accessions of chili from AVRDC, only PBC176 and PBC491 showed no TYLCV infection in the field, but none of the entries showed a positive reaction to a DNA hybridization test.

Disease incidence and yield of advanced mungbean lines

During kharif-II season (June–November) 1998, a trial was conducted at BSMRAU with 68 advanced lines of mungbean obtained from AVRDC. The seeds of those 68 lines were planted for the second time in the kharif-I season 1999. To provide an environment conducive to viral infection, rows of a susceptible (spreader) line (Barisal local) were planted alternately with rows of the advanced lines. The unusual weather conditions during the season were already favorable for the spread of mungbean yellow mosaic virus (MYMV). Even so, most lines showed a great degree of tolerance to MYMV. In most cases, less than 10% incidence of MYMV was seen at flowering stage. Some 18 genotypes yielded more than 1 t/ha.

Impact analysis of okra and summer tomato cultivation

A study was undertaken by the Agricultural Economics and Statistics Section of the Horticultural Research Centre (HRC), BARI, to assess the impact of new technologies on types of vegetable cultivation, profitability, consumption patterns, extent of adoption, etc. The study was conducted in Manikganj, Jessore, Rangpur, and Chittagong districts. The average land holding of the farmers in

the study areas was 0.99 ha, of which 0.33 ha was under vegetable cultivation. A total of 212 farmers were interviewed for the okra survey and 49 for the summer tomato survey.

Okra

BARI Dherosh-1, a new virus-resistant okra variety, has been cultivated for the past two years: the present cropping intensity is 252%. Use of this new variety has reduced the need (and cost) for pesticides, and the average area under okra cultivation on each farm has increased, from 0.13 ha in 1996 to 0.17 ha in 1997 and to 0.21 ha in 1998, thus increasing employment opportunities. The labor and power requirements for okra cultivation are 230 person-days and 26 animal-pair-days per hectare.

The average yield of okra was 11.4 t/ha, providing a gross margin of BDT 39,560/ha (about US$790/ha) and a benefit/cost ratio of 2.68 on a full-cost basis. The return to labor per day was BDT 220 (about US$4.4) against the daily wage rate of BDT 50 (about US$1). About 77% of the okra was sold immediately after harvest, and only about 9% was consumed by the farm family.

Consumption of all vegetables in the summer averaged 10 kg/family/week (238 g/person/day). In the winter, consumption was 14 kg/family/week (333 g/person/day).

The sampled farmers learned about improved technology for okra cultivation from NGOs. The index of adoption (area cultivated using improved technology as a percentage of total area under cultivation) of okra was 40. About 89% of sampled farmers said they would continue growing this crop in the next year.

Summer tomato

Most farmers in the study area started growing tomatoes in 1991–92, but summer tomato cultivation began only in 1996–97, with a cropping intensity of 241%. The area under summer tomato cultivation was 0.11 ha per farm in 1996 and 1997, but increased a little to 0.12 ha per farm in 1998. Most (78%) farmers grew summer tomato in the highlands. The labor requirement for summer tomato cultivation is 356 person-days per hectare, so the adoption of this crop has greatly increased employment opportunities.

The average yield of summer tomato was 12.3 t/ha; farms in Jessore produced the highest yields (17.1 t/ha). On average, gross margin was BDT 230,695/ha (about US$4600/ha) and the benefit/cost ratio was 5.15, on a full-cost basis. The return to labor per day was BDT 662 (about US$13.20) against the daily wage rate of BDT 50 (about US$1). About 71% of summer tomato produce was sold immediately after harvest and 20% was consumed by the farm family.

Average daily consumption of all vegetables per person was 167 g in the summer and 250 g in the winter.

The farmers obtained seeds/seedlings and information on improved technologies through NGOs.

The index of adoption for summer tomato was 31. The scarcity of supplies of Tomatotone hormone was a crucial constraint.

Socioeconomic study on food habits of tribal people

The Agricultural Economics and Statistics Section of HRC, BARI, Joydebpur, conducted a study of the food habits, especially the vegetable consumption, by tribal people in different parts of Bangladesh. Sixty households were surveyed in each of five areas over three seasons (kharif-I, kharif-II, and rabi). The main findings from the study were as follows:

- Area under vegetable cultivation ranged from 0.02 ha/farm (Cox's Bazar) to 0.42 ha/farm (Khagrachari).
- The tribal people with the largest vegetable growing area were the Chakma people in Khagrachari (0.42 ha/farm) and the people with the smallest vegetable area were Rakhain people from Cox's Bazar (0.02 ha/farm).
- Almost all of the respondents cultivated vegetables in their homestead areas in all seasons. Average areas under homestead cultivation were 0.03 ha/farm in kharif-I and 0.07 ha/farm in kharif-II and rabi.
- The respondents consumed about 70% of their vegetable production; the rest was sold in local markets.
- Vegetable consumption was recorded for the peak and lean periods of vegetable availability in each of the three seasons at each location. Over the peak periods, the Garo people in Sherpur had the highest average daily vegetable consumption (132 g/person) and the Rakhain people in Cox's Bazar the lowest (59 g/person). Over the lean

periods, average daily vegetable consumption ranged from 32 g/person in Dinajpur (Saotal) to 61 g/person in Sylhet (Monipori). Over all seasons and all locations, average daily vegetable consumption was 81 g/person in the peak period and 45 g/person in the lean period. Consumption varied across income groups.

- In all of the study areas, vegetables were in shortest supply in kharif-II.
- The average yield of vegetables was low in all the tribal areas.
- The major constraints to vegetable production were found to be non-availability of high yielding variety seeds, high price of seeds, insecticides, and other inputs, non-availability of irrigation facilities, and lack of information on improved methods of cultivation.

The investigators made the following recommendations:

- Tribal people should be offered short-term training on improved production technologies and on awareness of the nutritional value of vegetables.
- Tribal people should have access to quality seeds at the right time and at fair prices.
- The Department for Agricultural Extension and NGOs should implement extension programs on vegetable cultivation in tribal areas.

Technology transfer

Field demonstrations through BRAC, rabi season 1998–99

The Bangladesh Rural Advancement Committee (BRAC) gave more than 200 demonstrations of new varieties of different vegetable crops.

- **Tomato**: six varieties were demonstrated with 40 farmers. BARI-3 and Ratan performed extremely well and were liked by the farmers. Apurba was not popular with the farmers. All varieties fetched similar prices.
- **Eggplant**: three varieties (Kazla, Nayantara, and Shingnath) were demonstrated with two farmers. Kazla proved to be the superior because of its high yield, followed by Nayantara.
- **Radish**: all four varieties demonstrated were equally good, and high in yield.
- **Dwarf bean**: only one variety, BARI Jhar Seem-1, was demonstrated. Its yield was not high (7.4 t/ha).
- **Peas**: Motor Shuti 1 and 2 gave high yields and were in good demand among the farmers.
- **Bottle gourd**: BARI Lau-1 exhibited excellent performance (62 t/ha).
- **Coriander**: BARI Dhania-1 gave good yield and fetched a good price. Its green leaves were well accepted by farmers.
- **Okra**: BARI Dherosh-1 was quite good. The variety continued to be virus free and was well accepted by farmers.

Field demonstrations through PROSHIKA, rabi season 1998–99

The NGO PROSHIKA gave about 270 demonstrations, as follows:

- **Tomato**: Six varieties (Apurba, Chaiti, Shila, Lalima, BARI-3, and Ratan) were tested at 15 locations with 88 farmers. Chaiti was the earliest to flower—62 days after sowing, with a range of 53–72 days at different locations. Apurba first flowered 81 days after sowing (range 75–87 days), gave the highest yield (83.9 t/ha, range 75–95 t/ha), and had the highest average fruit weight (115 g, range 100–136 g) and the most fruit per plant (24, range 22–33). In an evaluation of Chaiti, BARI-3, and Ratan at nine locations with 40 farmers, Chaiti was first to flower (60 days); average fruit weight was 71 g, yield 65.4 t/ha.
- **Eggplant**: Three varieties were demonstrated at two locations in Manikganj. Singhnath gave the most fruit per plant, followed by Nayantara. Fruit weight ranged from 70 to 220 g, the highest was Kazla followed by Nayantara. Singhnath yielded more than the newer varieties, but none gave a satisfactory yield. When only Kazla and Singhnath were tested with four farmers at two other locations (Savar and Pakundia), Singhnath was again superior.
- **Cabbage**: When Agradut and Atlas-70 (a popular hybrid) were demonstrated at five locations, their yields were not significantly different: Agradut yielded 6–8 t/ha and Atlas-70 yielded 8–10 t/ha.
- **Cauliflower**: The BARI-released variety Rupa was demonstrated with Snow Crown F_1 at six locations with 14 farmers. Curd formation started

at almost the same time in both varieties. Snow Crown was superior in terms of average curd weight and average yield, but Rupa, being an open-pollinated variety, is more popular with the farmers because it can produce seeds.

- **Bottle gourd**: BARI Lau-1 was demonstrated along with BADC-recommended Khet Lau at five locations with 40 farmers. BARI Lau-1 had far superior yield and earliness at all the locations.
- **Coriander**: BARI Dhania-1 variety was compared with a local variety at three locations with 80 farmers. The BARI variety matured a few days later than the local variety, but had a better yield performance.

Field demonstrations through Gonokallyan Trust (GKT), rabi season 1998–99

During rabi 1998–99, GKT conducted 115 field demonstrations of newer vegetable varieties.

- **Tomato**: The six varieties (mentioned above) were planted in the fields of 23 farmers. The fruits of Apurba, BARI-3, and Ratan were liked by most of the farmers. Ratan and BARI-3 outyielded the other varieties. Chaiti, BARI-3, and Ratan were tested by 20 farmers, who liked all the varieties.
- **Radish**: Tasakisan and Mino Early performed better than Pinky and the local check Red Bombay. Druti also performed well wherever it was demonstrated.
- **Bottle gourd**: BARI Lau-1 performed better than did Khet Lau.

Field demonstrations through MCC, rabi season 1998–99

In all, 63 trials of different vegetable crops were allotted to MCC.

- **Tomato**: Six varieties were demonstrated in eight districts. Chaiti had the best yield (range and average) and fruit size. Farmers liked it for its good yield, taste, and large fruit size, and because there was good demand for it in the market. Ratan was still favored by several farmers for its yield.
- **Cabbage**: Agradut was not found to be better than Atlas-70 in terms of head size and yield.
- **Cauliflower**: Rupa was not preferred over Snow Crown by the farmers.
- **Radish**: Most of the farmers preferred the color, taste, and softness of Pinky over Mino Early.
- **Eggplant**: Kazla was liked by the farmers
- **Bush bean**: BARI Jhar Seem-1 yielded well.

Mungbean demonstrations through BARI

Some 920 demonstrations of six improved varieties of mungbean were undertaken. In all locations, the improved varieties performed better than local cultivars with respect to yield (>1000 kg/ha) and other agronomic traits.

Selection of partner NGOs

A workshop was held on 26 April 1999 to identify NGOs to participate in the project's technology transfer program. A two-day training program was organized on 29–30 June 1999 at BARI to brief the trainers of the 23 selected NGOs on conducting the kharif-I demonstration trials, and on data collection.

During kharif-I season, the 23 partner NGOs were involved in implementing 2796 demonstrations and 9800 homestead gardens in 45 thanas in 34 districts. About 12,600 farmers were involved in these activities covering most of the agroecological zones of Bangladesh. The main crops for the demonstrations and homestead gardens were summer tomato, okra, kangkong, red amaranth, yard-long bean, bottle gourd, and stem amaranth. Most of the crops appeared to perform well: data on comparative yield performance are now being compiled and analyzed.

About 50 demonstrations on okra seed production were given in eight thanas through four NGOs; the aim was to make the seed production technologies available to farmers. These demonstrations were much appreciated by the NGOs, the seed growers, and the farmers, and there is an increasing demand to expand these demonstrations in the future.

During kharif-II 1999, about 1455 demonstrations of six vegetable crops (country bean, batisak [*Brassica chinensis*], chinasak [*Brassica parachinensis*], radish, kangkong, and tomato) were given in 45 thanas through 23 NGOs. In addition, about 19,700 homestead gardens were also established. Three vegetable crops (country bean, red amaranth, and yard-long bean) have been selected for homestead gardening.

Non-availability of quality seed is one of the main barriers to vegetable cultivation in Bangladesh, and poor farmers cannot afford quality seed. With the aim of making seed production technologies

available to farmers, 50 demonstrations were organized on seed production of kangkong in 15 thanas through six NGOs.

There is a high demand for tomato in the kharif season, so there is wide scope for expanding summer tomato cultivation in Bangladesh. However, bacterial wilt is a serious problem in tomato cultivation, particularly in the kharif season. Grafting tomato onto bacterial wilt resistant eggplant rootstock can mitigate this problem, and 225 demonstrations of this technique were organized in 19 thanas through 10 NGOs.

Field days

During 1999, about 15 field days demonstrating baby corn, chili, eggplant, brocolli, summer tomato, okra, red amaranth, yard-long bean, and BARI Mungbean-2, 3, 4, and 5 were organized at various sties. They were attended by almost 1000 farmers, some local Department of Agricultural Extension workers, researchers, NGO personnel, and local people. The demonstrations concentrated on BARI summer tomato and BARI Mungbean varieties. BARI Tomato-4 and 5 performed excellently in most places: all the farmers were impressed and showed keen interest in cultivating the crop in the next year on a larger scale. BARI mungbean varieties also performed well in many places and impressed all who attended the demonstrations. All other vegetables performed well, to the satisfaction of farmers, partner NGOs, and extension workers. Farmers who attended these field days participated actively in the discussions, and asked for more demonstrations in their areas.

Exchange visits among NGOs

Exchange visits among NGOs is a new dimension of technology transfer and dissemination of AVRDC vegetable technologies. Banchte Shekha organized a visit for 25 of its demonstration farmers and field staff to see the demonstrations given by the Society for Social Service (SSS) in Tangail during the last week of September 1999. In return, SSS organized a visit of 10 persons to Banchte Shekha, Jessore. These exchange visits provided an opportunity for interaction among farmers and staff of two leading NGOs, which, it is hoped, will have a positive impact on technology dissemination.

Trainer training

During 1999, more than 650 trainers from partner NGOs attended 21 training courses on various vegetable technologies, organized by BARI regional stations and NGOs.

Farmer training

During 1999, partner NGOs and BARI regional stations organized more than 600 training courses, covering most of the agroecological zones of Bangladesh. The purpose was to make vegetable production technologies, developed by different research institutions, available to farmers. Almost 18,000 farmers attended these courses.

Monitoring of technology transfer and research activities

In order to check on project progress, assess the impacts of technology transfer, and decide on future directions, a monitoring and evaluation study was conducted throughout Bangladesh during kharif-I (July–September) 1999. The survey was specifically designed to evaluate the demonstration and homestead activities of the project. The collected information is still being analyzed, but preliminary analysis indicates that certain varieties of yard-long bean, okra, kangkong, bottle gourd, red amaranth and stem amaranth are well accepted by farmers and partner NGOs in most areas where the vegetables were introduced. Red amaranth variety BARI Lalsak-I did well in most places, except in southern and eastern areas. Summer tomato varieties BARI-4 and BARI-5 also showed good performance in most locations, despite moderate incidence of leaf curl virus.

Training, workshops, and publications

Eight BARI scientists attended specialized AVRDC training courses in Taiwan and Thailand during 1999.

A review workshop on vegetable research and development activities of the BARC/BARI–AVRDC–USAID Project was organized on 28–30 January 1999 at BARC, Dhaka. Twenty-two lectures were presented in the technical sessions, which were attended by more than 80 participants from NARS, NGOs, government organizations, international organizations, and private enterprise.

Vegetable cultivation technology packages for kharif-I, kharif-II, and rabi season have been developed by the Project and distributed to all partner NGOs. These manuals are very helpful to the partner NGOs in implementing demonstrations and homestead activities.

The Project printed 10,000 copies of two posters on the varieties of different vegetable crops released by BARI, one poster for winter crops and the other for summer crops.

Twenty-four units of seven titles of AVRDC publications were given to BARC's library.

AVRDC–Korea outreach program

The objective of research collaboration between AVRDC and the Korean Sub-Center is to increase farming productivity and profitability in Korea by developing improved varieties, especially of Chinese cabbage, tomato, pepper, mungbean, and soybean. As part of the crop improvement program, the Korean Sub-Center has introduced various germplasm accessions from AVRDC and implemented collaborative research activities with the National Horticultural Research Institute (NHRI) and the National Crop Experiment Station (NCES), Korea.

In 1999, a new mungbean variety was released by NCES for mungbean sprouts production. The variety, Jangan, has bruchid resistance introduced from an AVRDC mungbean breeding line, AV1-3-1 (Table 101). The AVRDC line was introduced in 1992 and used for making cross combinations to introduce the *Br* gene that confers resistance to bruchid (*Callosobruchus chinensis* L.), a major storage pest. Through repeated backcrosses, the resistant gene was successfully introduced in the background of a local variety, Keumseong, a productive and once-over harvest mungbean variety bred by Chonnam Agricultural Research and Extension Services.

The newly bred variety bears yellow flowers, black pods at maturity, and dull green seeds. It is shorter and more lodging resistant than V1973A, a mungbean variety bred by AVRDC and introduced in Korea by NCES. The new variety showed strong resistance against bruchids in field and growth chamber tests. The variety is 18% higher yielding (1.43 t/ha) than V1973A, locally known as Seonhwa.

Many other germplasm accessions received from AVRDC are being evaluated and used in several breeding programs. Cytoplasmic male sterile lines of Chinese cabbage and cherry tomato accessions are a few such examples.

Other activities in 1999 included evaluation of entries in AVRDC's 9th International Chili Pepper Nursery, and generation advance and seed multiplication of Korean breeding lines of legumes.

Contact: D G Oh

Table 101. *Yield and agronomic characteristics of new mungbean variety,* Jangannogdu

Variety	First harvest	Plant height (cm)	Bruchid damage (%)		Yield[2] (t/ha)
			Field[1]	Chamber	
Jangan	Aug 13	55	0	0	1.43
V1973A	Aug 16	61	7	100	1.18

[1] Field infection was scored at 60 days after harvest.
[2] Average yield of regional yield trials at two locations, 1997-1999.

AVRDC–Philippines outreach program

The Philippines outreach program tests and adapts vegetable varieties and technologies from AVRDC and transfers them to farmers. Research is concentrated on mungbean, soybean, tomato, pepper, and onion. Germplasm from AVRDC is evaluated in preliminary yield trials (PYT) and general yield trials (GYT) in wet and dry seasons. Lines with promising yield, resistance to pests and diseases, and market preference, are further evaluated in regional yield trials (RYT) conducted at 8–10 testing stations throughout the country, in collaboration with other Bureau of Plant Industry and Department of Agriculture stations, agricultural schools, colleges, and universities. Varieties considered suitable for release to farmers are recommended, by the technical working group, to the approving committee of the National Seed Industry Council (NSIC).

The Bureau of Plant Industry–Los Baños National Crop Research and Development Center (BPI–LBNCRDC) at Los Baños, Laguna, was identified as a national center for tropical lowland crops in 1988. Research is focused on varietal improvement and cultural management of vegetables (including legumes) and ornamental crops. BPI–LBNCRDC was also mandated to produce breeder and

foundation seed of NSIC-approved varieties, for multiplication at other BPI centers, local and national government units, and private seed companies. Developed varieties that have high yield and can be adapted to the multiple cropping schemes of lowland farmers play a vital role in productivity, profitability, and food security.

Contact: A A Virtucio

Seedboard varieties

Mungbean variety PSB-Mg6 (Centennial Mungo) was recommended in 1998 as part of the nation's centennial celebration, but was approved in 1999. It was developed from a cross between VC2755 and VC1482-E, both AVRDC lines. It was evaluated at 12 cooperating stations from 1995 to 1997, in eight wet season and 13 dry season trials. The variety has yield potential of 1.2 t/ha—13% more than the check. The plant matures in 58 days and shows moderate resistance to cercospora leaf spot and virus.

PSB-Mg7, another mungbean variety approved in 1999, was developed from a cross between VC1168-B and VC1973-A, both AVRDC lines. In 14 yield trials at 11 cooperating stations, this variety was a consistently high yielder with 1.13 t/ha in the wet season (16% higher than the check) and 1.08 t/ha in the dry season (11% higher than the check). A dull-seeded variety, its 100-seed weight is 5.4–6.3 g. The plant matures in 57 days and has moderate resistance to cercospora leaf spot and virus.

Table 102. *Number of entries evaluated in various crops, dry and wet seasons 1999*

Crop	Number of entries evaluated			
	IES	PYT	GYT	RYT
Mungbean	25	76	31	9
Soybean	46	29	11	10
Tomato		74	11	10
Eggplant	27	13		
Chili	20	23		
Okra	118			
Onion	12			
Shallot	13			
Garlic	15			
Squash	25			
Sweet potato		20	6	
Total	301	235	59	29

IES = introduction, evaluation, and selection; PYT = preliminary yield trials; GYT = general yield trials; RYT = regional yield trials.

PSB-Tm9 is a tomato variety developed from a cross between VC48-1 GS and Tamu Chico III, from AVRDC. A fresh market determinate type, the variety is recommended for both wet and dry seasons. Because of its heat tolerance, it has a potential yield of 25 t/ha (7% higher than the check) in wet seasons. Each plant produces 1.3 kg of fruit during the dry season and 0.85 kg in the wet season. The semi-globe, moderately firm fruit can be stored under ambient conditions for up to 44 days from harvest. The variety is moderately susceptible to radial cracking and early blight.

Varietal evaluations

The number of entries of various crops evaluated in 1999 are shown in Table 102. Okra had the highest number of entries in the introduction, evaluation, and selection (IES) scheme because it has been identified as a promising crop for export.

The RYTs in 1999 were conducted at up to 12 sites by the National Technical Working Group for Legumes and Vegetables. Results of the regional trials are highlighted below.

Mungbean

Nine mungbean lines were evaluated in eight to nine locations throughout the country. The wet season trial was planted on 10 February 1999. Three entries outyielded the local check (Table 103), but the differences were not significant. Seed size of EGM4195 was comparable to that of the check. The two AVRDC lines matured significantly (but marginally) later than did the check.

Table 103. *Performance of best mungbean entries in regional yield trials, various locations, dry season 1999*

Entry	Yield (kg/ha)	100-seed weight (g)	Days to maturity
IPB46-49-0	676 a	5.2 b	52 c
EGM4195	612 a	6.3 a	54 a
EGM4190	588 a	5.2 b	54 a
Mg50-10A (local ck)	585 a	6.2 a	53 b
Grand mean (of nine entries)	561	5.6	53
CV%	20.43	3.39	1.05

Means followed by the same letter within a column do not differ significantly.

The wet season trial, also of nine entries, was planted on 28 June 1999. Only one entry, EGM4310, outyielded the check (Table 104); its seed size was comparable to that of the check, but it matured significantly (although marginally) earlier.

Soybean

Ten soybean entries were evaluated at BPI-LBNCRDC, Los Baños; entries were planted on 11 February 1999.

The yield of EGSy98-4-27 was comparable to those of the national checks (Table 105). However, it had larger seeds and matured significantly earlier than did the highest yielding check.

Table 104. *Performance of best mungbean entries in regional yield trials, various locations, wet season 1999*

Entry	Yield (kg/ha)	100-seed weight (g)	Days to maturity
EGM4310	611 a	5.2 ab	51 a
PSBMg6 (national ck)	548 a	5.3 a	50 b
IPBM87-35-15	493 a	4.8 c	51 a
EGM4190	434 a	4.9 bc	51 a
Grand mean (of nine entries)	438	4.8	51
CV%	38.34	4.4	0.82

Means followed by the same letter within a column do not differ significantly.

Table 105. *Performance of best soybean entries in regional yield trials at BPI-LBNCRDC, dry season 1999*

Entry	Yield (t/ha)	100-seed weight (g)	Days to maturity
PSBSy6 (national ck)	3.3 a	15.4 b	102 a
EGSy98-4-27	3.2 a	19.0 ab	98 b
PSBSy8 (national ck)	3.1 a	19.6 ab	93 c
EGSy98-31-4	3.1 a	19.2 ab	104 a
Grand mean (of 10 entries)	2.9	19.1	99
CV%	10.07	6.07	0.96

Means followed by the same letter within a column do not differ significantly.

Tomato

Ten tomato lines were evaluated. Entries were transplanted on 10 February 1997, and harvested (four harvests) between 5 and 20 April.

ANT7 and ANT22, both AVRDC lines significantly outyielded the check variety (Table 106). ANT7 had larger fruit than either ANT22 or the check, and the AVRDC lines matured slightly (but not significantly) earlier than did the check.

AVRDC–ROC cooperative program

Bilateral vegetable research and development in Taiwan

The goal of the subproject is to increase the capacity of the national agricultural research system in Taiwan, to stabilize summer vegetable production, and to reduce seasonality of vegetable supply. The project continued to conduct adaptive research (trials) in cooperation with the NARS of the host country. The Republic of China (ROC) Council of Agriculture (COA) supports the project. Promising AVRDC vegetable varieties/lines are evaluated in the field in different seasons and locations in Taiwan in cooperation with various District Agricultural Improvement Stations (DAIS). The research and trials aim to complement the NARS and to identify promising vegetable varieties and improved cultural practices for release in Taiwan. To date, 15 AVRDC improved varieties of various crops, including mungbean, soybean, vegetable soybean, Chinese cabbage, processing tomato, fresh market tomato,

Table 106. *Performance of best tomato entries in regional yield trials at various locations, dry season 1999*

Entry	Yield (t/ha)	Fruit size (g)	Days to maturity
ANT7	18.1 a	40 a	55 a
ANT22	15.1 ab	28 b	55 a
DSF861-5	12.7 bc	29 b	57 a
BPI-Tm-1 (ck)	9.3 c	26 b	57 a
Grand mean (of 10 entries)	10.4	34	57
CV%	27.9	18.9	4.9

Means followed by the same letter within a column do not differ significantly.

and cherry tomato, have been released. Most of these varieties now make major contributions to vegetable production in Taiwan (Table 107).

Regional yield trials

In 1998–99, a total of 35 regional yield trials were conducted, in cooperation with Tainan, Taichung, Kaohsiung and Taoyuan DAIS, to evaluate AVRDC's improved varieties/lines of vegetable soybean, mungbean, fresh market and cherry tomato, and lettuce at different locations and in different seasons (spring, summer, and autumn).

In the vegetable soybean trials, nine lines were evaluated in 10 trials against three check varieties. The lines showed significant differences in pod yields. TS82-02V-03 gave the highest yield of 9.3 t/ha over seven locations in spring 1999, and also had the highest protein content at 44.4%.

Mungbean is a speciality in Chiayi. The local growers and consumers prefer large dull-seeded lines. The mungbean trials by AVRDC and Tainan DAIS identified three lines—NS81-36, VC6040A, and NS85-03—which outyielded the check (Tainan No 5). Their yields were in the range 1.81–2.06 t/ha.

Table 107. *Planted area and estimated production of AVRDC improved vegetable varieties in Taiwan, 1998*

Crop and varieties	Area planted to varieties: ha	Area planted to varieties: % of total production area of that crop	Production (t)
Fresh market tomato Taichung-ASVEG #4, Hualien-ASVEG #5	235	29	14,091
Cherry tomato Tainan-ASVEG #6	484	59	24,200
Mungbean Tainan #3 and #5	237	100	210
Soybean Kaohsiung #9 and #10, Tainan #1 and #2	793	100	2,300
Vegetable soybean Kaohsiung #1, Kaohsiung #2 and #3	2090	24	15,675

In fresh market tomato trials in spring 1999, three hybrids (FMTT552, FMTT553, and FMTT556) were tested against the check varieties Hualien ASVEG #5 and Taichung ASVEG #4 in three locations in Lanyang area. Mean yields ranged from 66.4 to 71.2 t/ha compared to 71.5 t/ha from the best of the checks, Hualien ASVEG #5. In the summer, five hybrids were evaluated in the Taichung area against the check, Taichung ASVEG #4. FMTT553, a large-fruited variety with dark green shoulders, gave the highest mean yield of 75.5 t/ha; average fruit weight was 155 g. The check yielded 74.8 t/ha with 122-g fruit. In trials of cherry tomato, none of the entries gave higher yields than the check, Tainan ASVEG #6 (CHT154).

Among the four lettuce varieties evaluated, LT86 gave the highest average yield, 28.6 t/ha, across spring and summer seasons in Taoyuan. The other two entries, LT40 and LT45, also outyielded the checks Takii and local variety Min Fun #3, but matured later than the local variety.

Variety evaluation trials

AVRDC continued to identify vegetables for recommendation to the host country NARS, to diversify the production and consumption of vegetables. In 1998–99, snap bean, yard-long bean, broccoli, cauliflower, and various green leafy vegetables were included in the project. Summaries of trial results and lists of promising accessions of these vegetables are presented in Table 108.

Samples of leafy vegetables were analyzed for nutrient content, and results are summarized in Table 109. Kale varieties (including *B. carinata*) were rich in vitamin C. Vitamin C, calcium, iron, and nitrate contents varied between spring and summer seasons within species.

Technology transfer

A fresh-market tomato hybrid developed by AVRDC is undergoing the process of naming and release by Taoyuan DAIS. This variety has large fruit with the dark green shoulder preferred by local consumers.

In order to transfer grafting technology to NARS and farmers in Taiwan, a field day and a four-day training course on grafting techniques for summer tomato production were conducted. The field day was held on 6 August 1999 in Taipao, Chiayi, to demonstrate the growth, productivity, fruit quality, bacterial wilt incidence, and flooding tolerance of

grafted cherry tomato. The field day attracted more than 60 farmers and nursery operators in the Chiayi–Tainan area.

The training course was offered to local nursery operators, extension workers, and farmers in September 1999. The course comprised lectures, hands-on practice, and visits to grafted-tomato production areas and a nursery that raises grafted seedlings. Twenty participants completed the course, which was supported by the ROC Council of Agriculture and conducted by the AVRDC Technology Promotion and Services Unit in cooperation with Tainan DAIS. Topics included:

- an overview of cherry tomato production and problems of summer production and continuous cropping, such as high temperature, diseases, and flooding
- important diseases in summer and continuous cropping systems
- application of grafting techniques in tomato production—principles and methodology
- results of on-farm trials including economic assessment

Stock seed production and distribution

AVRDC produced stock seeds of released vegetable varieties for NARS, with the COA's support. In total, 2154 kg of cherry tomato, soybean, vegetable soybean, and mungbean seeds were produced and distributed in 1998–99.

Contact: N C Chen

Table 108. *Promising accessions of vegetables identified in the variety evaluation trials*

Crop	Number of entries	Yield range (t/ha)	Promising accessions
Bush snap bean	49	3.7-7.2 (Au) 3.0-17.1 (Sp)	BN248, BN259, BN260, BN268, BN269, BN281
Pole snap bean	38	3.3-21.6 (Au) 3.5-32.4 (Sp)	BN318,BN321, BN322, BN323, BN325
Yard-long bean	22	7.5-22.8 (Au) 6.5-15.4 (Sp)	VU057, VU072, VU097, TUN206, TUN 209, TUN210
Broccoli	13	9.8-14.2	Dark Horse F_1, Green Treasure, Triumph No.3
Cauliflower	15	12.2-24.4	White Shot F_1, Hybrid 501, Fremont F_1, Milkyway F_1
Amaranth	41 (Sp) 19 (Su)	1.1-5.8 (Sp) 1.2-2.9 (Su)	TOT1807, TOT2215, TOT2263, TOT2265, TOT2353
Kale	12 (Sp) 8 (Su)	4.6-13.3 (Sp) 1.5-16.0 (Su)	LV019, LV020, LV021, CN103, CN104
Mustard	11 (Sp) 6 (Su)	6.4-12.8 (Sp) 2.6-4.6 (Su)	LV008, TB473, TB559, CN078
Paitsai	12 (Sp) 8 (Su)	3.9-15.0 (Sp) 3.1-5.0 (Su)	CN098, CN099, TB518, TB550
Rape	16 (Sp) 11 (Su)	7.5-16.4 (Sp) 1.6-5.4 (Su)	TB439, TB570, TB571, TB599

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

Table 109. *Nutrient contents of leafy vegetables*

Crop	Number of accessions	Dry matter (%)	Sugar (%)	Fiber (%)	Vitamin C (mg/100 g fresh matter)	Calcium (mg/100 g dry matter)	Iron (mg/100 g dry matter)	Nitrate (ppm)
Spring								
Amaranth	8	9.0	7.9	10.0	51	1769	50	2975
Kale	2	9.0	11.0	13.4	120	1048	16	3991
Mustard	6	5.2	8.4	13.3	65	828	40	3932
Paitsai	5	4.7	7.5	12.7	59	1320	62	3589
Rape	5	4.6	6.0	13.7	57	909	36	4239
Summer								
Amaranth	6	8.3	2.5	10.6	32	2330	22	3675
Kale	4	6.3	7.1	11.7	103	2131	28	4090
Mustard	3	6.2	15.1	11.6	80	1288	22	3754
Paitsai	3	5.5	13.4	12.0	65	1639	23	4165
Rape	5	5.4	10.3	12.3	70	1804	28	4168

REDCAHOR

Collaborative Vegetable Research and Development Network for Central America, Panama and the Dominican Republic

The Collaborative Vegetable Research and Development Network for Central America, Panama and the Dominican Republic (REDCAHOR) is a regional, coordinated effort aimed at evaluating genetic resources, validating varieties suited to growers' needs, and studying alternative methods for managing pests. The idea is to generate technological options and strengthen national varietal improvement programs, and teamwork, in the vegetable sector. The member countries conduct joint research activities aimed at solving problems affecting the crops to which they attach the greatest priority. A leader is assigned to each research project and common protocols are defined, so that results can be shared and materials exchanged. From June 1998 to June 1999, the Network conducted 54 research projects involving 66 researchers from 23 national institutions.

Contact: C G Kuo

Introduction of genetic resources

Tomato

Studies were aimed at selecting cultivars resistant to viruses, late blight caused by *Phytophthora infestans*, and bacterial wilt caused by *Ralstonia solanacearum*.

The selection of genotypes for resistance to whitefly (*Bemisia tabaci*) transmitted geminivirus complex was hindered by the fact that there was no significant infection in the field because of Hurricane Mitch. However, Nicaragua and Panama were able to make some observations, which were not conclusive but helpful. Nicaragua identified seven lines (i.e., 10660, TA02288, L00170, L06674, L02094, 6225, and L01830) as promising, and Panama three (05641, 08433, and 17337) that warrant further investigation.

Pepper

An average of 112 accessions were evaluated in each country, with a view to selecting plants resistant to viruses, to the pepper weevil, to bacterial wilt, and to early or late blight. In the Dominican Republic, PP977431, SN46, PP602, PP154, PBC590, PP977174 were promising in terms of fruit size, fruit form, fruit color. In Panama, 86 lines were found tolerant/ resistant to bacterial wilt. In Costa Rica**,** PP977122 and PBC830 were resistant to viruses with had good agronomic characteristics. Well-adapted sweet pepper or cayenne pepper were characterized and found to be acceptable for use in national selection and validation programs. Panama selected varieties (PP977116 and 6457) resistant to bacterial wilt, the most important constraint to pepper production in the country. Certain varieties of hot peppers were also evaluated and might be used by national programs.

Costa Rica reported identifying a sweet pepper variety (UCR-589) that shows great potential in terms of production and quality. This variety is being evaluated during the 1999-2000 growing season.

Cucurbitaceae

In Costa Rica, trials of summer squash (*Cucurbita pepo*) and winter squash (*C. moschata*) revealed great variability in yield, which might be attributable to the type of material used, or to the fact that the seeds came from plants in which pollination had not been controlled. REDCAHOR has also organized short courses, workshops and projects that have enabled researchers in the region to use molecular markers in the creation of a core collection of *C. moschata*.

Regional trials of commercial cultivars

The objective of these trials is to evaluate systematically the commercial cultivars and the advanced lines available, in terms of adoption, production, and market potential.

Tomato

Validation trials were conducted in two locations in each country. Each trial consisted of 22 cultivars and two checks (one regional and the other national). In all cases, quality, yield, and the incidence of the most important insect pests and diseases were evaluated.

In the case of fresh tomato, Costa Rica reported positively on the performance of the cultivars MTT-13 and IDIAP T-5, developed in Nicaragua and Panama, thus illustrating the potential of local research and the advantages of regional cooperation. In the Dominican Republic, resistance to nematodes and viruses was also evaluated. Heat Master, Acclaim, Saladinha, and Emperador were found tolerant to nematodes.

In trials of processing tomato: in Guatemala, Elios yielded 29 t/ha; in Honduras, Gem Pride yielded 110 t/ha, Sun 6216, 108 t/ha, APT391, 105 t/ha, Marina, 103 t/ha, Yaqui, 101 t/ha, Bright Pearl, 99 t/ha, and Veronica, 98 t/ha; in Panama, IDIAP–T7 yielded 64 t/ha; in the Dominican Republic, Gem Pride yielded 71 t/ha. In the Dominican Republic, IDIAP T-3 and F7332 yielded 58 t/ha and 56 t/ha, respectively. Despite displaying virus symptoms, they have potential in a zone where viruses are the most important threat to production. In Panama, it was decided that IDIAP-T7 is still the best option in terms of resistance to bacterial wilt.

Sweet pepper

The whitefly-transmitted geminivirus complex and weevils (*Anthonomous eugenii*) have restricted sweet pepper production in the region. Trials of sweet pepper were carried out in two different localities in each country, using one regional control and one line commonly used by producers.

Onion

Research on onions was conducted in the rainy (winter) and dry (summer) seasons. Thirty-three cultivars were evaluated in terms of yield, tolerance to pests and diseases, shape, color, precocity, and pryuvic acid.

For the dry season, several varieties, Nikita (Rio Colorado), Cougar (Peto), Mercedes (Peto), Yellow Granex (Sunseeds), and XPH 6700 (Asgrow), were acceptable in the market based on their shape size, color, neck size (thin), compactness, and dryness. Certain red and yellow onions did well in Santa Ana, Costa Rica, and Comayagua, Honduras. In Guatemala, the cultivars were evaluated in terms of both production levels and their susceptibility to *Alternaria porri*, *Botrytis* sp and *Peronospora* sp.

It was not possible to obtain results during the rainy season because of Hurricane Mitch.

Summer squash and winter squash

No conclusions could be reached due to bad weather and the lack of suitable cultivars. However, partial results were obtained in Costa Rica, Nicaragua, and the Dominican Republic. In Nicaragua, Criollo Mexicano and Criollo Nicaraguense varieties yielded promising results, 14 t/ha and 12 t/ha, respectively.

In the Dominican Republic and Panama, several trials were conducted with cultivars of zucchini, pumpkin, and summer squash. Dahifa variety, contributed by the IDIAP, Panama, had good thickness and good production at 9 t/ha.

Integrated pest and disease management

Emphasis was placed on development of varieties resistant to the whitefly-geminivirus complex, biological control of diamondback moth (*Plutella xyllostella*) of crucifers, development of options for managing pepper weevil (*Anthonomus eugenii* Cano), and on the biological management of larvae in tomato and onion.

Biological control of Plutella xyllostella *in cabbage*

The work focused on using three parasitoids from AVRDC headquarters, and it involved three stages: 1) quarantine of parasitoids; 2) multiplication; and 3) release and efficacy study. The introduced parasitoids had high survival rates and showed a high grade of dependency on the pest. *Diadegma semiclausum* and *Cotesia plutellae* had high parasitism in three areas (Sebaco, San Ramon, and Jinotega) in Nicaragua. The work deserves further study to evaluate the frequency of parasitoids by area and the pest density.

Because introduced parasitoid, *D. semiclausum*, was observed to be similar to native *D. insularis*, researchers at ZAMORANO investigated the reproductive processes of both species. Results suggest they are the same species.

The National University of Nicaragua (UNA) was responsible for multiplication of parasitoids. Preliminary results are available from UNA-INTA.

Evaluation of practices used to manage pepper weevil

Six chemical, biological, and cultural management options were evaluated, vis-à-vis the conditions prevalent in each country and the cultural practices most commonly used by farmers. *Bacillus thuringiensis*, *Beauveria bassiana*, polyhedrosis viruses, and extract of neem were tested. These products are being evaluated on plantations where pepper is grown in association with corn. The evaluation consisted of counting the number of diseased fruit, versus the results obtained with insecticides commonly used by farmers.

Alternative ways to manage larvae in tomato

Alternatives for managing *Heliothis* and *Spodoptera* were studied in Guatemala, including the use of *Bacillus thuringiensis*, polyhedrosis viruses, and neem. Results suggest that these biological control agents could be effective when applied at the right time, with the correct frequency, and in the proper dosage. More study is needed before a recommendation can be made. In the Dominican Republic, biological control agents were found to reduce pest attack by as much as 18% compared to the control treatment. Economic analysis is needed.

Other basic work in IPM

Work was carried out in Panama, Costa Rica, and the Dominican Republic with a view to learning more about the distribution and biology of pests. In Panama, studies were conducted to identify the species and biotypes of whiteflies, while in Costa Rica the principal insect pests of summer squash, and their natural enemies, were identified.

These studies contributed to a clearer understanding of important aspects of the specific problems affecting priority vegetables in the region. In Panama, it was determined that the B biotype of whitefly is the most abundant. In Costa Rica, it was determined that *Acalymma* sp and *Diaphania hyalinata* are devastating to the cultivation of winter squash.

Future studies must focus on determining their capacity to transmit viruses and on identifying their natural enemies.