Manila peri-urban vegetable project

Asian cities face the enormous challenge of increasing the poor's access to nutritious food while at the same time recycling solid wastes and reversing enviornmental degradation. The AVRDC peri-urban vegetable project in the Philippines, sponsored by BMZ/GTZ, is designed to stabilize the supply of nutritious vegetables to metro Manila and to develop an approach for the acquisition, testing, and dissemination of information related to peri-urban vegetable production and consumption. Year 2002 activities focused on the transfer of technologies developed in the previous four years of the project. These technologies involved improved practices for the production of safe leafy vegetables and off-season tomato.

Project Coordinator: JR Burleigh

Socio-economic studies

Evaluation of technology transfer methods

Over the five-year life of the Manila peri-urban vegetable project we introduced resource-poor farmers in four provinces of Luzon (Nueva Ecija, Quezon, Laguna, and Batangas) to a five-component improvement package for pak-choi cultivation using two extension methods: on-farm demonstrations and farmer field schools (FFS). Demonstrations and FFS were not treatments in a designed trial; rather, FFS evolved from the perceived failure of on-farm demonstrations to efficiently and effectively promote adoption of improved practices among farmers. Percent adoption among farmers trained by demonstration trials or by FFS can be used to compare success of the two methods. In addition, adoption by neighbors of farmer-cooperators enabled us to assess the effect of observation as a means to promote adoption.

Through on-farm demonstrations individual farmers learned from researchers to: 1) sow pak-choi on raised beds rather than on flat ground to reduce plant damage by flooding; 2) use net tunnels erected over beds to reduce insect pest damage rather than rely solely on insecticides for pest management; 3) sow seeds in rows rather than broadcast to produce a stand uniform in age and plant distribution; 4) use organic fertilizer as partial replacement for inorganic rather than use inorganic alone; and 5) monitor pest and disease populations before applying pesticides rather than follow the standard practice of frequent pesticide treatments regardless of pest and disease intensities. In contrast, FFS were conducted with groups of 20 to 35 farmers at a single site. Farmers organized themselves into subgroups of three to five with each subgroup responsible to determine the response of pak-choi when different combinations of two or more components were applied simultaneously. Farmer participants attended lectures given by researchers, conducted self-taught sessions, and shared results among subgroups.

Both demonstration and FFS were designed to promote adoption of the improvement package among farmers or if some improved practices were being used before training, then adoption of components of the package. Data on adoption were acquired by interviewing farmers in each training category.

A total of 92 FFS trainees, 14 on-farm research farmer-cooperators, and 47 neighbor-farmers of farmer-cooperators were interviewed to determine the direct impact of AVRDC introduced technologies on pak-choi production.

Thirty-three of the 92 (36%) FFS trainees and 2 of the 14 (14%) on-farm research cooperators did not plant pak-choi after the FFS training and farm demonstrations. The primary reasons identified by FFS trainees who stopped growing the crop were lack of water supply, lack of capital, low price of pak-choi in the market, lack of land ownership, and old age. The two farmer-cooperators stopped growing pak-choi because one chose to get a new job and the other farmer shifted into planting string beans instead.

Adoption by FFS trainees

Even before the FFS began, some of the trainees used raised beds and organic fertilizer (Table 131). Raised beds were used because farmers believed the technology provided better drainage during the rainy season and enabled easy irrigation of plants during the dry season. There was a slight increase in adoption after training, but this quickly dropped off due to the additional labor required.

Organic fertilizer, mainly chicken manure and burned rice hull, was used because farmers believed it neutralized the acidity of the soil and reduced expenses for inorganic fertilizer. However, there was a decline in the use of organic fertilizer after the FFS training because farmers could not find sources of chicken manure or other organic materials in the market (Table 131).

Eight of the 59 (14%) FFS farmers had monitored for pests before the training and 33 (56%) of the trainees utilized pest monitoring techniques after training was completed. But all soon stopped monitoring for pests because it was too laborious (Table 131).

Table 131. *Percentages of pak-choi farmers adopting production technologies among 59 FFS trainees in Nueva Ecija, Batangas, Laguna and Quezon*[1]

Technology	Before training (% adopters)	Growing seasons after training (% adopters)			
		1	2	3	>3
Pest monitoring	14	56	10	0	0
Organic fertilizer	42	37	31	2	7
Raised bed	24	29	14	2	0
Net tunnel	0	2	0	0	0
Line sowing	12	15	5	0	0

[1] Percentages do not include 36 FFS trainees who did not grow pak-choi after training

The use of line sowing and net tunnel showed low adoption among FFS trainees due to the high degree of labor and capital required for both technologies (Table 131).

Adoption by on-farm research cooperators

All five technologies showed positive adoption rates in the first season after the on-farm demonstration, but levels of adoption rapidly declined for all technologies in subsequent growing seasons (Table 132). Reasons for this decline varied depending on the technology. The most common reasons mentioned by non-adopters were they were "not used to" monitoring for pests, organic fertilizer was not available, net tunnels were too expensive, and net tunnels, raised beds, and line sowing all required too much labor.

Adoption by neighboring farmers

There was very little transfer of technology to farmers living next to the on-farm demonstration sites. There were no positive gains for the organic fertilizer, net tunnel and line sowing technologies (Table 133). A few farmers adopted pest monitoring techniques and raised beds, but the use of these technologies declined after the initial season.

In Nueva Ecija, an additional sample of 33 neighbors of farm cooperators in Castellano and Nieves were interviewed to determine if the AVRDC on-farm demonstrations held in the area have improved their pak-choi farming. However, results showed that 16 (48%) of these farmers already shifted in producing other crops, such as bitter gourd, eggplant and okra, instead of planting pak-choi. Low price of pak-choi is the primary reason why they stopped planting the crop.

Conclusions

Very few farmers adopted the introduced technologies, no matter the approach used for technology transfer. Capital and labor demands were too high, the organic

Table 132. *Percentages of pak-choi farmers adopting production technologies among 12 on-farm farmer-cooperators in Nueva Ecija, Batangas, Laguna and Quezon*[1]

Technology	Before demo (% adopters)	Growing seasons after demo (% adopters)			
		1	2	3	>3
Pest monitoring	17	50	25	17	–[2]
Organic fertilizer	67	83	33	8	–
Raised bed	42	100	25	0	–
Net tunnel	0	25	8	0	–
Line sowing	25	50	17	0	–

[1] Percentages do not include two farmer-cooperators who did not grow pak-choi after demos
[2] Data not available

Table 133. *Percentages of pak-choi farmers adopting production technologies among 47 neighbors of farmer-cooperators*

Technology	Before demo (% adopters)	Growing seasons after demo (% adopters)			
		1	2	3	>3
Pest monitoring	0	6	0	0	0
Organic fertilizer	32	30	15	0	0
Raised bed	28	32	19	4	4
Net tunnel	0	0	0	0	0
Line sowing	4	4	0	0	0

fertilizer was not available, and pak-choi prices at the market were not attractive. The project formulated a credit program for pak-choi producers to overcome the limitation of capital in adopting the technologies, but only five farmers participated in the program. Farmers who chose to not participate in the credit program cited the inappropriateness and high labor demands of the technologies, and lack of land ownership as reasons.

A closer look at the technology transfer methods themselves shows that higher percentage of farmer-cooperators adopted elements of the technology package than did FFS trainees, but this is the most expensive method of technology transfer and there was minimal transfer of technologies to neighboring farmers.

Differences in percent adoption among methods may be due to the manner used to select participants. Farmer-cooperators were pak-choi growers and known to project researchers, whereas FFS trainees were nominated by municipal agricultural technicians. In addition, farmer-cooperators worked with project researchers on their own farms. FFS trainees also worked with project researchers but on municipal land. Therefore, land ownership and participant selection may be key factors to consider in efforts designed to promote adoption. That is, when training is conducted on a participant's land there may be heightened awareness that results apply to his land. In contrast, the linkage between lessons learned from training conducted on municipal land or on the land of a FFS participant and the relevance of those lessons to land owned by each participant might not be apparent. Conceivably, selection of FFS trainees based on their prior knowledge of pak-choi cultivation might increase percent adoption among them.

Broadening our discussions to include our work with grafted tomato technology, in which both on-farm demonstrations and FFS were also used, we do not propose to abandon FFS as a means to promote adoption of improved practices for vegetable production. However, we do emphasize that those conducting the training must select trainees assiduously. Also, we propose that FFS trials be placed on farm fields rather than on municipal land.

A major constraint to technology adoption by the FFS approach was that local municipalities selected participants, and then only on the basis of interest expressed. That is, farmer selection was not based on previous experience in vegetable culture and ready access to capital (needed to invest in rain shelters or net tunnels, for example). Consequently, many trainees are unable to adopt the grafted tomato technology package because they lack confidence and capital.

Selection of FFS participants is another key to adoption of peri-urban technologies, particularly the grafted tomato package. Farmer-cooperators with little or no experience with tomato may express interest but lack the confidence to tackle the subtleties of growing grafted tomato under shelter. Consequently, participants should have experience with tomato culture as well as access to capital.

A reassessment of the technology packages is called for. Some farmers report using improved practices for pak-choi after receiving training in FFS, but no FFS participant is using the grafted tomato technology. The appropriateness of capital-intensive technologies needs to be considered. The optimization model suggests that 200,000 PHP (US$4000) per ha is needed to maximize net income from peri-urban technologies that include the grafted tomato package. That level of investment is beyond the capacity of most Filipino farmers. Clearly, cost reduction is a prerequisite to adoption among resource-poor farmers. We should also approach farmer-investors who have the capital to purchase materials required to produce grafted tomato during the rainy season.

It is further recommended that the project investigate the possibility of reducing the labor demands of these technologies through the introduction of mechanical seeders and bed shapers. In addition, the market for pak-choi should be continuously analyzed to determine the most appropriate time to sow and best markets to sell the crop.

Consumer preferences for qualities of selected leafy vegetables

It is important to understand the preferences of consumers when evaluating cultivars and types of vegetables. The objectives of this study were to determine consumer preferences for qualities of selected leafy vegetables and to calculate the price and income elasticities of these crops.

Trader and consumer preferences

A total of 101 traders and 96 consumers buying in the market were interviewed to determine their preferences when purchasing pak-choi, mustard, kangkong, sweet potato vine tips, bitter gourd vine tips, and jute mallow. Preferences across the survey sites (Nueva Ecija, Laguna, Batangas and Metro Manila) were generally similar. Freshness (within one day of harvest) was most highly valued for all vegetables.

Consumers preferred white-stem types of pak-choi, light-green leaf types of mustard, heart-shaped leaf types of kangkong, large-leaf types of bitter gourd vine tips, and smooth-leaf types of jute mallow. Regional differences were detected for kangkong and sweet potato vine tips: Laguna and Batangas consumers preferred violet types while Nueva Ecija consumers preferred green types.

A total of 117 consumers of leafy vegetables were interviewed in their homes to evaluate their preferences. Freshness was again the most desired quality for all leafy vegetables. For pak-choi, its cleanliness, amount of leaf damage, and size of leaves significantly affected its price. In other words, consumers would pay more for pak-choi that was clean, undamaged, and large-leaved.

The value of kangkong is significantly affected by the characteristics of its stem. Darker green stem color, short stem length (24–34 cm), and short stem diameter (0.4–0.6 cm) was preferred.

For sweet potato vine tips, four factors influenced its value: freshness, leaf shape, stem length and color. Consumers would pay more for fresh tips with heart-shaped leaves, short stem length, and light green or light violet stem color.

No significant attributes explained the price variations of mustard, bitter gourd vine tips, or jute mallow.

Price and income elasticities of vegetables

Price and income elasticity coefficients were calculated using linear regression functions. The data used were from the survey of 117 consumers interviewed in their homes. The vegetables studied as a whole manifested moderate price elasticity. It is projected that a price increase of 10% would reduce consumption of these leafy vegetables by 5%.

These vegetables have low income elasticity, suggesting that changes in consumer incomes will not affect their consumption of leafy vegetables. It is projected that a 10% rise in income would lead to only 1.2% more leafy vegetables in the diet.

Since higher income levels are not likely to lead to significant gains in consumption of leafy vegetables, there is an urgent need to educate Filipinos on the importance of vegetables in the diet. Currently Filipinos eat less than 40% of the amount of vegetables recommended for healthy diets.

Crop and soil management

Promising leafy vegetable cultivars

Trials were conducted on farms in central and southern Luzon and at the research station at Manila to identify superior cultivars of leafy vegetables.

BPI-LBNCDC on-station trials

The same 20 cultivars were planted monthly from March to December 2002. The cultivars were set in 1 × 2 m raised beds, distributed in RCBD with four replications. Net tunnel structures were installed immediately after planting and were lifted during weeding, sidedressing and spraying of fungicides/ insecticides. Plants were maintained using recommended fertilization and other cultural practices.

Results are presented in Table 134. The yields of pak-choi peaked in December. The top performers were Bp 03 and check Black Behi. Bp 03 was the highest yielder in four of the six monthly trials.

Recommendations are more difficult with the non-heading Chinese cabbage trials since not all cultivars were planted each month. But the data clearly show that this leafy vegetable struggles in the summer heat of June and July.

Choysum also grew best in autumn. Cultivar Bc 13 gave the highest yield in June and November while Bc 36 was superior in August and December.

Indian mustard performed best in December. Significant yield differences were observed in July and September. Bj 03 significantly outyielded both other cultivars in July and was comparable with the check cultivar Excell in September cropping. Overall, Bj 03 was judged as the top performer.

Yields of Chinese kale peaked in December; Ba 24 was the top yielder across six planting dates.

Yields of kangkong peaked in September. Ia 18 significantly outyielded other cultivars in November, while Ia 02 produced significantly higher yields in December. Overall across six plantings, both Ia 02 and Ia 18 outyielded the check line by approximately 10%.

Table 134. *Yields (t/ha) of leafy vegetable types and entries evaluated at Bureau of Plant Industry, Manila, Philippines, 2002.*

Type/entry	Month sown June	July	August	September	November	December	Mean
Pak-choi							
Bp 03	2.1 a[1]	5.1 c	5.9	3.3 a	7.1 ab	19.0 a	7.1
Bp 09	1.7 b	7.7 ab	5.7	–[2]	–	–	5.0
Bp 21	1.6 b	6.6 b	4.8	1.6 b	8.7 a	13.0 b	6.0
Black Behi (ck)	1.4 b	8.7 a	4.8	2.6 a	5.8 b	17.0 a	6.7
Mean	1.7	7.0	5.3	2.5	7.2	16.3	6.7
CV (%)	12.6	9.7	14.5	21.9	14.0	12.7	
Non-heading Chinese cabbage							
Bcc 02	1.1 b	1.2	–	–	–	–	1.1
Bcc 04	1.8 a	1.3	7.5 b	4.9	7.8	7.8 b	5.2
Bcc 12	–	–	6.6 b	4.3	7.8	8.7 b	6.8
Bcc 23	1.8 a	1.2	10.4 a	4.7	7.3	13.2 a	6.4
Mean	1.6	1.2	8.1	4.6	7.6	10.0	5.5
CV (%)	15.1		13.6			11.4	
Choysum							
Bc 12	2.1 b	1.8	4.7 b	8.0	9.4 b	10.6	6.1
Bc 13	3.2 a	1.8	2.5 c	8. 5	12.1 a	10.6	6.4
Bc 36	2.3 b	1.5	7.2 a	6.1	6.6 c	13.0	6.1
Mean	2.5	1.7	4.8	7.5	9.4	11.4	6.2
CV (%)	16.2	16.4	11.6	17.1	15.0	15.0	
Indian mustard							
Bj 03	4.1	4.1 a	7.1	6.2 ab	6.5	12.4	6.7
Bj 11	3.0	2.8 b	6.3	5.3 b	6.3	11.3	5.8
Excell (ck)	3.5	3.3 b	6.2	7.3 a	6.7	11.0	6.3
Mean	3.5	3.4	6.5	6.3	6.5	11.6	6.3
CV (%)	18.8	13.7	10.8	12.9	15.6	11.9	
Chinese kale							
Ba 11	1.6	1.1	3.0 b	2.4	2.6	8.2	3.1
Ba 17	1.5	1.3	2.0 c	2.6	3.2	8.4	3.1
Ba 24	1.7	1.2	4.0 a	2.4	2.9	9.0	3.5
Mean	1.6	1.2	3.0	2.4	2.9	8.5	3.2
CV (%)	15.1	9.5	13.6	11.1	20.1	6.8	
Kangkong							
Ia 02	9.5	7.4	14.6 a	20.0	10.8 b	10.9 a	12.2
Ia 18	9.0	8.2	15.7 a	17.6	13.5 a	8.2 b	12.0
Kaneko (ck)	9.1	8.3	12.3 b	19.2	9.7 b	7.9 b	11.1
Mean	9.2	8.0	14.2	19.0	11.3	9.0	11.8
CV (%)	11.1	12.4	6.9	18.5	12. 8	12.6	

[1] Mean separation within columns of vegetable species by Duncan's multiple range test, $P \leq 0.05$

[2] Not planted

In conclusion, these trials show that kangkong yields are relatively stable through the summer and autumn, whereas the other leafy vegetables (all Brassicas) grow much better during the autumn. Differences were noted among the cultivars for each species and superior cultivars were identified.

BPI-LBNCDC on-farm trials

Twenty cultivars of six leafy vegetable types were planted in five to six locations. Plants were grown in 1 × 2 m sub-plots, using the project's recommended production practices and net tunnels. At each location, plots were established using randomized complete block design (RCBD) and four replications. Locations were planted on different dates ranging from 8 May to 22

November 2002. Data were taken from 2 m^2 plots and analyzed statistically.

The performance of the cultivars varied due to the differences in time of planting, soil conditions, and crop management (Table 135). Among sites, crops performed best at the Santa Cruz farm, because the trial was set in November when rain was not as frequent and the site had been fallow for a long time.

Across locations, the best yielding entries were: Ia 02 kangkong with potential yield of 15.6 t/ha; Bj 11 Indian mustard, 10.6 t/ha; Bcc 12 non-heading Chinese cabbage, 10.1 t/ha; Bc 12 choysum, 15.2 t/ha; Bp 03 pak-choi, 13.1 t/ha; and Ba 17 Chinese kale 3.8 t/ha. These entries have all performed well in previous trials and are recommended for commercial production.

Table 135. *Yields of leafy vegetable entries grown in on-farm trials in Luzon, Philippines*

	Yield (t/ha)						
Type/entry	Tiaong, Quezon 8 May	Tanauan, Batangas 30 July	Bagong Silang, San Pablo City 4 Sept.	Lumban, Laguna 2 Oct.	Sto. Angel, San Pablo City 20 Nov.	Sta. Cruz, Laguna 22 Nov.	Mean
Pak-choi							
Bp 03	15.5 a[1]	14.3	7.2 a	12.6	9.6 a	19.3 b	13.1
Bp 09	1.75 c	–[2]	–	10.7	–	–	6.2
Bp 21	6.7 b	17.2	5.8 b	11.3	8.4 ab	26.2 a	12.6
Black Behi (ck)	8.1 b	17.2	6.9 a	10.5	6.7 b	28.4 a	13.0
Mean	8.0	16.2	6.6	11.3	8.3	24.6	11.2
CV (%)	18.6	5.5	4.3	21.4	12.4	14.9	
Non-heading Chinese cabbage							
Bcc 04	6.2 b	8.3	7.8 a	–	3.9 b	21.5 b	9.5
Bcc 12	6.8 b	7.8	6.5 a	–	5.2 b	24.3 a	10.1
Bcc 23	7.8 a	9.2	3.2 b	–	7.2 a	22.1 b	9.9
Mean	6.9	8.4	5.8	–	5.4	22.6	9.8
CV (%)	18.2	11.8	21.9		15.7	10.4	
Choysum							
Bc 12	12.2 a	15.4 a	17.1 a	–	8.4 a	23.0 a	15.2
Bc 13	6.8 b	15.8 a	17.0 a	–	5.6 b	18.9 b	13.0
Bc 36	7.6 b	9.2 b	11.6 b	–	6.1 b	14.7 c	9.8
Mean	8.8	13.5	15.2	–	6.7	18.9	12.7
CV (%)	17.4	13.0	10.0		9.0	8.0	
Indian mustard							
Bj 03	13.5	9.6 ab	8.3	6.5 b	8.6	16.5	10.5
Bj 11	13.1	11.9 a	5.9	8.4 a	9.5	15.0	10.6
Excell (ck)	12.7	7.1 b	6.4	6.7 b	8.6	17.4	9.8
Mean	13.1	9.5	6.8	7.2	8.9	16.3	10.3
CV (%)	19. 9	15.7	13.9	23.3	9.7	13.2	
Chinese kale							
Ba 11	1.0 b	3.4 a	2.1 b	–	3.4 a	6.5	3.3
Ba 17	1.5 a	3.4 a	3.3 a	–	3.3 a	7.6	3.8
Ba 24	1.9 a	2.2 b	2.6 ab	–	2.5 b	6.3	3.1
Mean	1.5	3.0	2.7	–	3.1	6.8	3.4
CV (%)	19.8	19.9	17.3		9.5	12.9	
Kangkong							
Ia 02	16.1	11.4	6.6 a	20.0 ab	14.5 a	25.8 a	15.7
Ia 18	14.3	11.1	4.0 b	16.9 b	12.8 b	16.9 b	12.7
Taniya (ck)	14.5	14.0	4.8 b	21.9 a	12.9 b	17.5 b	14.3
Mean	14.9	12.2	5.1	19.6	13.4	20.1	14.2
CV (%)	10.3	17. 9	10.4	16.3	3.1	10.4	

[1] Mean separation within columns for individual vegetable species by Duncan's multiple range test, $P \leq 0.05$
[2] Not planted

Introduction to CLSU trials

The objective of his research was to identify the superior cultivars of leafy vegetables for year-round production in metro Manila. Cultivars of four leafy vegetables, namely: pak-choi (Bp 22, Bp 23, and Black Behi as check variety); Indian mustard (Bj 03, Bj 14 and native check), Chinese kale (Ba 11, Ba 17, and Ba 24) and upland kangkong (Ia 02 and Ia 07) were planted in non-replicated trials at five farms to evaluate their adaptability. These accessions were the highest yielding performers in yield trials conducted at Central Luzon State University (CLSU) from 1998 to 2001. The on-farm trials were situated in San Miguel, San Jose del Monte, and Doña Remedios Trinidad of Bulacan province, and in San Leonardo and San Jose City of Nueva Ecija province. For each plot, four rows were planted in a space of 1 × 3 m on 30-cm-high raised beds. Pak-choi, Indian mustard, and Chinese kale were provided with net tunnels after planting to protect plants from insect pest damage and impact of rainfall during the late summer (July to September 2002) crop and from insect pest damage during the winter (November 2002 to January 2003) crop. The same accessions were evaluated at CLSU in replicated trials (seven replications) both in open field and nethouse. Analyses of yield data were done within species. Mean monthly rainfall amounts from the months of July to December in Nueva Ecija were 605, 300, 362, 159, 38, and 12 mm.

CLSU on-station trial

Damaging rainfall and *Rhizoctonia* rot caused 6 of the 11 accessions to fail to produce marketable yields in the open field planting sown in July. Only kangkong produced reliable yields.

In several cases, the effects of net tunnels were dramatic during this rainy season trial. For example, Bp 23 failed to produce any yield in the open field, but it was the highest yielding pak-choi accession under the net. Similarly, Bj 03 and the native mustard check failed to produce marketable yields in the open field, but both outperformed Bj 14 under the net. None of the Chinese kale accessions produced marketable yields in the open field, but all of them produced crops under the net. Finally, Ia 02 was relatively low yielding in the open field, but it produced a remarkable 79.2 t/ha of yield under the net. The net tunnel, therefore, may be a profitable technology to produce reliable yields during this wet season when leafy vegetable supplies are low and prices are highest. A comparison among the leafy vegetables grown in this season's trial shows that Chinese kale yields were relatively low and kangkong yields were very high. So high, in fact, that even the lowest yielding kangkong accession produced at least five times more yield than the best of any other accession of any leafy vegetable grown under similar conditions.

The yields of pak-choi, Indian mustard, and kale varieties increased tremendously under nethouse during the cool-dry winter (Table 136). This is attributed to cooler temperatures and higher plant survival. Kangkong yield however, decreased due to lower temperatures and less available water compared to the wet season trial. Similar trend in yield was observed under open field, but the yields were slightly lower due to higher pest pressure particularly flea beetle and diamondback moth on the crucifers.

In conclusion, the net tunnel contributed to higher marketable yields in both seasons. The benefit of the tunnel was evident for all accessions but to differing degrees. Kangkong was the only productive leafy vegetable in the rainy season trial and crucifer yields dramatically increased in the cool season.

Table 136. *Yields (t/ha) of cultivars grown with and without net tunnels during the rainy season (July) and cool-dry season (November) at CLSU, Muñoz, Philippines*

	July		November	
Crop/entry	Net	Open	Net	Open
Pak-choi				
Bp 22	5.9 b[1]	5.0 a	37.4	25.4
Bp 23	9.2 a	0.0 b	28.7	22.5
Black Behi (ck)	8.9 a	3.4 ab	29.1	25.0
Submean	8.0	2.8	31.7	24.3
Indian mustard				
Bj 03	8.7	0.0 b	40.4 a	25.8
Bj 14	7.4	5.9 a	28.7 b	21.0
Native (ck)	9.2	0.0 b	38.0 a	25.2
Submean	8.4	2.0	35.7	24.0
Chinese kale				
Ba 11	3.7	0.0	13.9 a	10.1
Ba 17	3.9	0.0	8.1 b	7.9
Ba 24	4.3	0.0	16.8 a	10.1
Submean	4.0	0.0	12.9	9.4
Kangkong				
Ia 02	79.2 a	37.0 b	29.2	24.5
Ia 07	51.2 b	50.8 a	27.2	23.4
Submean	65.2	43.9	28.2	24.0

[1] Mean separation within columns by Duncan's multiple range test, $P \leq 0.05$.

CLSU on-farm trials

During the rainy season trial (July to September) marketable yield of pak-choi variety Bp 22 was highest on four of five farms (Table 137). Yields ranged from 6.5 to 30.0 t/ha, with differences due to different levels of soil fertility and farm management skills. Yields slightly declined in the next cropping season but rose again in the cool-dry winter. All lines performed satisfactorily. Bp 22 had the highest yields overall but its green stems were less desirable to consumers. Black Behi was a reliable performer and has white stems, which consumers preferred.

For Indian mustard, the check variety was the highest yielder for the first two cropping seasons. The yield of Bj 14 was highest in the third season, due in large part to a whopping yield of 60.6 t/ha at one farm. All three lines performed well, usually producing yields in the range of 15 to 20 t/ha.

Chinese kale yields were low due to poor seed quality for all accessions. Yields ranged from 0 to 13.5 t/ha. When data were pooled across all farms, yields for this vegetable were low but fairly steady through the three seasons.

Kangkong yields were consistently the highest among all the leafy vegetables tested. Both accessions produced high yields at all locations during all seasons.

Table 137. *Yields (t/ha) of leafy vegetables entries tested on five farms in Luzon, Philippines*

	Date sown			
Crop	July	September	November	Mean
Pak-choi				
Bp 22	19.8	15.3	17.8	17.6
Bp 23	14.0	14.6	17.8	15.5
Black Behi (ck)	17.3	15.6	18.5	17.1
Submean	17.0	15.2	18.0	16.7
Indian mustard				
Bj 03	16.5	15.1	21.7	17.8
Bj 14	18.3	15.0	24.6	19.3
Native	20.8	15.6	19.1	18.5
Submean	18.5	15.2	21.8	18.5
Chinese kale				
Ba 11	6.2	6.9	7.0	6.7
Ba 17	6.4	7.5	6.9	6.9
Ba 24	7.4	7.6	7.3	7.4
Submean	6.7	7.3	7.1	7.0
Kangkong				
Ia 02	24.0	23.0	27.8	24.9
Ia 07	28.4	22.3	27.0	25.9
Submean	26.2	22.7	27.4	25.4

In conclusion, these on-farm trials showed that all these entries could be grown successfully throughout the year under net tunnels, and in the case of kangkong, without net tunnels. Although yields were satisfactory, growers would be advised to consider consumer preferences when selecting cultivars to plant. As stated earlier, Bp 22 may be high yielding, but its green stems are undesirable. The upland kangkong accessions Ia 02 and Ia 07 were very productive, but their narrow leaf shapes are less desirable compared to the heart-shaped leaves of other kangkong types.

Grafted and non-grafted tomato production under rain shelters

BPI-LBNCRDC on-station trial

The trial at the BPI-LBNCRDC station in Manila consisted of four lines (CHT501, CL5915, CLN2026D and PSB Tm9) grafted onto EG203 eggplant rootstocks. Grafted and non-grafted plants were transplanted into beds with and without rain shelters. Beds were 2.5-m-wide and mulched with polyethylene. Seedlings were transplanted in 3 rows, 0.5 m between rows and 0.4 m between hills. Each sub-plot had 3.75 m^2 area and a 15-plant population. Entries were distributed in RCBD with three replications.

The yield performance of grafted and non-grafted seedlings significantly varied under shelter and open conditions (Table 138). PSB Tm9 produced the highest yields under shelter and CHT501 produced the highest yields in the open field. Both of these lines are tolerant to heat.

Grafted plants, in general, outyielded non-grafted plants by a significant margin, 41% under shelter and 20% in the open field. Grafted plants had higher levels of plant survival, contributing to higher yields. There was no interaction between the lines and grafting.

BPI-LBNCRDC on-farm trials

Five demonstration trials were set in October 2002. Grafted and non-grafted plants of one to two tomato lines at each site were grown under three regimes: 1) 2.5-m-wide, 10-m-long raised bed, provided with polyethylene mulch and open-side rain shelter; 2) same bed size with polyethylene mulch without rain shelter; and 3) farmers' practice of planting in flat-bed rows spaced 1 m apart and 0.5 m between plants.

Grafted plants, whether under rain shelters or in the open field, gave higher yields at all sites (Table

Table 138. *Yield (t/ha) of grafted and non-grafted tomato varieties under rain shelter and in open field conditions at Bureau of Plant Industry, Manila, Philippines*

	Yield (t/ha)					
	With shelter			Open field		
Line	Grafted	Non-grafted	Mean	Grafted	Non-grafted	Mean
CHT501	17.1	11.4	14.2 b	14.9	14.0	14.5 a
CL5915	18.0	12.9	15.4 b	12.8	10.0	11.4 ab
CLN2026D	18.6	16.5	17.3 b	8.2	6.8	7.5 b
PSB Tm9	26.3	14.2	21.4 a	12.9	9.9	11.4 ab
Mean	20.0 a	14.2 b	17.1	12.2 a	10.2 b	11.2
CV (%)			20.7			17.1

Grown in Summer 2002
[1]Mean sepearation in columns by LSD at 5% level

139). The tomato lines grown under rain shelters produced higher yields than the open field practices of BPI-LBNCRDC and farmers. The Santa Cruz site produced the highest yields peaking at 41.5 t/ha for grafted plants grown under rain shelters. Yields of "farmer-practice" plots were only about one-third the yield of plots managed using researcher practices.

BPI-LBNCRDC Batangas trial

In Tanauan, Batangas, grafted and non-grafted seedlings of four tomato lines were transplanted in a non-replicated trial under two growing regimes (with and without rain shelter). Each regime had two plots, 1-m-wide, 25-m-long with 0.5 m distance between plots. One plot in each regime was planted with grafted plants and the other plot with non-grafted plants. All plots were mulched with polyethylene. Transplanting was done on 5 September 2002 and harvesting was done from 8 November to 1 December.

PSB Tm9 produced the highest mean yield (22.2 t/ha)(Table 140). Following the same trend as the BPI-LBNCRDC trial, PSB Tm9 gave the highest yield under shelter and CHT501 in the open field. Grafting improved the yield of the lines by 22% under shelter and 29% in the open field. Rain shelters provided 37% higher yields compared to the plants grown under open field conditions despite the fact that the trial was not planted in the rainy season. Monthly rain totals in Nueva Ecija for September, October, and November were 362, 159, and 38 mm, respectively.

Table 140. *Yields (t/ha) of grafted and non-grafted tomato lines under shelter and open field conditions in Tanauan, Batangas, Philippines*

	With shelter		Open field		
Line	Grafted	Non-grafted	Grafted	Non-grafted	Mean
CHT501	20.1	16.6	22.3	20.3	19.8
CL5915	22.3	19.4	16.58	11.1	17.3
CLN2026D	23.0	18.3	16.0	9.9	16.8
PSB Tm9	31.8	25.3	18.4	13.2	22.2
Mean	24.3	19.9	18.3	14.0	19.0

Transplanted 5 September 2002

Table 139. *Mean yield (t/ha) of tomato lines in on-farm demonstration trials in Luzon, Philippines*

		With shelter		Open field		Farmer's practice		
Site	Line(s)	Grafted	Non-grafted	Grafted	Non-grafted	Grafted	Non-grafted	Mean
San Pablo City	CHT501, CLN2026D	10.9	7.2	6.4	5.4	3.2	1.8	5.8
San Pablo City	CHT501, PSB Tm9	17.7	14.3	14.7	13.3	3.3	2.3	10.9
Laguna	CLN2026D	13.4	11.0	9.3	6.2	1.5	1.0	7.1
Laguna	PSB Tm9, CLN2026D	41.5	28.5	35.2	25.8	14.4	9.6	25.8
Batangas	CL5915, Floradade	9.2	6.7	4.5	3.2	1.8	1.7	4.5
Mean		18.5	13.5	14.0	10.8	4.8	3.3	–

Transplanted October 2002

CLSU on-station trials

The use of grafted tomato has shown promise as a technology that can stabilize yields in the hot-wet season. This trial evaluated the performance of four promising scions (Apollo, CHT501, CL5915, and CLN2026D) all grafted onto the recommended rootstock, eggplant EG203.

A field was divided into three blocks representing replications with each block. Blocks were subdivided into two main plots (with and without shelter) and each main plot further divided into four subplots (tomato lines). The four subplots were further subdivided into two sub-sub plots (non-grafted and grafted).

Plant survival was markedly influenced by line and graft level, but no interaction effects were noted among the factors evaluated. The non-grafted plants obtained a percent survival of 24% while the grafted plants obtained 74%, a difference of 208%. Among the four lines of tomatoes, the survival rate of CLN2026D was highest (62%), followed by CHT501 (54%), both of which were statistically superior to the survival rates of Apollo (41%) and CL5915 (40%).

The differences in percent survival of the lines may be viewed from their resistance to flooding and wilt diseases. While the rootstock EG203 is resistant to the above conditions, floodwater in the experimental plots often rose above the graft union. Therefore, scions with greater tolerance to flooding and bacterial wilt survived better.

Yields differed among varieties between grafting treatments, rainshelter × line, and line × graft level (Table 141). CHT501 grown under shelter had the highest yield of 7.0 t/ha. The same line obtained the highest yield under open field conditions, 3.3 t/ha. While CLN2026D had the highest percent survival, it was a low yielder.

Table 141. *Effects of grafting and rain shelter on yields (t/ha) of lines grafted onto eggplant rootstock, evaluated at CLSU, Philippines*

	Grafting		Rain shelter	
Line	Grafted	Non-grafted	With	Without
Apollo	2.4 d[1]	0.1 c	1.4 d	1.1 c
CHT501	8.3 a	2.0 a	7.0 a	3.3 a
CL5915	3.7 c	1.0 b	2.7 c	2.1 b
CLN2026D	4.8 b	1.5 ab	4.0 b	2.2 b

Grown in Summer 2002

[1] Mean separation within columns by Duncan's multiple range test, $P \leq 0.05$

CHT501 was the highest yielding line, whether grafted or non-grafted. When grafted it had a yield advantage of 250, 121 and 74% over Apollo, CL5915 and CLN2026D, respectively.

From the results of study, grafting again provided a significant yield advantage in the hot-wet season. Rain shelters also provided an advantage, although less pronounced. CHT501 was the top scion and is recommended to growers.

CLSU on-farm trials

On-farm trials were conducted to evaluate the yield potential of grafted tomato in farmers' fields. Seedlings of CL5915 and CHT501 were grafted onto rootstocks of EG203 and tested on six farms, with and without rain shelters, using the standard cultural management practices adopted in on-station trials. The trial was transplanted in Guimba on 19 July, the recommended time to use grafted plants in order to gain the fullest advantage from the rootstock's tolerance to flooding, water-logged soils, and bacterial wilt. Plantings at other sites were delayed until September.

The rain shelter led to a higher rate of plant survival for both lines at all sites. Survival of CHT501 ranged from 85.0 to 97.5% under shelter and 77.5 to 92.5% in the open field. Survival of CL5915 had percent survival ranged from 87.5 to 100.0% under shelter and 62.5 to 95.0% in the open field. The differences in plant survival among sites can be attributed to the incidence of wilt-causing organisms.

The highest fruit yield of CHT501 under shelter was obtained from the farm in San Jose City (25.4 t/ha) followed by the trial in San Leonardo 23.9 t/ha (Table 142). The lowest yield was obtained from the farm in Llanera, which was highly prone to flooding.

Table 142. *Yields (t/ha) of grafted tomatoes, grown with and without shelter, in on-farm trials in Luzon, Philippines*

Date		With shelter		Open field	
trans.	Location	CHT501	CL5915	CHT501	CL5915
19 July	Guimba	22.7	10.1	13.4	3.6
02 Sept.	Llanera	18.0	9.0	12.7	6.7
13 Sept.	Florida Pamp.	19.2	15.0	15.1	11.5
17 Sept.	San Jose City	25.4	16.5	23.5	13.2
19 Sept.	Muñoz	21.5	15.2	18.3	13.3
30 Sept.	San Leonardo	23.9	15.0	10. 6	9.3
Mean		21.8	13. 5	15.6	9.6
CLSU (4-year avg)		17.2	13.1	7.4	3.1

Guimba trial transplanted 19 July 2002; others transplanted in September

The beneficial effects of rain shelter on CHT501 was seen in Guimba where planting was done during the rainy season (Table 142). It was also dramatically observed in San Leonardo. Moderate effect of rain shelter was seen in Muñoz and Llanera and in Florida Pampanga where the farms are laden with *lahar* (mudflow from volcanic debris).

Yields were higher under shelters compared to the open field for both scions at all sites. Fruit yield of CHT501 from the six farms under rain shelter averaged 21.8 t/ha while the yield of CL5915 averaged 13.5 t/ha, a difference of 62%. CHT 501 in the open field yielded 15.6 t/ha as against 9.6 t/ha for CL5915, again a yield difference of 62%. On-farm yields were higher than the average yield of four years of testing at CLSU, an encouraging sign that the technology is adaptable to on-farm conditions.

Tarlac College of Agriculture

In a non-replicated trial on the campus of Tarlac College of Agriculture, CHT501 yielded 27.4 t/ha when grafted onto eggplant rootstock and transplanted under a rain shelter, but only 11.57 t/ha when not grafted. In contrast, yields were 18.6 and 8.8 t/ha for grafted and non-grafted CHT501, respectively, in the open field. The trial was not unbiased, but data support conclusions from other locations and past seasons that yields from grafted tomato raised under shelters are greater than yields from non-grafted tomato raised in the open field during the hot-wet season. CHT501 consistently yielded more than CLN5915.

Mass production of grafted tomato seedlings

Adoption of the grafted tomato technology depends, in part, on the availability of grafted seedlings to participants in FFS, farmer-cooperators, and growers. A temperature and humidity-controlled grafting chamber was constructed on the campus of CLSU in 2001 to provide grafted transplants. In 2002, 5000 seedlings were distributed among 10 FFS, 1500 seedlings were used in six on-farm trials, and 2000 seedlings were used in three farm demonstration sites. These seedlings consisted of scions of CHT501 and CL5915 grafted onto EG203 rootstocks.

A potential constraint to adoption of the grafted technology among growers is that the number of transplants dispersed in 2002 would meet only 5% of the demand indicated by interested farmers in 2003 (159 trainees expressed interest and requested a total of 167,000 seedlings). Increased efficiency of the graft chamber at CLSU is necessary but increased efficiency alone will not meet the projected demand. Therefore, the project has proposed to construct a second graft chamber in the province of Bulacan where the projected demand for grafted seedlings in 2003 is greatest.

Planting media for grafting tomatoes

An inexpensive but effective planting medium is required for large-scale production of tomato and eggplant seedlings for grafting purposes. The standard rootstock, eggplant line EG203, and two productive scions, tomato lines CHT501 and CL5915, were seeded in decomposed sawdust, coconut coir, and carbonized rice hulls mixed with organic fertilizer. To each of the media were added either a controlled release fertilizer, a complete fertilizer (14N–6P–11.6K), a controlled release fertilizer + 2% urea, or the complete fertilizer + 2% urea in similar, but unspecified amounts. Media were evaluated based on percent seedlings with matching stem diameters fitting the latex sleeve used for grafting.

Generally, the highest percentage of seedlings with uniform stem diameter came from coconut coir. Fertilizer effects were not measured and fertilizer types did not appear to make a significant difference.

Integrated pest management

Infection of grafted tomato plants by black leaf mold disease

Black leaf mold (*Pseudocercospora fuligena*) is the dominant foliar disease of grafted tomato during the hot-wet season. Whether in open field or under rain shelter, tomato cultivars reacted similarly and there was no difference in disease intensity among scions tested (Apollo, CHT501, CL5915 and CLN2026D); all were susceptible. We did not analyze the yield loss due to black leaf mold, but the disease merits scrutiny since it is ubiquitous during the hot-wet season.

Efficacy of insecticides for control of striped flea beetle

Striped flea beetle is a major pest of pak-choi that has the capacity to destroy entire crops. Studies were conducted at CLSU in the rainy season (September to October 2002) and cool-dry season (November to December 2002) to identify superior insecticides for control of the pest. Five commercial insecticides, namely Pennant (phenthoate), Mimic (tebufenozide), Ascend (fipronil), Success (spinosad), and Brodan (chlorpyrifos + BPMC) were tested along with an untreated control. Treatments were evaluated using four replications. Individual plot size was 2 × 5 m with 1-m distance between plots. Plants were managed using recommended cultural practices.

In the rainy season, plots sprayed with insecticides suffered less damage by striped flea beetle in comparison to untreated plots, but there were no significant differences among the insecticides. In the cool-dry season, none of the insecticides could control the pest and marketable yields were minimal.

Chlorpyrifos is not registered for use on pak-choi in the Philippines; however, it is the insecticide of choice by many farmers because it is inexpensive. Spinosad is an organic fermentation product from bacteria. Our results suggest that Spinosad is as effective as other pesticides (all synthetic) tested.

Effect of rainfall on cabbage webworm populations

Cabbage webworm (*Hellula undalis*) is a major insect pest of pak-choi in Central Luzon. Larvae can be found year-round but populations vary among months. When we regressed plant density and rainfall on numbers of larvae, total monthly rainfall explained 81% of the variation in numbers, whereas plant density was not significant. The regression coefficient was negative as expected, indicating that as rainfall increases, numbers decrease. Rainfall, therefore, may be a good predictor of larval numbers and perhaps of larval activity.

Hellula undalis sex pheromone studies

Experiments were conducted to determine how to use pheromone traps in the field. Studies were done on trap heights, trap designs, pheromone concentrations, and trap longevity. Dr. Griepink from the Netherlands provided the sex pheromone. Dosages used were from 1 µg to 500 µg active substance dispensed in red rubber septae. Trials were conducted on farms in San Leonardo and the CLSU experimental area in Muñoz.

A total of eight separate fields were used to set up traps. The sizes of the field for the trap height and concentration trials were 3000 m^2 for Block A, 5000 m^2 for Block B, and 8000 m^2 for Block C. The field for the longevity trial was 5500 m^2 and for the trap design trial, one ha. The field size inside CLSU was 1200 m^2. Control traps without lures were included in all trials, but the number of males caught in the control traps was so little that the numbers are not included in the results. The experiments were conducted using either RCBD or completely randomized design (CRD). Data were transformed to $\log_{10}$ scale and analyzed using the analysis of variance (ANOVA).

Except for the trap design trial, the traps used in this research were handmade using corrugated plastic. A 25 × 25 cm section was folded in the middle and a triangle of two opposite sides were pressed in the plastic with a ball pen to be able to fold these parts upward or downward. Holes were made in the middle line 1.5 and 4 cm from the edge to connect the upper and lower parts with wire. Yellow sticky paper was attached with double-sided tape on the bottom part. The lures were attached with a steel pin through the upper part. The traps were tied to bamboo sticks with two attachment threads to stabilize the traps from wind.

Trap height

Eight traps were placed at random within each of three blocks in a field planted in radish. Each trap had a 10 µg lure placed at heights of either 10 cm, 50 cm, 100 cm or 200 cm above ground. The minimum distance between traps was 15 m. The trial in San Leonardo was conducted from 25 October to 1 November. The trial was repeated at CLSU in January 2003 in a field planted to radish, mustard, and pak-choi. The height of 200 cm was excluded in the CLSU trial due to the smaller size of the area.

No significant differences were found among the numbers of male moths caught daily from traps of different heights in San Leonardo. In CLSU, traps at heights of 25 and 50 cm caught significantly more moths than the traps at the height of 100 cm; no significant differences were detected between the 25 and 50 cm heights at this location. The results support previous findings and the height of 50 cm is recommended.

Pheromone concentration

Traps were loaded with 1, 5, 10, 20, 50, 100, 200, and 500 µg lures. Concentrations were distributed using a RCBD with three replications. Traps were placed 50 cm aboveground. The trial started on 2 November 2002 and completed on 15 January 2003. The fields were monitored several times and sticky traps replaced when needed. The number of trapped males was 957 per night for traps with the 1-μg treatment, rose steadily as pheromone concentrations increased, and peaked at 1210 for the 500-μg treatment; however, differences were not statistically different. In a related study, it was shown that the effects of higher pheromone concentrations persist longer, albeit by nonsignificant margins (with the exception of the extreme 500 vs. 1 μg treatments). Due to the high costs of the pheromone (1 g costs US$418), the lowest concentration is recommended.

Trap design

Traps were arranged in two adjacent radish fields, each 2000 m² in size. The traps were set up in a complete randomized design with three replicates. Trap designs tested were wing traps, delta traps, water bowl traps, plastic bottle traps, and tube traps. All traps were handmade. Yellow sticky paper was used in wing, delta, and tube traps. The water bowl and the plastic bottle traps were filled with a mix of water and either motor oil or a soap solution. Tube traps were made of plastic pitchers with the bottom removed, i.e. they were open on two sides. The wing and the delta traps were made of corrugated plastic. The plastic bottle traps had four openings in the upper third of the bottle, bent to the top such that the cut parts could protect the openings from rain; for this trap, lures were hung from the lid 3 cm above the water level. The water bowl traps were made of plastic bowls with a square piece of corrugated plastic attached to the sides and curved over the bowl to a height of 15 cm above the bowl. Lures were attached to the cover and hung on a wire 3 cm above the surface of the water level. The trial was conducted from 16 November to 6 December 2002.

The wing trap caught significantly more male moths (652 moths per night) than all other designs. The daily trap counts of bottle trap (236), delta trap (194) and water bowl trap (161) were statistically similar. All traps were significantly superior to the tube trap (97).

Although the wing trap was most effective, it was costly since it could not withstand the effects of rain and its sticky surface required replacement at least every three days due to dusty conditions. More trap designs will be tested in the future, looking for sturdy traps that do not rely on sticky materials.

Flight activity of male H. undalis

Male *H. undalis* are most active during the night. Nevertheless, there is not much known about the flight activity of males when searching for a female partner. Traps with virgin females and synthetic pheromones were checked for five nights. Results showed that the main activity starts at 2:00 AM and generally reaches a peak between 4:00 AM and 6:00 AM (Table 143). After 8:00 AM it was rare to catch a male moth.

Training and outreach

Training of trainers

Twenty-six participants (25 local government officials with the Department of Agriculture and 1 farm leader) were trained to serve as FFS facilitators and to provide technical information to farmers.

Farmer field schools

Fifty-two local government officials and 323 farmers from the provinces of Bulacan, Batangas, Laguna, and Tarlac were trained to use the grafted tomato technology package of rain shelters, raised beds, plastic mulch, and trellising.

Fourteen Farmer field schools on grafted tomato were begun in 2002 and 13 were completed. Local

Table 143. *Flight activity of male* H. undalis *observed in San Leonardo, Philippines during February 2003*

Date	Minimum temp. (°C)	Time of night: 8:00 PM	10:00 PM	12:00 AM	2:00 AM	4:00 AM	6:00 AM	8:00 AM
9–10 Feb.	23.0	0	0	1	1	5	29	6
10–11 Feb	23.8	0	0	1	1	6	8	0
11–12 Feb.	24.2	0	1	0	–[1]	2	0	14
16–17 Feb.	–	0	0	1	0	52	204	68
27–28 Feb.	21.8	0	0	0	2	9	11	0

[1]No data

governments constructed the rain shelters and conducted training with the assistance of CLSU faculty.

Unfortunately, there was considerable variation in shelter design among municipalities. Most used bamboo rather than materials recommended by AVRDC/CLSU. Bamboo was chosen to reduce cost, but by cutting cost the durability and effectiveness of the shelters at most locations was compromised and yields from the technology package were low. By allowing municipalities to select participants with limited experience in growing tomatoes and to choose flimsy materials for shelter construction, performance of grafted tomato was generally mediocre.

Eleven local government officials and 101 farm leaders were trained to use the technology package developed for pak-choi.