Manila peri-urban agriculture project

Asian cities, such as Manila, face an enormous challenge to remedy micronutrient deficiencies in diets of the poor, to recycle solid wastes, and reverse environmental degradation. The AVRDC peri-urban vegetable project in the Philippines, sponsored by Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), is designed to: stabilize the supply of safe and nutritious vegetables to metropolitan areas; and to develop an approach for information acquisition, testing and dissemination suitable to peri-urban areas in Asia.

Project Coordinator: JR Burleigh

Socio-economic studies

Consumer preference of pak-choi cultivars

When selecting a variety, farmers prefer to grow one for which consumers will pay higher prices. High yielding accessions of pak-choi have been identified after four years of trials at Central Luzon State University (CLSU). Two of these accessions were rated by seven qualified panelists from CLSU on color and shape of leaves; color, size and number of stalks; and general acceptability to determine which of these features are discernable by consumers. Results showed that leaf color, stalk color and leaf shape were the most visually discernable features. Three potentially high-yielding accessions were subsequently evaluated by 50 consumers in Los Baños, Laguna to determine preference based on these features. The native cultivar, Black Behi, was the most preferred followed by Bp21, Bp03, and Bp29 (Table 104). Bp21 was judged as being "liked very much" and therefore may be acceptable in the market.

Table 104. *Consumer ratings[1] of selected characteristics of pak-choi accessions in Laguna, Philippines.*

	Accessions[2]			
Characteristics	Black Behi	Bp 21	Bp 03	Bp 29
Leaf color	1.90	2.66	3.02	3.58
Leaf shape	2.08	2.72	3.16	3.54
Stalk color	2.08	2.72	2.94	3.70
General acceptability	2.08	2.72	3.10	3.35

[1]Ratings: like extremely = 1.00-1.88; like very much = 1.89-2.77; like moderately = 2.78-3.66; like slightly = 3.67-4.55.
[2]Chi-square values are highly significant.

Technology adoption after training in Farmer Field Schools

Interviews were conducted with 30 persons who attended Farmer Field Schools (FFS) on pak-choi production. Trainees were from *Barangay* (community) Mallorca which is located in the Municipality of San Leonardo, Nueva Ecija Province; Barangays Hornalan and Bunggo in the Municipality of Calamba, Laguna Province; and Barangay Cale in the City of Tanauan, Batangas Province. They received training in monitoring for pests systematically from crop emergence to harvest, fertilizing with organic materials, using raised beds, excluding insects through the use of net tunnels, and sowing in lines. Trainees listed those practices that they used before and after training, and reasons for use and non-use.

Depending on practice, there was a 23 to 47% increase in number of farmers using a practice after receiving training in the FFS (Table 105). Dramatic increases were noted in the use of raised beds, use of net tunnels for insect control, and sowing in lines. These practices were rarely, if ever used before the FFS. Organic fertilizer was used by 15 (50%) participants before FFS, but an additional seven farmers adopted the practice after. Even pest monitoring showed an increase in adoption as farmers noted that monitoring reduced labor and pesticide expenses.

Table 105. *Number of farmers using improved practices for pak-choi production before and after training in Farmer Field Schools (FFS).*

		No. farmers using practice		
Practice	No. farmers in FFS	Before FFS	After FFS	Percent increase
Pest monitoring	30	8	20	40
Organic fertilizer	30	15	22	23
Raised beds	30	1	15	47
Net tunnels	30	0	12	40
Sowing in lines	30	1	12	37

Farmers noted that good quality pak-choi was produced under net tunnels, which had been provided to farmers at no charge for testing. Farmers who grew crops under nets used less pesticide and pak-choi leaves were relatively free of surface debris. The 13 farmers who did not adopt net tunnels expressed interest if credit were provided to purchase netting.

The labor needed to raise beds was considered excessive by 33% of the participants, but 67% adopted the practice because they noted an improvement in drainage. Almost 75% of farmers used organic fertilizer. They understood that organic matter supplies plant nutrients, improves soil structure, and reduces inorganic fertilizer costs.

Socio-economic survey of farmers from new provinces

From the expansion provinces, Quezon, Laguna, and Batangas, the project randomly selected 160 farmers to serve as respondents to questions on age, household size, education, years in farming, land tenure status, production practices, labor utilization, and gender roles. These factors were used to construct regression models with yield and income as dependent variables.

Farmer income and employment from pak-choi. The project calculated net income and labor for: 1) farmers who cultivated five consecutive crops of pak-choi followed by two crops of rice, and 2) those that cultivated two crops of rice with each crop followed by a fallow period. Farmers in Group 1 had a mean net income of 220,136 PHP/ha, whereas those in Group 2 earned 40,219 PHP/ha. That is, a pak-choi/rice farmer had a net income fivefold greater than a farmer who grew rice only.

Although the difference in net income is dramatic, the sustainability of the pak-choi-based system is questionable. The rice-only farmer includes two periods of fallow in his rotation, whereas the pak-choi/rice farmer does not. Furthermore, the net income for the pak-choi/rice system is based on five consecutive crops of pak-choi and given the uncertainty of rainfall, and damage from pests and diseases, the probability of five successful crops may be low and the income calculation somewhat inflated.

Gender roles in pak-choi/rice and rice-only farming systems. In both the pak-choi/rice and rice-only systems, males prepared the land, seeded the crop, applied fertilizer, sprayed pesticides, irrigated, harvested, and threshed rice. In contrast, women did most of the transplanting of rice and pak-choi. And women did most of the weeding in pak-choi. That is, when equipment was used, men were the operators, but when hand labor was employed, it was the women and sometimes children who were drafted into the labor force.

Factors affecting yield and income/ha from pak-choi. A linear regression analysis showed that farming experience, amount of nitrogen fertilizer used, and time spent in transplanting significantly influenced yield and explained 72% of the variation in yield of pak-choi. With regard to variation in income, the cost of chemicals used in production; cost of labor for fertilizer application, spraying, weeding and watering; and cost for fuel, irrigation fees, plastic bags, and transportation explained 67% of the variation in income (Table 106).

Table 106. *Significant variables associated with yield of pak-choi and farm income.*

Dependent variable	Regression coefficients	t-value	Probability	R^2
Yield	$0.22X_1$ [1]	4	0.001	
	$0.17X_2$	3	0.012	
	$0.20X_3$	2	0.035	0.72
Income	$0.30X_1$ [2]	4	0.002	
	$0.79X_2$	4	0.003	
	$-0.28X_3$	2	0.032	0.67

[1] X_1 is years in vegetable farming; X_2 is amount (kg/ha) of nitrogen fertilizer; X_3 is hours for transplanting.
[2] X_1 is cost of chemicals; X_2 is cost of labor for fertilizer application, spraying, weeding, and watering; X_3 is cost for fuel for irrigation pumps, as well as irrigation fees, plastic bags, and transportation.

Regression implies cause and effect. A positive yield response from farming experience, N fertilizer, and time spent transplanting is reasonable. However, the positive signs for cost of chemicals and cost of labor probably reflect an indirect effect of those variables on income; that is, cost reflects quantity used and quantity used affects production and therefore, income. A similar argument can be used to explain the positive sign for the variable, labor cost, which reflects time spent to apply fertilizer, spray, weed and irrigate.

Income and job creation generated by post-harvest vegetable activities

Vegetable production generates business in the input and output markets. Vegetable production requires more inputs (labor, fertilizer, chemicals, funds) than rice, and increases agribusiness activities of suppliers and creditors. On the other hand, the bulkiness and perishability of vegetables require that market traders use appropriate postharvest facilities and practices in handling the commodities until they reach the consumer. It is well understood, therefore, that an increase in vegetable production will impact businesses beyond the production sites.

Data presented below show current income and employment among input suppliers (n = 28) and vegetable traders (n = 130), and projected values based on assumed increases in hectarage planted to pak-choi in three provinces of Southern Luzon: Quezon, Laguna, and Batangas. Using a questionnaire, the data gathered included the traders' socio-demographic and business profile, and trading operations. Marketing margin was likewise calculated. Changes in traders' incomes and labor hired by them as a result of extensive cultivation in the area were determined.

It is assumed that by increasing hectarage planted to pak-choi, inputs, income and employment will increase proportionately and that there would be sufficient market demand for the increased production (Table 107). Thus, input suppliers will increase the number of employees from 22 based on the current number of hectares devoted to vegetables to 26 and 44 with increases to 600 ha and 1000 ha, respectively.

Table 107. *Input volumes, income, and employment of distributors and dealers based on existing and projected operations for vegetable production, May–June 2001.*

Input suppliers	Current operations (500 ha)	Projected operations (600 ha)	(1000 ha)
Distributor			
Volume procured			
Seeds (kg)	968	1,162	1,936
Fertilizers (bags)	3,382	4,058	6,764
Chemicals (liters)	3,805	4,566	7,580
Chemicals (kg)	1,302	1,563	2,605
Income (PHP)[1]	38,590	42,618	59,094
Employment (persons)	17	20	34
Dealer			
Volume procured			
Seeds (kg)	1,452	1,742	2,904
Fertilizers (bags)	318	382	636
Chemicals (liters)	11	14	23
Chemicals (kg)	3	3	5
Income (PHP)[1]	12,709	14,788	23,443
Employment (persons)	5	6	10

[1]PHP = Philippine peso. 50 PHP = 1 US dollar.

Accordingly, income would increase from 51,299 PHP to 57,406 and 82,537 per production cycle for 600 and 1000 ha, respectively (50 PHP = 1 USD). These figures are projections but suggest that by increasing the area growing pak-choi, both income and employment among input suppliers will increase over that associated with rice cultivation.

Table 108 shows pak-choi volume handled and net income during one month (one crop cycle) among a sample of 130 vegetable traders in Southern Tagalog provinces and in Manila. These traders handled 1.22 Mil kg of pak-choi and earned a net income of 3.97 Mil PHP. Figures on total volume produced during this period were not available. These traders employed 559 persons to perform all postharvest activities associated with pak-choi and other vegetables. That is, an employee sorts and packages all vegetables procured, not just pak-choi. The division of labor of an employee among several vegetable species is not known.

Soil and crop nutrition

Composted household waste as fertilizer

Results from previous studies showed that pak-choi yields were unchanged when half the nitrogen requirement came from composted household organic waste, rather than from inorganic fertilizers. The present effort was designed to demonstrate to farmers the effectiveness of composted household waste as a supplement to their usual fertilizer practice of relying solely on inorganic fertilizers.

Replicated trials with two treatments were established on 14 farms in nine barangays in Central and Southern Luzon. Treatment one (T_1) was the farm fertilizer practice, and treatment two (T_2) was an introduced fertilizer practice based on available N, available P and exchangeable K (Table 109). Experimental plots were raised beds, 20 cm in height and 2 x 10 m in size. Both treatments were seeded in lines and beds were covered with screen netting to prevent ingress of insect pests. Nitrogen was applied to T_1 plots at the time of seeding according to the farm practice. Composted household waste and inorganic fertilizer (14N–6P–11.6K) were applied to T_2 plots during land preparation. In addition, urea (46N–0P–0K) was applied to T_2 plots 10 and 21 days after seeding.

Two crops of pak-choi were seeded on each farm. In Central Luzon, crop 1 was seeded on seven farms

Table 108. *One month volume and net income of 130 pak-choi traders in Southern Tagalog and Manila during May–June, 2001.*

Vegetable traders	Traders interviewed	Pak-choi handled (kg)		Net income (PHP[1] x 1000)	
		Average	Total	Average	Total
Assembler-Wholesaler	42	20, 552	863, 163	48.4	2,034
Wholesaler-Retailer	22	15,754	346,588	83.5	1,837
Retailer	66	171	11,286	1.5	100
Total	130		1,221,037		3,971

[1]PHP = Philippine peso. 50 PHP = 1 US dollar.

between June and Aug. 2001; crop 2 was seeded between Oct. and Nov. 2001. In Southern Luzon, crop 1 was seeded on seven farms between July and August 2001; crop 2 was seeded between Nov. 2001 and Jan. 2002. Yield data from each location/crop combination were subjected to analysis of variance (ANOVA) to determine treatment effects. Yield for Barangay Mallorca is an average of four farms and that for Barangay Castellano, of three farms. Farms within barangays used the same fertilizer practice (T_1) and received the same combination of inorganic and organic fertilizer in the introduced practice (T_2).

In Central Luzon, there was no treatment effect on marketable yield of pak-choi in either crop (season). During the hot-wet season in Southern Luzon, there was no treatment effect except at the Barangay Kiling location in which T1 yield was significantly greater than that from T2. During the hot-dry season in Southern Luzon, yields were significantly greater from T2 in Barangays St. Tomas and Balele, but there was no treatment effect in the other five barangays (Table 109). Mean yields were 11 t/ha in the hot-wet season crop and 24.6 t/ha during the hot dry. Overall there was a much greater yield difference between seasons (crops) than between treatments.

Data from this study support our previous findings and indicate that many farmers habitually overfertilize with nitrogen. Nearly all farmers applied more inorganic N than researchers to their plots. Yield responses to this additional N varied and were, with the exception of the Kiling farm, not significant. The one farmer (from Balele) who applied less inorganic N than researchers produced significantly lower yields. Finally, we cannot rule out factors other than fertilizer regime that affect pak-choi yield.

Table 109. *Location, farm fertilizer practice, introduced fertilizer practice, and marketable yield of pak-choi from 14 farms in Central and Southern Luzon, Philippines, hot-wet season 2001 and hot-dry season 2001–2002.*

Luzon	Barangay	No. farms	Farmer fertilization (kg/ha)	Introduced fertilization (kg/ha + t/ha)	Marketable yield (t/ha) Crop 1(hot-wet)		Crop 2 (hot-dry)	
					T_1	T_2	T_1	T_2
Central	Mallorca	4	120N–0P–0K	45N–6.5P–12.5K + 4.0CHW[1]	5.7	7.8	20.0	21.3
Central	Castellano	3	75.8N–0P–0K	35N–4.3P– 8.3K + 3.1CHW	8.6	7.0	23.7	26.1
Southern	Bunggo	1	110N–0P–0K[2]	60N–6.5P–12.5K + 5.4CHW	22.5	17.5	29.9	23.4
Southern	St. Tomas	1	132N–0P–0K	60N–6.5P–12.5K + 5.4CHW	16.6	13.5	25.8*	42.5*
Southern	Santisimo	1	120N–0P–0K	60N–6.5P–12.5K + 5.4CHW	15.8	9.8	12.6	20.3
Southern	Balele	1	52.5N–0P–0K	60N–6.5P–12.5K + 5.4CHW	2.0	2.5	7.7*	22.0*
Southern	Lusacan	1	87N–0P–0K	60N–6.5P–12.5K + 5.4CHW	8.6	10.6	23.3	23.3
Southern	Kiling	1	250N–0P–0K	60N–6.5P–12.5K + 5.4CHW	15.5*	8.5*	24.6	26.2
Southern	Bantilan	1	250N–0P–0K	60N–6.5P–12.5K + 5.4CHW	15.1	10.5	31.0	41.3
Treatment means within crop					12.2	9.8	22.0	27.3
Mean crop yield over treatments					11.0		24.6	

[1]CHW = Composted household waste.
[2]Farmer included 7 t/ha chicken manure in fertilizer practice.
*Significant at $P \leq 0.05$.

Fertilizer regimes for grafted tomatoes

Tomatoes can be grown during the wet season in Luzon only by grafting tomato scions onto eggplant rootstock. Such grafted plants tolerate flooding and bacterial wilt, the main impediments to wet season production. Fertilizer regimes have only been developed for production in the dry season, not the wet. It is likely that the response of grafted tomato grown in the wet season will differ from the response of non-grafted tomato grown during the dry. This study was designed to determine the response of grafted tomato to different fertilizer regimes in two soils, an entisol on the CLSU campus in Muñoz and an alfisol in Los Baños, Laguna. The campus site was reported to be low in N with low to moderate P. The Los Baños site also was low in N, but with high P. Both sites had adequate K.

The tomato variety CL5915 was grafted onto the eggplant EG 203 rootstock and seedlings transplanted onto beds 30 cm high and 2.5 x 3 m in size. Transplants were spaced 1 m between rows and 0.5 m within rows and trellised individually. Transplanting was done June 25 at CLSU and July 25 at Los Baños. Rain shelters protected experimental plots and beds were covered with black plastic mulch.

Seven fertilizer treatments in kg/ha were applied randomly to beds in three blocks: T_1 = 0N–38.7P–124.5K, T_2 = 60N–38.7P–124.5K, T_3 = 90N–38.7P–124.5K, T_4 = 150N–38.7P–124.5K, T_5 = 180N–38.7P–124.5K, T_6 = 180N–77.4P–124.5K, and T_7 = 240N–38.7P–124.5K.

In the entisol (CLSU campus) only yield from T_7 with 240 kg/ha N was significantly different from T_1 and T_6 with 0 and 180 kg/ha N, respectively (Table 110). In contrast, in the alfisol (Los Baños) mean yield from T_2 with 60 kg/ha N was significantly different from T_1 and from other treatments except T_3 at 90 kg/ha N.

These results suggest that the recommended rate of 150N–38.7P–124.5K kg/ha can be reduced to 60N–38.7P–124.5K in an alfisol (total N 0.042%; available P 259 ppm). There was a response to 240 kg/ha N in an entisol that is considered to be low in N and P (total N 0.109%; available P 54.89 ppm).

Table 110. *Effect of fertilizer treatments on yield of grafted tomato in an entisol at Muñoz and in an alfisol at Los Baños, Philippines, hot-wet season 2001.*

Fertilizer treatment (kg/ha)		Entisol-Muñoz yield (t/ha)	Alfisol-Los Baños yield (t/ha)
T_1	0N–38.7P–124.5K	20.68 b[1]	14.40 d
T_2	60N–38.7P–124.5K	25.28 ab	19.77 a
T_3	90N–38.7P–124.5K	24.42 ab	18.06 ab
T_4	150N–38.7P–124.5K	22.59 ab	15.60 cd
T_5	180N–38.7P–124.5K	26.27 ab	15.59 cd
T_6	180N–77.4P–124.5K	21.93 b	16.70 bc
T_7	240N–38.7P–124.5K	28.30 a	15.93 cd

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

Effect of potting medium on growth of eggplant and tomato seedlings

Two non-replicated experiments were conducted to determine percent uniformity in stem diameter of eggplant and tomato seedlings grown in three potting media (factor A) treated with five fertilizers (factor B). The three potting media were carbonized rice hulls (CRH), decomposed rice hulls (DRH), and coconut coir (CC). The five fertilizer treatments were controlled released fertilizer (CRF), 14N–6P–11.6K, foliar soluble fertilizer containing 2% urea (Foliar), CRF + Foliar, and 14N–6P–11.6K + Foliar.

In experiment 1, each medium was characterized by water holding capacity, water retention and infiltration rate, then moistened to saturation and placed in plastic trays containing 50 holes, each 5 x 5 cm. There were 15 trays representing treatment combinations of potting media x fertilizer. Twenty-five holes were seeded with eggplant a week earlier than tomato. Each hole was seeded with two to three seeds. Controlled-release fertilizer at three granules per hole (equivalent to 45N–19.4P–37.4K kg/ha) was added to all holes just prior to seeding; 14N–6P–11.6K at the same dose was added one week after emergence. Application of foliar fertilizer prepared from urea commenced a week after emergence and was repeated weekly until grafting.

In experiment 2, the same methodology was followed except that the potting mixes were selected based on results from experiment 1. The fertilizer treatments were the same as in experiment 1. Two potting mix combinations were tested: equal portions of CC and composted household waste (CHW), and equal portions of CC and DRH.

Among the three media, CC has the highest water holding capacity (436%), highest water retention, and very rapid infiltration rate (>2 mm/min). CRH was second in water holding capacity (285%), but had very low water retention and medium infiltration rate. DRH was the lowest in water holding capacity (200%).

Because there was little difference among fertilizer treatments within media, mean values were pooled and are presented in Table 111. Percent germination of both eggplant and tomato seeds in all trays containing the three potting media was 100%. However, percent uniform seedlings varied. Eggplant seedlings performed poorly in CRH; the seedlings germinated, but there was a progressive desiccation of the leaves. The very low water retention of CRH and electrical conductivity of about 1.8-2 dS/cm are suspected to be the causes of poor seedling performance. Even if fertilizer is applied, the nutrients are lost in the leachate from rapid drainage.

These results indicate that CC + CHW is the best medium from among those tested for both eggplant and tomato. About 80% of the seedlings were suitable for grafting.

Table 111. *Mean percent seedlings of eggplant and tomato with stem diameter suitable for grafting in five potting media[1] over five fertilizer treatments.*

Potting medium	% seedlings suitable for grafting: Eggplant	Tomato
Experiment 1		
CRH	4.0	33.6
DRH	40.8	64.8
CC	43.4	77.2
Experiment 2		
CC + CHW	83.4	86.8
CC + DRH	62.4	74.8

[1]CRH = carbonized rice hulls, DRH = decomposed rice hulls, CC = coconut coir, and CHW = composted household waste

Yields of leafy vegetable accessions

Nineteen accessions of five leafy vegetables were planted in July, Aug., Oct., and Dec. 2001 at the Bureau of Plant Industry (BPI), Los Baños. Seeds were sown in rows 15 cm apart on raised beds 1 x 2 m in size. Plots were arranged by species, and there were 3–4 replications depending on the number of accessions per species. Before sowing, plots were treated with 1 kg/m^2 organic compost. Inorganic fertilizer at 90N–8.6P–16.6K kg/ha was applied as basal with a split sidedressing of 35.0N–0P–0K kg/ha at 10 and 20 days after sowing. Plots were protected from insects by screen tunnels of 32-mesh netting. Irrigation was done when necessary. Yields were subjected to ANOVA to test for differences within accessions and planting dates.

The pak-choi accessions Bp21 and Bp29 yielded significantly more than accessions Bp04 and Bp09 in July, but there were no differences in August, October, and December (data not shown). Mean yields across planting dates showed little difference among accessions. Mean yields of Bp21 were highest (16.6 t/ha), followed by Bp04 (16.2), Black Behi (15.6), Bp03 (14.2), Bp29 (13.5), and Bp09 (12.2).

Kangkong accession Ia02 yielded as much or more than Ia04 and Ia18 across planting dates. Mean yields of Ia02 were highest (14.2 t/ha), followed by Ia04 (13.2), and Ia18 (11.5). There were no yield differences among the accessions of choysum (Bc 12, 13, 17, and 36), and nonheading Chinese cabbage (Bcc 03, 04, and 23). The Indian mustard accession Bj11 yielded significantly more than Bj01 and Bj03 in August, but only more than Bj01 in July. Bj01 appears not to be adapted to the Los Baños area. Yields of trials at BPI, grouped by species within month planted, are shown in Table 112.

When pak-choi accessions were grown on six farms in Laguna and Quezon, using researcher practices, the pak-choi accession Bp21 yielded significantly more than other accessions only on one farm. On five farms there were no differences among accessions. The kangkong accession Ia02 was among the highest yielders on two farms, whereas on four farms there were no differences among accessions. These data indicate that yields from Bp21 and Ia02 were relatively stable in most locations and over time. Both accessions therefore, appear to be adapted to environments in Southern Luzon and may be recommended for cultivation. In fact, nearly all evaluated accessions were found to be similar in productivity and could be successfully grown in Southern Luzon.

Table 112. *Yields of leafy vegetables for four planting dates. BPI-Los Baños, Philippines, 2001.*

Vegetable	Yield (t/ha): July	Aug.	Oct.	Dec.	Mean
Pak-choi	9.8	15.5	17.4	18.2	15.2
Indian mustard	8.3	7.5	–[1]	–	–
Nonheading Chinese cabbage	9.8	15.0	–	–	–
Choysum	11.3	15.5	–	–	–
Kangkong	17.3	10.8	15.9	8.0	13.0
Mean	11.3	12.8			

[1]Not tested.

Grafted tomato studies with rain shelters

Two experiments were conducted during the hot-wet season of 2001. The first experiment tested the performance of two scions, Apollo and CL 5915, each grafted onto eggplant rootstock EG203 and tomato rootstock H7996. All plants were grown under rainshelters. Experiment 2 evaluated the effect of rainshelter on the performance of two scions, Apollo and CHT 501, grafted onto eggplant rootstock EG203. In both experiments grafted seedlings were transplanted onto beds 2.5 x 5 m, raised 30 cm. There was 1 m between rows and 0.5 m between plants within rows. Both experiments were treated with a basal application of 10 t/ha of organic matter followed by 60N–25.8P–49.8K kg/ha. A sidedressing of 90 kg/ha N was done at flowering and after first harvest. Plots were arranged in a randomized complete block design with three replications.

Results confirm that grafting enhances yield as non-grafted plots were unproductive (Table 113). CL5915 yielded significantly more than Apollo when grafted onto tomato rootstock, but not when grafted onto eggplant or non-grafted.

Table 113. *Yield (t/ha) of grafted tomato scions grown under rainshelters. CLSU, Muñoz, Philippines, hot-wet season, 2001.*

	Rootstock		
Scion	EG203	H7996	Non-grafted
Apollo	11.2 b[1]	9.8 b	3.0 c
CL5915	8.9 b	15.7 a	4.1 c

[1]Mean separation in a row and/or column by Tukey's mean separation test at $P \leq 0.05$.

Grafted CHT501 significantly yielded more than grafted Apollo when grown under plastic shelter, but not in open field (Table 114). Grafting improved yield under shelter for both scions and both rootstocks. In open field, grafting improved yield of both scions grafted onto EG203, but when grafted onto H7996 only CHT501 yielded more than nongrafted.

Our results confirm the value of rain shelters and grafting in hot-wet season production and indicate that CL5915 and CHT501 are valuable as scions.

Grafted tomato and cucurbit studies

Four fresh market tomatoes, CL 5915, BPI-Tm9, Del Monte and Momotaro were grafted onto eggplant rootstocks (EG203) and transplanted 7 Aug. 2001 on raised beds in plots 2.5 m^2 in size with 16 plants/plot. Beds were covered with polyethylene mulch for weed control and an arched net structure for protection from rain. Cultivars were planted in a randomized complete block design with four replications. Plots were fertilized with organic fertilizer at the rate of 1 kg/m^2. Inorganic fertilizers were applied at the rate of 168N–70.5P–269.8K kg/ha, split among basal and sidedressings at 2 and 4 weeks after transplanting. Tomatotone was sprayed five times at 4 to 7 day intervals. Fruit were picked seven times from 10 plants/plot.

Yields for the cultivars CL5915, BPI-Tm9, and Del Monte were 13.7, 11.0, and 14.7 t/ha, respectively, and those yields were not significantly different. Only the cultivar Momotaro yielded significantly less (6.6 t/ha).

On 16 Nov. 2001, following tomato, we seeded the cucumber cultivars, BPI Cu #4, BPI Cu #22 and 6T #1, and the squash cultivars EG SQ #39, EG SQ #41 and Rizalina in the same holes. Each entry occupied 8 m^2 and was replicated four times. One-half kilo ordinary compost and 10 g of 14N–6P–11.6K were applied to each hill prior to seed sowing. The cucurbits were sidedressed at 20 and 30 days after sowing with 10 g of 14N–6P–11.6K and 5 g of urea (46N–0P–0K) per hole. Sevin and wood ash at 1:1 ratio were dusted on plants to control pests. Yield data for each

Table 114. *Yield (t/ha) of grafted tomato scions grown under rainshelter and in open field. CLSU, Muñoz, Philippines, hot-wet season, 2001.*

	Rain shelter			Open field		
Entry	EG 203 rootstock	H7996 rootstock	Non-grafted	EG203 rootstock	H7996 rootstock	Non-grafted
Apollo	11.9 c[1]	10.3 c	3.6 d	6.0 a	5.3 ab	0.9 b
CHT 501	21.5 a	17.0 b	3.6 d	8.4 a	7.6 a	1.1 b

[1]Mean separation in a row and/or column by Tukey's mean separation test at $P \leq 0.05$.

plot were taken from 40 hills for cucumber and 20 hills for squash.

There were no significant differences in yield among the cucumber cultivars (overall mean was 19.9 t/ha). Among squash cultivars, EG SQ #39 and Rizalina (20.6 and 22.9 t/ha, respectively) yielded significantly more than EG SQ #41 (15.1 t/ha).

Integrated pest management

Soil solarization to curb flea beetle infestation of pak-choi

Two replicated trials were conducted on the CLSU campus to determine the effectiveness of soil solarization to control flea beetle (*Phyllotreta striolata*) infestation of pak-choi. Raised beds were prepared and covered with black polyethylene plastic for 2 weeks. After solarization, beds were tilled and standard practices were used for sowing and fertilization. After sowing, all beds were covered with screen tunnels to prevent infestations from exogenous insect pests.

In trial 1, solarization significantly increased yield and significantly lowered the number of damaged plants. Mean yield from solarized plots was 1.9 kg/m^2, but only 0.8 kg/m^2 from nonsolarized. The number of plants damaged by flea beetles was 5/m^2 from solarized plots and 18/m^2 from nonsolarized. In trial 2, there were no treatment differences.

Soil solarization may be a useful technology and when coupled with the use of screen tunnels may offer farmers a non-chemical procedure to curb infestations from important insect pests of pak-choi. Further testing is required.

On-farm testing of ICM strategies for pak-choi

Integrated crop management (ICM) practices for pak-choi developed by this peri-urban vegetable project include: 1) seeding in lines on raised beds; 2) screen tunnels; 3) composted household waste as fertilizer; and 4) spraying practices based on insect pest and disease monitoring. In 2001-2002, this management regime was used on seven farms in Nueva Ecija and eight farms in Southern Tagalog and contrasted with the farmer standard practice over hot-wet and hot-dry seasons. Insect pest and disease ratings were rated on a 0 to 9 scale, where 0 = no leaf damage, 1 = ≤ 20%, 3 = 21-40%, 5 = 41-60%, 7 = 61-80%, and 9 = 81-100% leaf damage.

There was no substantial difference in insect damage and disease ratings among the 14-farm/season combinations in Nueva Ecija, but among the 16-farm/season combinations in Southern Tagalog, the ICM regime reduced the mean insect damage rating from 4.98 to 2.57 (Table 115). The ICM regime in Southern Tagalog, therefore, reduced leaf damage by about 50%.

Table 115. *Mean insect and disease damage ratings for farmer practice and integrated crop management (ICM) regime for pak-choi over hot-wet and hot-dry seasons on seven farms in Nueva Ecija and eight farms in Southern Tagalog, Philippines, 2001-2002.*

	Insect damage[1]		Disease damage[1]	
Province	Farmer practice	ICM regime	Farmer practice	ICM regime
Nueva Ecija	2.73	2.70	1.68	1.83
S. Tagalog	4.98	2.57	0.45	0.76

[1]Rated using a 0-9 scale, where 0 = no leaf damage, 1 = ≤ 20%, 3 = 21-40%, 5 = 41-60%, 7 = 61-80%, and 9 = 81-100% leaf damage.

Insect and disease damage of leafy vegetables grown in screenhouse and open field

Four accessions of pak-choi (*Brassica campestris* cv. *pakchoi*), three of Chinese kale (*Brassica oleracea* cvg. *alboglabra*), three of Indian mustard (*Brassica juncea*) two of choysum (*Brassica rapa* cvg. *caisin*), and two of kangkong (*Ipomoea aquatica*) were planted in replicated trials under screenhouses and in open field on the CLSU campus over the hot-wet (June/July) and hot-dry (September/October) seasons of 2001. Accessions were direct seeded in rows on raised beds 1 x 2 m with 20 cm between rows and 10 cm between plants using a randomized complete block design with three replications. Beds were fertilized with 10 t/ha organic fertilizer and 60N–12.9P–24.9K kg/ha just before seeding. Thirty kg/ha N was applied as a sidedressing two weeks after seeding.

All accessions were examined for damage caused by such insects as diamondback moth, armyworm, cabbage webworm; and diseases such as damping-off and web blight. Insect damage and severity of disease were rated using a 0-9 scale, where 0 = no leaf damage, 1 = 1-20%, 3 = 21-40%, 5 = 41-60%, 7 = 61-80%, and 9 = 81-100% leaf damage.

Insecticides and fungicides were applied as needed to control pests and diseases within species. Foliage biomass was weighed from 20 plants selected randomly from the two interior rows.

There was little difference in insect damage among accessions within species, but there were some notable differences in disease damage (Table 116). For example, the pak-choi cultivar Black Behi grown in the open field was given a disease rating of 1.3 in contrast to others rated 3.0 to 4.4.

Table 116. *Mean insect and disease damage ratings[1] for leafy vegetables grown in a screenhouse and in the open field, CLSU,Muñoz, Philippines, hot-wet and hot-dry seasons (combined), 2001.*

	Screenhouse		Open field	
Accessions	Insect	Disease	Insect	Disease
Pak-choi				
Bp21	3.3	3.5	3.5	4.4
Bp22	3.9	3.4	2.7	3.0
Bp23	5.1	1.1	2.6	3.4
Mean pak-choi[2]	4.1	2.6	2.9	3.6
Black Behi (ck)	–[3]	–	3.3	1.3
Indian mustard				
Bj03	2.0	2.9	3.0	2.2
Bj11	1.7	1.8	3.9	2.0
Bj14	1.9	2.2	3.9	2.7
Mean	1.8	2.3	3.6	2.3
Chinese kale				
Ba11	3.0	2.3	0.8	1.5
Ba17	1.8	3.3	0.4	1.8
Ba24	2.5	2.5	1.2	2.9
Mean	2.4	2.7	0.8	2.1
Choysum				
Bc02	2.9	1.3	2.7	2.0
Bc20	2.3	4.3	1.7	2.3
Mean	2.6	2.8	2.2	2.1
Kangkong				
Ia02	1.0	0.1	1.3	0.0
Ia07	1.0	0.0	0.8	0.0
Mean	1.0	0.0	1.0	0.0

[1]Insect damage and severity of disease were rated using a 0-9 scale, where 0 = no leaf damage, 1 = 1-20%, 3 = 21-40%, 5 = 41-60%, 7 = 61-80%, and 9 = 81-100% leaf damage.
[2]Excludes Black Behi.
[3]Not tested.

In the hot-wet season, Black Behi and Bp22 produced higher yields than Bp21 and Bp23 for both screenhouse and open field conditions (Table 117).

Kangkong, the only non-Brassica among the group, was less subject to insect and disease damage than pak-choi, Indian mustard, Chinese kale, and choysum. Yields for all species were higher in the screenhouse compared to the open field (Table 118).

Table 117. *Yield of pak-choi accessions over two trials under screenhouse and in open field, CLSU, Muñoz, Philippines, hot-wet and hot-dry seasons, 2001.*

	Screenhouse		Open field	
Accession	Hot-wet	Hot-dry	Hot-wet	Hot-dry
Bp21	12.9 b[1]	14.8	9.3 b	22.7
Bp22	33.6 a	29.7	18.3 a	16.3
Bp23	13.9 b	–[2]	10.5 b	–
Black Behi	29.6 a	22.1	22.4 a	22.1

[1]Mean separation within columns by Duncan's multiple range test at $P \leq 0.05$.
[2]Not tested.

Table 118. *Mean yields (t/ha) for accessions of pak-choi, Chinese kale, Indian mustard, choysum, and kangkong in a screenhouse and in open field, and percent yield increase, CLSU, Muñoz, Philippines, hot-wet and hot-dry seasons (combined), 2001.*

Crop	Screenhouse	Open field	% increase
Pak-choi	18.1	17.4	4.0
Chinese kale	12.6	8.8	43.2
Indian mustard	25.1	14.4	74.3
Choysum	39.6	19.8	100.0
Kangkong	94.6	55.0	72.0
Mean	38.0	23.1	64.5

Seasonal fluctuations in populations of insect pests of pak-choi

Consecutive plantings of pak-choi on four beds 15 x 0.8 m and on two beds 15 x 2 m were made monthly from August 2001 to February 2002 at CLSU to monitor the number of insect pests attacking pak-choi. Two plots, each one square meter, were randomly selected from the small beds and delineated with cord. Plant numbers, both damaged and undamaged, and pest numbers were noted in the plots. Then the number of *Hellula undalis*, *Phyllotreta striolata*, *Spodoptera litura*, *Plutella xylostella*, *Crocidolomia binotalis* were counted and recorded (Table 119), as well as the number of pests/plant on surrounding crops (data not shown). No insecticides were used.

H. undalis was found every month except September and we believe that was due to a poor stand of pak-choi caused by non-uniform emergence perhaps exacerbated by flooding from rain. Interestingly, we found few *P. xylostella* larvae and numbers are not included in the table. P. *striolata*, *S. litura* and *C. binotalis* were found on most plantings as well. These observations support the view that insect pests are a constant threat to pak-choi production.

Table 119. *Number of pak-choi plants and insect pests[1] observed per square meter on monthly plantings in a plot at CLSU, Muñoz, Philippines, 2001–2002.*

Month	Observ.	Plants	*H. undalis*	*P. striolata*	*S. litura*	*C. binotalis*
Aug.	2	66.5	20.5	0.0	0.0	0.0
Sep.	4	20.2	0.0	7.0	0.5	0.0
Oct.	5	38.2	6.4	1.0	0.0	0.2
Nov.	15	46.0	20.4	6.1	13.1	8.4
Dec.	34	67.5	9.9	14.6	10.9	7.0
Jan.	19	55.6	10.9	11.0	6.5	3.5
Feb.	16	55.8	9.8	14.3	5.3	1.6

[1]*Hellua undalis, Phyllotreta striolata, Spodoptera litura, Crocidolomia binotalis.*

Insecticides for IPM of pak-choi

As in previous years, the project tested various insecticides for efficacy against insect pests of pak-choi. In 2001-2002 the project tested chlorpyrifos (Brodan), spinosad (Success), profenofos (Selecron) and phenthoate (local brand Pennant, not to be confused with Pennant herbicide) in a replicated trial. Insect damage was rated using a 0-9 scale, where 0 = no leaf damage, 1 = ≤ 20%, 3 = 21-40%, 5 = 41-60%, 7 = 61-80%, and 9 = 81-100% leaf damage. The mean values were: control 5.5, profenofos 2.0, chlorpyrifos 1.25, phenthoate 0.5, and spinosad 0.25. All insecticides significantly reduced damage rating, and phenthoate and spinosad were superior to the others.

Synthetic pheromone to monitor populations of Hellula undalis

In cooperation with the Pherobank®, Dr. Frans Griepink of the University of Wageningen provided 20 rubber septae each of six different dosages (10, 20, 50, 100, 200, 500 µg) of a pheromone designed to attract male moths of *H. undalis*. Two trials were conducted: trial one in San Leonardo, and trial two in Matinkis in Muñoz (2 cropping seasons), and Palestina in San Jose. Trials were not replicated within sites.

In trial one, all six dosages were randomly placed in a radish field (50 x 100 m) with a minimum distance of 20 m between traps and a trap height of 0.5 m. The traps were set to face the prevailing wind direction. During week one, the number of male moths was recorded early in the morning and lures were kept in a cool box until being reset in the field during the late afternoon. After week one, traps were left in the field and examined three more times.

In trial two, traps were left in the field from the outset. The number of males caught was recorded daily for two weeks.

Male *H. undalis* were trapped at all locations and the 10-µg dosage appears adequate to attract adult males (Table 120); it is also the most cost-effective. The cost of the pheromone is 750 Euro for the first gram and 450 Euro for each additional gram. Future studies, therefore, will be conducted with only 10-µg dosages.

Table 120. *Daily mean number of male* Hellula undalis *moths trapped at four locations by six dosages of a synthetic pheromone, Philippines, 2001–2002.*

Dosage	San Leonardo	Palestina	Matinkis crop 1	Matinkis crop 2
10 µg	20.1	1.4	0.8	12.9
20 µg	18.7	0.8	1.3	3.5
50 µg	15.1	0.2	0.8	3.7
100 µg	12.0	0.6	1.0	3.2
200 µg	14.0	0.8	1.0	3.2
500 µg	12.1	1.0	2.6	3.4

Efficacy of artificial diet to rear Hellula undalis

A preliminary trial was conducted to test the efficacy of an artificial diet for rearing *H. undalis*. The diet was prepared using nine parts of Bioserv, an artificial diet which is commonly used to rear beet armyworm, to one part of pak-choi leaves that were boiled in distilled water. From 619 eggs placed in 46 containers with artificial diet, 103 adults emerged with a sex ratio of 38 males to 44 females. The mortality rate of 83.4% was unacceptably high and further studies are required.

Technology transfer

Participatory rural appraisal

Based on the results of a participatory rural appraisal, no farmer organization operates in Laguna, Batangas, Quezon Province, Nueva Ecija, Tarlac, Pampanga, Bulacan and Pangasinan. To date, no attempt has been made to create an organization for them. Thus, existing structures in the barangays were utilized to mobilize farmers for the purpose of training in ICM of pak-choi and in grafted tomato production.

The appraisal conducted in the provinces of Batangas, Quezon, Laguna, and Nueva Ecija indicated an unstable trend in the supply of leafy vegetables to Manila markets. This was due to production constraints caused by insect pests, diseases, and flooding damage during the wet season. These findings served as an entry point for on-farm trials and succeeding technology promotion activities.

Declarations of cooperation

Memorandums of Agreement (MOA) between the project and local government units were signed in which duties and responsibilities of each party were stipulated. In 2001, ten MOAs were maintained/ renewed and four new MOAs were signed with local chief executives.

Capacity building

Technologies, particularly on ICM of pak-choi and production of grafted tomato, were packaged and presented for evaluation to selected local government unit (LGU) extension workers and farmers during trainings.

A training of trainers (TOT) was conducted to equip future trainers with technical knowledge and skills needed to conduct Farmer Field Schools (FFS) in their respective municipalities. Fourteen LGU agricultural technicians and 6 researchers were trained.

Farmer Field Schools were subsequently implemented to facilitate learning and cooperation among pak-choi farmers. The FFS provided farmers with hands-on experiences in using raised beds to reduce flooding damage, applying urea in rates that maximize production and profits, sowing in rows instead of broadcasting for superior plant growth, and using mesh netting for shelters to improve quality and reduce pesticide use. In all, 263 farmers participated in the nine FFS. Funds for this training were primarily provided by the LGUs, with limited support from the project and the participants themselves.

Similarly, TOT on grafted tomato production was conducted. The number of participants totaled 33, consisting of 9 representatives from state colleges and universities (SCUs), 17 LGU agricultural technicians, and 7 officers from NGOs.

Technology promotion

The project's technologies were showcased in technology fairs conducted by LGUs, state colleges and universities (SCUs), and other scientific organizations. Research reports were presented in 13 local and national forums; four papers were judged as best of their forum. The project was showcased and featured in newspapers, radio and TV broadcasts.

The Land Bank of the Philippines (LBP) through its Technology Promotion Center (TPC) has earmarked a modest amount of funds to validate the cost and return from grafted tomato seedlings production, grafted tomato production, and physical net barriers for pak choi production. If found feasible and economically viable, TPC will provide credit to farmers for the purchase of these technologies.

On-farm trials were done in 19 sites to enhance farmers' awareness and verify the applicability of developed technologies.