Special project. Manila peri-urban vegetable project

Urban sprawl is common in Asia, and competes directly with urban and peri-urban vegetable production zones. New technologies could help to meet the unprecedented demands being placed on tropical Asian cities, to alleviate micronutrient deficiencies among the urban poor, recycle solid wastes, and reverse trends toward environmental catastrophe.

The AVRDC peri-urban project in the Philippines, sponsored by GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit), is designed to:

- stabilize the supply of safe and nutritious vegetables to metropolitan areas, such as Manila
- develop an approach for information acquisition, testing and dissemination suitable to other peri-urban areas in Asia

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Characterization of environments suitable for technology transfer

Technology transfer requires that farmers possess the education and experience necessary to evaluate the usefulness of technologies. They also need access to information, access to resources to invest in new technologies, labor, and access to markets. They must also believe that their investments will pay off. This study was undertaken to characterize farmers' social and economic environments so that constraints to technology transfer can be identified and so that effective methodologies might be developed.

A survey of *barangay* (community) Castellano and neighboring *barangay* Nieves found that: vegetable growers spend an average of 6.6 years in school and complete primary education, they have 16.6 years of farming experience, 28% own their land (mean farm size 1.1 ha), 65% are tenants (mean farm size 0.64 ha), 7% rent land, and 94% own their homes. One hundred percent of farms are irrigated, 28% of the soil area is classed as silt loam, and therefore excellent for vegetable farming. Seventy-eight percent of farmers do not borrow money, and among the 22% who do, 18% borrow from family or friends and 4% borrow from money lenders or banks. The maximum amount borrowed is 35,000 PHP. Mean household size is 4.42 persons, with a mean of 1.58 adults per household as laborers. Mean gross income is 197,000 PHP, of which 98% is from vegetable farming. Return on investment ranges from 56% for mustard to 909% for onion. Return from pak-choi, the project's principal target crop, is 87%. The ratio of total cost of production to gross income is 0.53 for pak-choi and 0.01 for onion. Seventy-four percent of households own a television, 76% own a radio, 3% own a truck. Eighty-one percent of farmers sell their pak-choi (for example) to local assemblers, whereas only 19% sell directly to markets. The mean yield of pak-choi on 15 farms in Nueva Ecija in the wet season 1999 was 2.8 t/ha.

These data suggest that farmers in San Leonardo (the project's principal site) possess the education and experience needed to assess new technologies. Because 93% of farmers are owners or tenants, we assume they value the long-term productivity of their farms. And gross income figures suggest that San Leonardo vegetable farmers are not poor, and can perhaps invest in new technologies. Formal borrowing is minimal, but informal borrowing, in the form of seed and fertilizer supplied by assemblers, is common. Such arrangements tie farmers to a marketing system controlled by the assemblers—the money owed must be paid at the time of sale. Considering that only 3% of farmers own a vehicle to transport produce to market, assemblers are virtually indispensable, whatever the terms of their loans. Few farmers (3%) obtain technical information from television and radio; rather they rely on friends and relatives (29%), and sales agents (22%). Researchers and government technicians were sources of technical information for 8 and 7% of respondents, respectively.

All farmers interviewed (119) reported using chemicals to control pests and diseases. In fact, use of pesticides is synonymous with pest management. Yet, 85% of farmers perceive insecticides to be less than fully effective. Neighboring farmers most often provide recommendations on choice of insecticide. Organophosphates, such as Brodan, Selecron, Ascend, and Hostathion, are preferred because they are considered effective, relatively inexpensive, and available. Pak-choi and mustard receive more insecticide treatments per day of crop duration than do radish and onion, but onion receives the largest quantity (Table 85). Only 20% of farmers knew

about enemies of pests, but among these farmers, all knew that killing predators with insecticides would lead to increases in pest infestations.

Safe handling and storage of pesticides is a concept, but not a practice among farmers. Most (82%) apply pesticides while walking into the wind. Most (93%) wear clothing that might provide partial protection from spray drift (e.g., short or long pants, short- or long-sleeved shirts), but only 3% wear masks and gloves. Clearly, farmers are exposed to pesticide drift and that might explain why many respondents reported episodes of headache (77%), weakness (65%), dizziness (49%), vomiting (45%), and stomach pain (26%) following application. Nonetheless, farmers persist in using unsafe practices.

The study suggests that vegetable production is profitable, but that profitability of pak-choi lags behind other crops, such as onions and radish, which are part of the cropping sequence employed by farmers in Castellano. Farmers, therefore, approach pak-choi production with less intensity and interest. Nevertheless, technologies that improve pak-choi productivity and/or decrease production expenses should be marketable among farmers in San Leonardo. Regarding unsafe use of pesticides; if we are to foster a change in practices, we must first understand the reasons for farmers' *laissez-faire* attitude.

Perceived appropriateness of AVRDC technologies to leafy vegetable production systems

Farmer opinion about integrated pest management (IPM)—raised beds, rain shelters, and organic fertilizer—for pak-choi management has changed as a result of the project's on-farm activities in San Leonardo. Initially perceived as having low sustainability, at the end of the second year of the project farmers rated those practices as having moderate sustainability. Here, sustainability refers to a farmer's perception of his/her capacity to dedicate resources to implement new practices. About 90% of farmers perceive IPM to require moderate labor inputs and time, yet 82% consider implementation of IPM practices to be complicated and therefore not adaptable. Even farmer-cooperators, those intimately associated with IPM activities, want a "silver bullet" (a potent pesticide) to solve pest problems. It is imperative, therefore, that training documents and training exercises express the interrelationships of pest intensity, crop damage, and economic environment, and therefore the complexity of IPM, in a way that is understandable to farmers. Farmer adoption of IPM practices would lead to reduced pesticide use, reduced pesticide residues on farm produce, and the improved health of consumers and producers.

Farmers acknowledge that screen shelters reduce insect damage, yet they consider shelters too expensive and too labor intensive to be adopted.

The number of farmers who visited research sites or otherwise heard of the management innovations being implemented in San Leonardo increased from 53 in 1998 to 81 in 1999. We interpret this increase as a measure of the interest generated by our work among potential users.

Table 85. *Number of insecticide applications and average quantity of product used in vegetable production in San Leonardo, wet season 1998*

Vegetable	Number of applications			Quantity (liters/ha)
	range	average	crop duration	
Pak-choi	3-10	7	31 days	4.8
Radish	2-10	6	45 days	2.67
Mustard	4-10	7	31 days	3.17
Onion*	2-12	5.9	80-95 days	5.25

* Dry season 1999 data.

Effects of technology transfer on food consumption patterns among farmers and urban dwellers

We conducted a quarterly survey of 239 households in San Leonardo and Gapan to generate base-line data against which changes in food consumption can eventually be measured.

As expected, the survey revealed seasonality in vegetable supply. One-day total food consumption among all households ranged from a mean of 1115 g in April–June to 942 g in October–December; a drop of 15%. Meanwhile, vegetable consumption dropped a full 40%, and total energy consumption dropped only 5%. Consumption of vitamins A and C dropped 35 and 33%, respectively, due to reduced vegetable consumption—vegetables account for 67% of Filipinos' vitamin A intake and 84% of their vitamin C intake. This project focuses on technologies to

improve vegetable production during the hot-wet season in order to reduce seasonality of supply and the resulting vitamin deficiency. But at present, we can only speculate about changes that might occur as a result of technology transfer.

Farmers consume 1110 g of food per day, whereas urban dwellers consume 961 g, a difference of 13%. But farmers eat more vegetables, 227 g/day compared to 175 g/day consumed by urban dwellers, a difference of 23%. In contrast, per capita vegetable consumption in Metro Manila is only 87 g/day, 62% less than the farmers in San Leonardo. As expected, consumption of vitamins A and C by residents of Metro Manila is also deficient, by 38 and 34% of the recommended daily allowance, respectively.

Price and income elasticities can be used to assess consumer response to changes in vegetable prices resulting from variability in supplies. Price elasticity is a measure of percent decline in demand (and as such is represented by negative values) after a 1% increase in price, or a percent increase in demand after a 1% decrease in price. If the elasticity value is greater than 1, then the percent decline in demand is greater than the percent increase in price. If the elasticity value is less than 1 then the percent decline in demand is less than the percent increase in price. The survey revealed price elasticities for meat and vegetables of -1.015 and -0.553, respectively. These values indicate that demand for vegetables is less affected by price increases than is demand for meat. However, compared to cereals (-0.329), vegetables are more affected by price increases. Price elasticity values for individual vegetables indicate that demand for leafy types (value of -0.969) is more affected by price increases than is demand for tomatoes (-0.412). That is, with equal increases in price, the demand for leafy vegetables will be more affected than will the demand for tomatoes.

Income elasticity values represent percent increases in demand (and as such are represented by positive values) that result from a 1% increase in income. A value of 1 indicates that income and demand increase equally, in percentage terms. Values greater than 1 indicate that a 1% increase in income leads to >1% increase in demand, whereas values less than 1 indicate that a 1% increase in income leads to <1% increase in demand. In our study, income data for respondents were not available so we used household expenditures as a substitute. Expenditure elasticity values for meat and vegetables were 1.632 and 0.775, respectively, indicating that the demand for meat increases more per unit increase in household expenditure than does the demand for vegetables. Households buy more meat than vegetables as income increases. The difference in choice between meat and vegetables is reflected in budget allotments as well: 27% of household budget goes to purchase meat, but only 7% to purchase vegetables.

Review of the absolute values for price and income elasticities of vegetables (-0.553 and 0.775, respectively) suggests that demand is slightly more responsive to income than to price. Therefore, technologies that improve income will increase consumption, perhaps more readily than technologies that reduce price.

Constraints to technology adoption for pak-choi

There are three main constraints to adoption of the project's pak-choi technologies: 1) pak-choi does not receive intensive management by farmers, 2) the capital/output ratio for pak-choi is high relative to onion, and 3) farmers persist in their search for effective pesticides rather than adopt more intensive management practices.

Farmers must be convinced that monitoring pests prior to pesticide application, use of screen shelters to reduce insect damage, and reduction of fertilizer cost through sound crop management, will reduce their expenses and raise their incomes.

Soil and crop nutrition

Peri-urban vegetable production systems in *barangay* Castellano are characterized by excessive use of inorganic fertilizers and pesticides. Farmers apply up to 92, 218, and 368 kg/ha of nitrogen-containing fertilizers to pak-choi, radish, and onion, respectively, and burn 70–380 t/ha of rice hulls every year or every 2–3 years. Farmers believe these practices contribute to sustainability.

Between 30 and 50% of the above-ground biomass of onion, radish, and pak-choi is discarded at harvest as nonmarketable or waste. This discarded material contains 30–50% of the total nutrients taken up by the plants. The nutrients contained in the edible parts end up in metropolitan areas, such as Manila. To ensure the sustainability of production systems in

Nueva Ecija, and therefore ensure long-term supplies of vegetables to urban consumers, nutrient cycling must be practiced.

Research presented here suggests alternative fertilization practices for peri-urban vegetable production systems in Nueva Ecija, a principal supplier of leafy vegetables to Metro Manila consumers.

Effects of burned rice hulls on soil properties and pak-choi yield

Burning rice hulls on cropland is a common practice among vegetable farmers in San Leonardo. It is done primarily to control weeds. The ash is incorporated in the soil prior to seeding. The project is interested in the long-term effects of the practice on soil factors and on crop yield.

In a replicated trial carried out at the project site, 147 t/ha of rice hulls were burned. Soil organic matter (SOM), exchangeable K, and soil porosity increased, while bulk density and particle density decreased (Table 86). Weeds were reduced in crop 1, which was seeded immediately after incorporation of the ash (Table 87). Weeds were also reduced in crop 2, indicating a residual effect. Yield generally was unaffected, although treatment 5 (147 t/ha rice hulls + inorganic fertilizer) did show a significant yield increase over the control, treatment 1 (inorganic fertilizer alone) (Table 87). The increase in SOM should be explored further, as our measures probably included undecayed and decayed organic matter. Based on these findings, rice hull burning reduces weeds and might increase SOM. Further study is needed to determine if repeated incorporation of ash affects yield.

Effects of composted vegetable refuse from households in contrast to chicken manure and inorganic fertilizer on growth performance of pak-choi, radish, and onion

The project carried out a replicated yield trial of pak-choi, radish, and onion, to determine the effects of composted household (vegetable) waste (HW) and chicken manure (CM) (actually 50% chicken manure and 50% carabao manure), with and without inorganic fertilizer. The cropping sequence followed for the trial at Central Luzon State University (CLSU), Muñoz, was typical of that followed by farmers at the project site in San Leonardo. Pak-choi, radish, and onion received 12, 9, and 17 t/ha of organic fertilizer (HW or CM), respectively. They received 120-30-30, 90-30-30, and 170-40-40 kg/ha N-P-K of inorganic fertilizer (as recommended), respectively. Treatments included organic fertilizers

Table 87. *Effect of rice hull burning, prior to seeding crop, on weed numbers and yield of pak-choi*

No.	Application		Weed numbers (per 0.5m^2)		Marketable yield (t/ha)	
	Rice hull (t/ha)	N-P-K (kg/ha)	Crop I	Crop II	Crop I	CropII
1		90-30-30	30a	25a	4.55a	3.90b
2	74	90-30-30	10b	12b	4.70a	3.95b
3	74	45-30-30	12b	12b	4.05a	3.35b
4	147	90-30-30	4c	3c	5.35a	4.60a
5	147	45-30-30	4c	2c	4.10a	3.40b

Note: Mean recovery of carbonized rice hull from rice hull is 31.5%.
Second crop did not receive rice hull.
Means followed by the same letter in a column are not statistically different using Tukey's HSD Test.

Table 86. *Soil properties during the first and second crops in plots treated with burned rice hulls, December 1998– February 1999*

No.	Application		Organic matter (%)		Exchangeable K	Bulk density	Particle density	Porosity
	Rice hull (t/ha)	N-P-K (kg/ha)	Crop I	Crop II	(meq/100g)	g/cm^3	g/cm^3	(%)
1		90-30-30	1.76b	1.70b	0.20c	1.36a	2.33a	41.36b
2	74	90-30-30	2.94a	3.00a	0.49b	1.26b	2.25a	43.68b
3	74	45-30-30	3.14a	3.19a	0.50b	1.27b	2.25a	43.11b
4	147	90-30-30	3.20a	3.23a	0.80a	0.91c	1.90b	52.56a
5	147	45-30-30	3.15a	3.17a	0.79a	0.90c	1.90b	51.93a

Means within each cropping period with similar letters are significantly different using Tukey's HSD Test.
Note: Mean recovery of carbonized rice hull from rice hull is 31.5%.

alone and in combination with recommended rates (RR) and half recommended rates (½RR) of inorganic fertilizer.

RR or ½RR inorganic fertilizer produced about equal yield (Table 88, treatments 4 and 5), with the exception of pak-choi crop 5. Only the radish crop and final pak-choi crop showed a significant benefit from HW or CM alone, while the onion was found to benefit from HW alone (Table 88, treatments 1, 4, and 5). Organic fertilizers alone had no effect on yield of crops 1, 4, and 5, all pak-choi crops.

Only pak-choi crops 1 and 5 benefited from 6 t/ha of organic fertilizer (½HW or ½CM) added to ½RR inorganic fertilizer. The other crops yielded just as well with ½RR inorganic fertilizer alone. However, crop 4 treated with ½RR + ½CM yielded higher than the ½RR alone. (The ½RR +½HW treatment showed no such benefit.) This study, which looked solely at crop yield, does not justify substituting organic for inorganic fertilizer.

Effects of farmer practices and introduced management practices on yield of pak-choi

Two treatment plots were placed on each of five farms. Treatment 1 was the farmer practice of transplanting seedlings in low beds to which nitrogen at 100 kg/ha was applied. Treatment 2 was the introduced technology of transplanting seedings in lines in beds raised 20 cm over which screen was stretched on bamboo arches. Raised beds were treated with inorganic fertilizer at 45-10-10 kg N-P-K/ha plus 4.5 t/ha of chicken manure compost. Analysis of variance (ANOVA) with farms as repetitions was done to determine treatment effects.

The introduced technology package was clearly superior to the farmer practice (Table 89). Yield was increased by 21%, which can be explained by the increase in plant density (29%) and increase in plant height (12.6%). The farmer plots received nine pesticide applications, whereas treatment 2 plots received only three; a reduction of 66%.

Table 88. *Marketable yield (t/ha) of pak-choi, radish, and onion as affected by fertilizer treatment in a pak-choi, radish, onion, pak-choi, pak-choi, pak-choi cropping sequence*

		Marketable yield (t/ha)					
No.	Treatment	Crop I Pak-choi[1]	Crop II Radish[1]	Crop III Onion	Crop IV Pak-choi	Crop V Pak-choi	Crop VI Pak-choi[2]
1	nil	3.7c	19.4c	12.9d	12.2d	7.1d	1.8c
2	HW	5.2c	26.5b	21.3bc	17.2bcd	9.9cd	3.6b
3	CM	5.2c	26.5b	18.0cd	14.9cd	9.9cd	3.5b
4	½ RR	17.0b	29.7b	20.7bc	16.4cd	9.9cd	6.5ab
5	RR	20.0ab	34.3ab	25.1ab	20.4bcd	19.3a	6.1ab
6	½ RR + ½ HW	21.0a	30.8b	25.7ab	23.2abc	14.5b	6.6ab
7	½ RR + ½ CM	22.0a	31.5b	25.5ab	31.9a	21.0a	5.1ab
8	½ RR + HW	21.7a	32.8b	27.3a	24.2abc	12.3bc	9.1a
9	½ RR + CM	23.2a	40.8a	24.2ab	27.1ab	15.1b	9.4a

RR = recommended rate of inorganic fertilizer application, 120-30-30, 90-30-30, and 170-30-30 kg N-P-K/ha for pak-choi, radish, and onion, respectively.
CM = chicken manure; HW = household waste.
[1] Part of first year accomplishment.
[2] Severe diamondback moth damage in all plots.

Table 89. *Yield and yield components of pak-choi on farmer-practice plots and introduced technology plots, October–December 1999*

Treatment	Fresh yield (t/ha)	Marketable yield (t/ha)	Percent marketable yield	Plants per m² Days after emergence 8	20	35	Plant height (cm)
Farmer practice	20.2b	14.0b	70.6a	100b	99b	99b	25.8b
Introduced technology	28.9a	17.7a	61.3b	271a	216a	140a	29.5a

Soil factors associated with yield of pak-choi

In an effort to better understand variability in pak-choi yield, we took soil samples from 21 farms and analyzed them for organic matter, pH, texture, available P, exchangeable K, total soil N, cation exchange capacity, available N, and amount of NPK applied as fertilizer. Soil factors were regressed on yield by using stepwise regression with $a = 0.05$ as the acceptance level. When cation exchange capacity was used as a constant, only available P and exchangeable K emerged as significant factors and partial correlation coefficients were -0.634 and -0.777, respectively. The negative sign indicates that yield was depressed as P and K values increased, which is counter to our understanding of plant response to these elements. These results suggest that due to continuous heavy application of burned rice hull, P and K have accumulated to an excessive level.

Technologies to increase tomato productivity during the hot-wet season

In the Philippines, tomatoes are primarily grown in the lowlands in the dry season. Hundreds of hectares are planted; consequently, net returns are low due to market glut. In contrast, during the rainy season, particularly in Nueva Ecija, tomato production is restricted to a few small hilly areas, supplies are limited and high prices make tomatoes almost unaffordable to consumers. For example, the retail price of tomatoes during the wet months can reach 80 PHP/kg (about US$1.75/kg). There is justification, therefore, based on economics and nutrition, to introduce technologies shown to enhance tomato productivity during the hot-wet season: tomato grafted onto eggplant rootstock for flood tolerance and resistance to bacterial wilt (BW), and sheltered raised beds to limit exposure to water logged soils and heavy rains, which can be particularly damaging during pollination.

Two trials were conducted on the Central Luzon State University campus. Trial 1 tested the performance of a local variety, Apollo, and a line from AVRDC, CLN5915, grafted onto eggplant line EG203, and onto BW resistant tomato line H7996. The trial was conducted under screen shelter on beds raised 30 cm. Trial 2 tested the performance of Apollo and CLN5915 grafted onto EG203 under screen shelter and in open field.

Yield was subjected to analysis of variance to determine treatment effects. In trial 1, transplanted in September, mean yields for Apollo grafted onto EG203 and H7996, and nongrafted were 15.6, 14.4, and 2.7 t/ha, respectively, whereas mean yields for

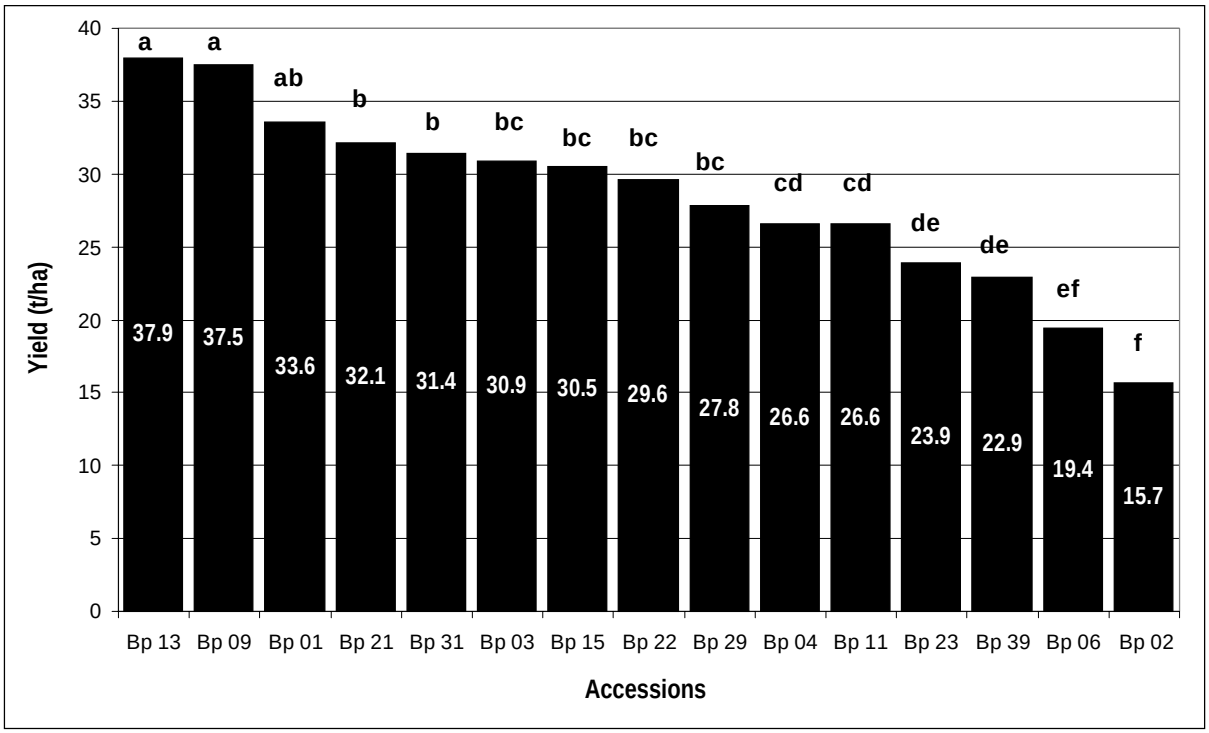

Figure 19. *Yield per ha of pak-choi accessions grown in a net house.*

CLN5915 grafted onto EG203 and H7996, and nongrafted were 14.7, 25.2, and 14.1 t/ha, respectively. Yield of nongrafted Apollo was significantly (P = 0.105) less than yields of other treatments. Based on single degree of freedom orthogonal comparisons, mean yield of CLN5915 across graft levels (18.0 t/ha) was significantly (P = 0.014) greater than that of Apollo (10.9 t/ha), and grafted lines (17.5 t/ha) yielded significantly (P = 0.015) more than nongrafted (8.4 t/ha) lines.

In trial 2, transplanted in September, mean yields for Apollo grafted onto EG203 and Apollo nongrafted were 21.2 and 18.4 t/ha, respectively, and the difference was not significant. Mean yields of CLN5915 grafted onto EG203 and CLN5915 nongrafted were 15.8 and 10.8 t/ha, respectively, and the difference was not significant. But, when yields of Apollo across graft levels were contrasted with CLN5915 across graft levels, yield of Apollo (19.8 t/ha) was significantly greater than yield of CLN5915 (13.3 t/ha). Yields under shelter and in open fields across graft levels were 18.0 and 15.3 t/ha, respectively, and the difference was not significant. There was no shelter × graft level interaction. When graft across varieties was contrasted with nongraft, mean yields (18.5 and 14.5 t/ha) were significantly (P = 0.096) different.

In both trials, grafted plants yielded more than nongrafted plants, but Apollo across graft levels was not clearly superior to CLN5915. There was no shelter effect, which might reflect the absence of severe flooding.

Three on-station trials and one on-farm trial were conducted by the Bureau of Plant Industry–Laguna. In on-station trial 1, eight tomato cultivars were grafted onto eggplant EG203 rootstock and transplanted in December. There were differences in cultivar yield within graft level (grafted, nongrafted), but no differences between graft levels within cultivar. When grafted onto EG203, FMTT-22 and CHT-261 yielded 46.2 and 48.2 t/ha, respectively, significantly more than local cultivar, Apollo, grafted onto EG203 (29.4 t/ha). Nongrafted FMTT-22 and CHT-261 yielded 36.6 and 40.8 t/ha, respectively, significantly more than nongrafted Apollo (15.9 t/ha).

On-station trial 2 was designed to test the interaction of shelter, variety, and graft level. Plants were transplanted in July. There was a shelter × cultivar interaction. Apollo yielded 3.7 and 3.2 t/ha in open field and shelter, respectively, but FMTT-586 yielded 8.4 and 11.4 t/ha, respectively. Across graft level and shelter, FMTT-586 yielded 9.9 t/ha, whereas, Apollo yielded 3.4 t/ha, and that difference is significant (P = 0.05).

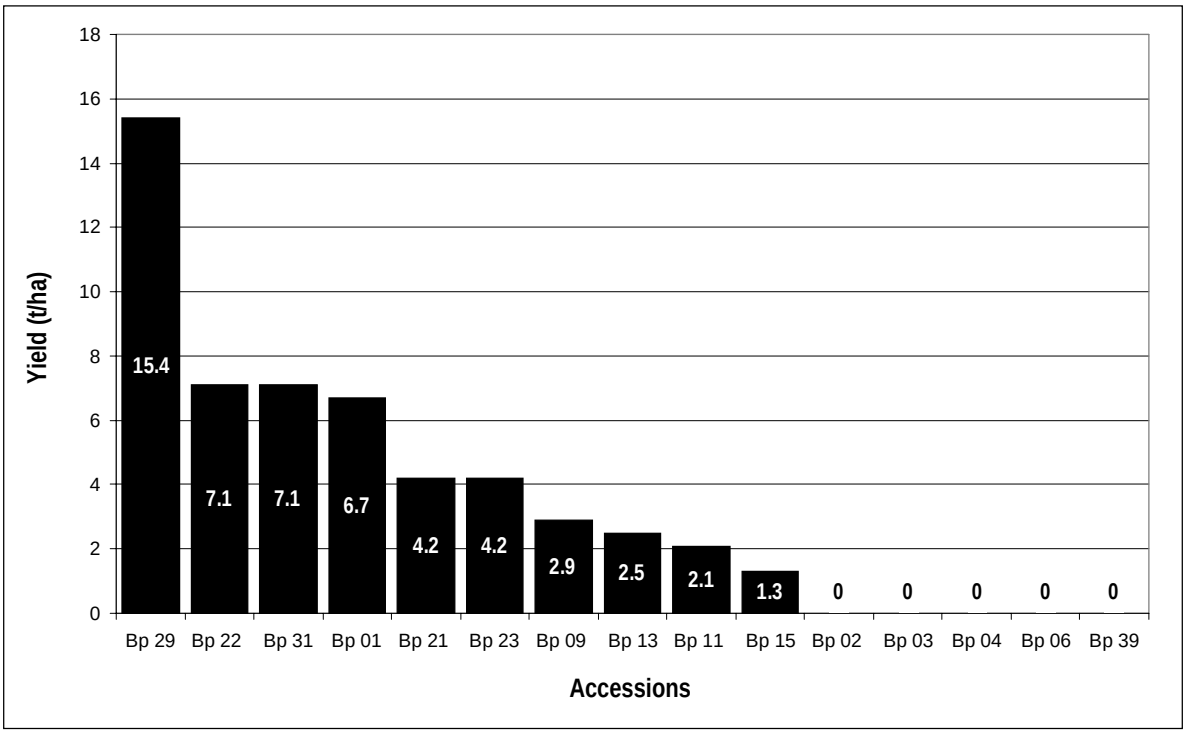

Figure 20. *Yield per ha of pak-choi accessions grown in open field.*

Trial 1 was conducted in the dry season, when flood tolerance from grafting is less important. Consequently, the nonsignificance of grafting among cultivars is expected. But, trial 2 was conducted during the wet season and there was no graft effect on cultivar yield. Other studies have provided strong evidence for grafting as a means to combat the effects of flooding and BW infection, but if those deterrents to yield are not present, or are present but not severe, then grafting becomes an exercise in futility. These data suggest that probability of flooding and BW infection should be taken into account when grafting is being considered as a management option.

On-station trial 3 tested the effect of hormones on off-season tomato production. When Nevirol and Tomatotone at 2% were applied to pistils of Apollo flowers, yields were 3.7 and 3.7 t/ha, respectively, and those yields are not different from the yield of nontreated plants (4.9 t/ha). The yield means across three cultivars, FMTT-22, CL-143, and CHT-261, treated and nontreated with Tomatotone, were 14.6 and 12.7 t/ha, respectively, and the difference is not significant (P = 0.05).

FMTT-589 and CL-143 were grown on-farm at three locations in nonreplicated trials. Yields across cultivars were 10.3, 21.3, and 0 t/ha at Batangas, Cavite, and Laguna, respectively. Zero yield at Laguna was attributed to frequent and heavy rain and to strong winds, which affected vegetative growth. We believe, but cannot document, that similar conditions were the cause of low yields in Batangas, in contrast to yields in Cavite.

Identification of leafy vegetable cultivars for year-round production in the tropics

Leafy cultivars belonging to the genus Brassica (*Brassica rapa* L. cvg. pak-choi; *B. juncea*, Indian mustard; *B. rapa* L. cvg. Chinese cabbage, non-heading Chinese cabbage; *B. oleracea* L. cvg. alboglabra, Chinese kale; *B. rapa* L. cvg. caisin, choy sum) were evaluated for their performance in fields at Central Luzon State University, Muñoz. They were seeded in raised beds in net houses (18 × 18 m) constructed of galvanized pipe with 16 mesh screen. The experiment followed a random complete block design. To contrast performance in net houses and open field, pak-choi was also seeded in an adjoining field, but in a non-replicated trial. We report here yield data from pak-choi as illustrative of relative performance under net houses and in open field. Yields were analyzed by ANOVA and by Tukey's HSD pairwise mean comparison test.

In the net house, yields ranged from 15.7 to 37.9 t/ha (Figure 19). In contrast, yields in the open field ranged from nil to 15.4 t/ha (Figure 20). There were cultivar differences in the net house. Bp 13 (Hua-Guan F_1) and Bp 09 (No. 341 F_1) yielded significantly more than all other accessions, with the exception of Bp 01 (Shanghai Green). Pak-choi was severely infested by cabbage webworm and diamondback moth (DBM) in the open field, but infestations were nil in the net house. Flea beetles did gain entry into the net house, but damage was minimal.

Another experiment was conducted at the Bureau of Plant Industry–Laguna. Eighty leafy vegetable cultivars were seeded on raised beds, 1 × 4 m and covered with 32 mesh net tunnels in a replicated trial on four occasions. There were few differences in yield among cultivars within species. Yields from February, March, and June plantings were similar; November was the least favorable month (Table 90). Most leafy species yielded about the same across plantings, but there were exceptions: yields of Chinese kale and celery were low, whereas yield of kangkong was high.

Table 90. *Mean yield of leafy vegetable cultivars across months*

	Yield (t/ha)				
Species	Feb	Mar	Jun	Nov	Mean
Indian mustard	10.9	15.6	13.8	4.3	11.0
Nonheading Chinese cabbage	14.1	12.8	17.0	7.2	12.8
Chinese kale	6.3	5.3	9.7	3.4	7.1
Kangkong	22.8	28.5	27.3	8.4	20.1
Choysum	18.7	14.2	13.1	6.4	12.3
Pak-choi	15.5	12.7	12.3	9.9	12.6
Lettuce	17.7	5.7	17.9	14.5	13.9
Celery	5.7	-	5.9	4.5	5.4
Month mean	13.9	11.8	14.6	7.3	

Kangkong is not a host to DBM and cabbage webworm and might be a candidate to replace leafy brassicas in those areas where damage by insect pests is severe.

Integrated pest management for peri-urban vegetable production

Replicated field trials were conducted on two farms to contrast farmer practice of pesticide treatment with treatments based on field monitoring of pest intensity, and nil pesticide. On farm 1 there were two crops of pak-choi, two of onion, and one radish crop. On farm 2 there was one crop of pak-choi, two of onion, and one radish crop. We noted the pesticides used, frequency of application, and dose. Pest numbers were counted twice weekly and yield was recorded. Treatment effects were analyzed by ANOVA and pairwise mean comparison.

Pak-choi trials

Replicated trials of pak-choi, onion, and radish were conducted on two farms in San Leonardo. There were three treatments for each farm/crop combination: treatment 1 was the farmer practice for pesticide use, treatment 2 was pesticide use as determined by researchers, and treatment 3 received no pesticide.

Results were mixed. For farm 1, crops 1 and 2, cabbage webworm larvae were fewer and yields greater in farmer practice plots than in researcher managed plots. In contrast, researcher managed plots from farm 2 had fewer diamondback moth (DBM) larvae, fewer damaged plants, less incidence of web blight, and higher yield than did farmer practice plots (Table 91). The researcher managed plots received nine pesticide treatments compared to the five treatments on the farmer managed plots, but the volume of pesticide used by researchers was 21% less than the volume used by the farmers. Yields were extremely low in plots managed by farmers and researchers, and nil where no pesticide was used. We learned that the farmer practice of applying an insecticide immediately at crop emergence is more effective for cabbage webworm management than our strategy of delaying treatment until larvae are detected. Yet, cabbage webworms are not always a threat, and therein lies the problem: pesticides are often applied when there are no pests present, or when infestation is below the level at which action makes economic sense (action threshold, in this case unknown), but 1st instar larvae often escape detection because they are small and move to the plant's growing point soon after hatching, where they are enclosed by young, developing leaves. By the time larvae are visible, meristematic tissue has been destroyed and the plant dies. We believe, therefore, that the farmer practice of treating pak-choi at emergence during periods of high risk of cabbage webworm is a necessary part of IPM. Only when improved methods of detection are available can we defer treatment.

Onion trials

Over four onion trials there were 35.7% fewer sprays made to researcher plots than to farmer practice plots, and 66% less product applied. Mean yields across farms and crops were 13.7, 14.1, and 12.5 t/ha for farmer practice, researcher managed, and nil pesticide plots, respectively. There were no yield differences between farmer practice and researcher managed plots for any trial, but in two of the four trials yields from farmer practice (22 t/ha) and

Table 91. *Effect of pesticide treatments on number of diamondback moth and cabbage webworm larvae, percent damaged plants, web blight incidence, and marketable leaf weight in pak-choi on Farm 2 of R. Manalo, 6 September –12 October 1999*

Pesticide treatment	Pesticide sprays		Diamondback moth larvae/0.25m^2	Cabbage webworm larvae/0.25m^2	Damaged plants (%)	Web blight incidence (%)	Marketable yield	
	number	liters/ha	27 DAS	13 DAS	27 DAS	27 DAS	kg/m^2	t/ha
Farmer practice	5	20	1a	0.67 b	47.79 b	35.50 a	0.07b	0.80
Researcher managed	9	15.7	0.33 b	0.78 b	29.72 c	11.31 b	0.23 a	2.3
Nil pesticide	0	0	0 b	5.11 a	100.0 a	0 b	0 c	0

Means in a column with common letter are not significantly different using Bonferroni test.
DAS = days after sowing.

researcher managed (20.6 t/ha) plots were higher than yields from nil pesticide plots (18 t/ha). In trials where yield was affected by treatment, the mean incidences of plants infected by *Colletotrichum gloeosporiodes* (cause of twister disease) were $3/m^2$ in the nil pesticide plots, and $2/m^2$ in the researcher managed plots. That is, fungicide sprays by researchers reduced incidence of *C. gloeosporiodes* by 33% and increased yield by 12–18%. Farmers mixed fungicide maneb with insecticides for each application (nine), whereas researchers made one application each of maneb and benomyl separately. We believe the farmer practice of mixing fungicides with insecticides and the poor coverage of plant surfaces by the spray account for the difference in disease incidence between farmer practice and researcher managed treatments.

Radish trials

Results from two farms show that farmers made a mean of nine pesticide treatments and applied 17 liters/ha of product, whereas researchers made a mean of 2.5 treatments and applied 4.3 liters/ha. Mean yields across farms were 6.1, 7.6, and 6.5 t/ha for farmer practice, researcher managed, and nil pesticide plots, respectively, and those yields are not significantly different. Pesticide treatments did not consistently reduce numbers of DBM larvae or prevent damage to foliage. Incidence of feeding damage by DBM ranged from 80–100% across treatments. Clearly, pesticide treatments were ineffective. Low root yields suggest that crop loss did occur, but we cannot conclude that that loss was due to DBM alone.

Pesticide residue analysis

Three samples of pak-choi (each 1 kg) were collected before harvest from each treatment/repetition to compare pesticide residue on farmer managed, researcher managed, and nil pesticide plots. The samples were placed in plastic bags, stored in a cool box and taken immediately to the National Pesticide Analytical Unit at the Bureau of Plant Industry (BPI), Quezon City, for pesticide residue analysis. We also purchased pesticides from agricultural stores in Gapan and Talavera and submitted them to BPI to check whether active ingredients conformed with information on the pesticide package labels.

Results show that residues of chlorpyrifos were significantly higher in farmer practice plots than in researcher and nil pesticide plots (Table 92) and exceeded the established maximum residue level of 0.05 mg/kg set by the Association of Southeast Asian Nations. Although chlorpyrifos and methamidophos were not applied to researcher managed and nil pesticide plots, residues were detected. Chlorothalonil was applied to researcher managed plots and residues were detected (0.004 ppm), but farmer practice plots were not treated yet residues were present (0.005ppm), as they were in the nil pesticide plots (0.005ppm). Assuming that the analytical procedures used by BPI were sound, these results suggest that spray drift might play an important role in pesticide residue levels. We do not know the proximity of fields treated with methamidophos relative to our plots.

Of the 17 pesticides submitted to BPI for analysis of purity, two gave markedly different quantities of active ingredient than was listed on the label. Both samples came from the same store in Gapan. A commonly used insecticide, chlorpyrifos (31.5 EC), had listed 210 g/liter active ingredient, but the quantity determined by analysis was 57.87 g/liter, a difference of 72%. Another insecticide, BPMC, was declared to have 105g/liter active ingredient, but the amount determined by analysis was 284.99 g/liter, 63% more than the label amount. BPI cites FAO specifications for plant protection products in stating that the active ingredient for products with 100 to 250 g/liter should be within 6% of the declared content. Three additional pesticides taken from the same store in Gapan and all 12 from a store in Talavera gave active ingredient amounts within FAO specifications.

There is speculation among plant protection specialists in the Philippines that reduced efficacy of some pesticides might be due to repackaging of materials with inert ingredients added to replace

Table 92. *Pesticide residue on pak-choi, July 1999*

Pesticide treatment	Pesticide and amount detected in ppm			
	Chlorpyrifos	Fipronil	Cypermethrin	Methamidophos
Farmer practice	0.19a	<0.01	ND	0.83a
Researcher managed	0.04b	<0.01	0.13	0.41 a
Nil pesticide	0.06b	ND	ND	0.68 a

Analysis done by the National Pesticide Analytical Unit at the Bureau of Plant Industry, Quezon City, Philippines. Residue values with common letter are not significantly different.
ND = not detected.

active ingredient. We believe additional testing should be done to determine if a pattern of faulty labeling exists among certain products and among certain sellers of agricultural chemicals.

Pesticide bioefficacy tests

We conducted two field trials in San Leonardo to test the bioefficacy of pesticides on pak-choi pests and diseases: trial 1 tested 12 insecticides on DBM and cabbage webworm infestations, and trial 2 tested 3 fungicides on infection by *Rhizoctonia solani*, the cause of web blight on crucifers.

No cabbage webworm larvae were observed in plots treated with diafenthiruron, whereas there were 7 larvae per meter row in control plots. Numbers of DBM larvae were reduced to 1.3/m-row from 11/m-row in control plots. Pak-choi yield from control plots was nil, but 4.4 t/ha was harvested from plots treated with diafenthiruron. Cypermethrin as Cymbush 5EC, but not as Arrivo and Sherpa 5 EC, significantly reduced numbers of cabbage webworm and DBM larvae, from 7 to 0.3 and from 11 to 2.7/m-row, respectively. And yield of treated plots was 3.65 t/ha. Diafenthiruron and Cypermethrin (Cymbush 5 EC) were superior to chlorpyrifos but not to profenofos, two common insecticides used on pak-choi.

Iprodione, but not chlorothalonil followed by mancozeb, reduced incidence of infection by *R. solani*, and increased yield of pak-choi.

There are differences in efficacy among insecticides and fungicides used for pest management in pak-choi. Chlorpyrifos is the insecticide of choice for pest control in pak-choi because it is cheap and available, but our data indicate that better choices exist. Iprodione is not sold in San Leonardo, but it is clearly superior to available fungicides.

Survey of Spodoptera by using sex-pheromone traps

Insect pests *Spodoptera litura* and *S. exigua* feed on many crops, and their host plants are grown year round in the project area. Host plant preferences and fecundity in relation to different host plants of both species are unknown, but it is unlikely that these factors play a major role in the abundance of Spodoptera species. From the larvae collected, only a few parasites emerged. Therefore, we believe parasites are not responsible for population fluctuations. Pheromone traps do not permit evaluation of numbers as a function of pesticide treatment because adult male moths are attracted across treatment boundaries. Climate data collected in Cabanatuan City showed an average daily temperature between 20 and 30°C, which is optimal for insect development. Also, relative humidity values recorded were favorable for development. We were unable to demonstrate a quantitative relationship between daily rainfall and insect numbers.

Identification of local beneficial arthropods of major insect pests on pak-choi

A wasp from the family Braconidae was identified from a larva of *Plutella xylostella*. Two species of fungi (based on color of mycelium) were observed on larvae of *S. litura*. Nuclear polyhedrosis virus (NPV) symptoms were observed on one larva of *S. litura*. Many larvae of cabbage webworm were infected with a protozoan belonging to the phylum Microsporidia (identified by the Federal Biological Control Centre for Agriculture and Forestry in Germany). Quantification of the Hellula larvae infected in the field with Microsporidia is difficult. Larvae were transferred to the laboratory for rearing on pak-choi, and because only older larvae show symptoms under stress, there is a chance that infection is transferred from larva to larva in the rearing cages. In February 2000, 500 Hellula larvae were placed singly in small plastic containers. Three died with Microsporidia symptoms after 2 days. Symptoms included immobility of the larvae, slow development, and color change from yellow-brownish to gray.

Of 511 *H. undalis* larvae collected from July 1998 to November 1999, none was infested with a parasite. A total of 547 *P. xylostella* larvae were collected from July 1998 to February 2000; one larva in October 1998 was parasitized by a Braconid wasp. For *S. litura*, 83 larvae were collected. Two died from a fungus infection, one had NPV symptoms, and one was parasitized by a Diptera.

Development of IPM training materials

The project has prepared a training poster and a pictorial guide to assist in the identification of insect pests and diseases on pak-choi in the San Leonardo area. The poster and the guide contain information about the three major insect pests, *Hellula undalis*, *Plutella xylostella*, and *Spodoptera litura*, and the

disease web blight. In addition to the poster, information sheets for each pest were developed. These sheets contain information about host plant and damage, pest morphology, monitoring procedures, and pest management. And a booklet was designed that helps farmers determine when management intervention makes economic sense (based on number of larvae or number of infected plants). All materials, except the pictorial guide, were evaluated by farmers and Local Government Units from the San Leonardo area. Results of the evaluation were favorable and the materials were used in farmer training.

Biological control of the podborer, *Maruca vitrata* Fabricius on yardlong bean, *Vigna unguiculata* sp *sesquipedalis,* in lowland areas of the Philippines

Mass rearing of M. vitrata

We observed that females laid 42% more eggs when there were 10 pairs per cage than when there were fewer. Eggs were laid on upper leaf surfaces, on undersides of leaves, and on flowers. No eggs were found on stems or pods. It is very difficult to accurately count the number of eggs laid on cowpea. Therefore, we assumed that the number of eggs laid per female was the same as the number of first instar larvae observed. Furthermore, we assumed that only 70% of the eggs laid had hatched.

Upon hatching and then feeding for two days, first instar larvae were transferred to 50-ml plastic containers and given an artificial diet. Weight of pupae was greatest when larvae were fed a diet of 40 g of pods, 14 g of a commercial Spodoptera diet, and 3 g of potato dextrose agar in 150 ml of water. Adult *M. vitrata* moths survived significantly longer when fed sugar (7.4 days) and honey-sugar (7.9 days) than when fed water alone (4.9 days).

Survey of indigenous enemies of M. vitrata

During 1999, a total of 763 Maruca larvae were collected. Of these, 26 larvae were infested by an Agathidinae wasp, one larva by a fungus, and one larva by a Tachinidae. The wasp isolated from *M. vitrata* was identified by a Taiwanese research institute as *Bassus* sp (family Agathidinae). *Bassus* sp is a solitary-living larval parasitoid, but its efficacy has not been determined. *Agathis vulgaris* is the only insect belonging to the family Agathidinae that has been utilized for pest management in the tropics. Therefore, little is known about these insects.

In addition to these larval parasitoids six Braconidae, and *Trichogramma evanescens*, emerged from Maruca eggs, collected in April 1999 on the Central Luzon State University (CLSU), Muñoz, campus.

The insect pests *Aphis craccivora* Koch, *Maruca vitrata* Geyer, *Nephtottetix virescens* (Distant) and *Ophiomya phaseoli* (Tryon) were identified as major pests on yard long bean in Muñoz in 1999. *O. phaseoli* was observed to be a secondary pest on pods infested previously with *M. vitrata* larvae.

Seventeen percent of *M. vitrata* larvae collected from bean flowers and only 3% collected from pods were infested by the parasitoid *Bassus* sp.

Efficacy of neem and diatomaceous earth on black bean aphids

Mean numbers of aphids per yardlong bean plant 10 days after treatment with different neem-diatomaceous earth formulations were 996.4 for water, 144 for azadirachtin (100 mg/liter), 25.2 for azadirachtin (100 mg) + diatomaceous earth (1g/liter) and 2 for azadirachtin (100 mg) + diatomaceous earth (2g/liter). All treatments were significantly different from water alone (Tukey's HSD test).

Building partnerships

Technology transfer in the Philippines requires support from local government units (LGUs). We refer here to mayors, barangay captains, and extension agents. Municipalities have the authority to assign responsibility to extensionists and grant or withhold resources. Because of the hierarchical nature of municipality governance and social structure, extensionists and farmers follow the lead of elected officials. Therefore, farmer support of technology adoption is linked to official support. To further the testing and adoption of technologies among farmers in San Leonardo, we have enlisted the support of LGUs in San Leonardo and Marilao.

Memorandum of agreement (MOA) and memorandum of understanding (MOU)

An MOA was signed on 15 June 1999 by CLSU President Dr. Rodolfo C. Undan, representing the CLSU-AVRDC-TUM (Technical University of

Munich) peri-urban vegetable project, and by Mayor Eulinio Nagaño, representing the local government of San Leonardo, Nueva Ecija. Dr. Undan and Engr. Leoncio Duran, Mayor of Marilao, Bulacan, signed an MOU on 15 November 1999. Both agreements aim to 1) encourage sustainable vegetable production practices that enhance year-round vegetable supplies to urban areas, and 2) evaluate a combination of farmer participatory and farming systems research methods for the development and dissemination of peri-urban vegetable production technologies.

Capability building and technology promotion

Evaluation of training materials

Selected farmer leaders and extension workers evaluated training materials on 18 February 2000. Integrated nutrient management (INM) and IPM information materials were rated excellent, while an INM flip chart, IPM poster, and IPM booklet were rated good, which indicates room for improvement. It was suggested that more information be provided to clarify IPM and INM concepts, and that a larger typeface be used. All respondents recommended that the materials be reproduced so that more people can benefit.

Field days

Two field days showcasing production of leafy vegetables using net barriers and organic + inorganic fertilizer were held, one on 11 March 1999, the other on 17 February 2000. A total of 43 farmer leaders, 4 extension workers, 29 researchers, and 14 local government officials attended. Attendees expressed satisfaction and gave positive feedback about the technologies. They said that the net barriers could be used for other vegetables.

Training

Training on management of pak-choi was conducted on 7 March 2000 for farmers growing pechay in Nieves and Castellano, and with extension workers assigned to those areas.

Technology fairs

Grafted tomato for off-season production, solid waste management for peri-urban vegetable production, and management of pak-choi were showcased at technology fairs conducted by local government units and some state colleges and universities.

Scientific conferences

Two papers were presented at local and national scientific conferences. *Grafted tomato for off-season production* was judged best paper, crops sector, and *Waste management for peri-urban vegetable production* was judged best paper, agricultural resources sector, at the CLSU Agency In-house Review of Completed and On-going R&D Projects. The papers were also presented at the annual conference of the Crop Science Society of the Philippines, 10–13 May 1999, General Santos City.

Print and broadcast media

The peri-urban vegetable project was showcased in several local and national newspapers, and on radio and television.

Other linkages were developed. The Land Bank of the Philippines, through its Technology Promotion Center (TPC) Project, has earmarked money to document the cost and return from grafted tomato seedlings production. If found feasible, TPC will produce grafted seedlings for farmer cooperators. TPC is also interested in validating the use of net barriers for pak-choi production. If such production is found feasible, TCP will provide loans to farmers.