

# The Periurban Vegetable Project of Xavier University College of Agriculture<sup>1</sup>

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## 1 ABSTRACT

A research project on periurban vegetable production and marketing systems was conducted from October 1997 to August 2000 in three Southeast Asian cities which represent different levels of urbanization: Ho Chi Minh City (Vietnam), Vientiane (Laos) and Cagayan de Oro (Philippines). The study was jointly carried out by research institutions from the Philippines, Vietnam, Laos, France and Germany funded by the INCO-DEV program of the European Union Commission.

The project was structured into six workpackages: (1) economic, sociological and anthropological situation of periurban vegetable production, consumption and marketing in Cagayan de Oro, Ho Chi Minh City and Vientiane, (2) crop improvement, (3) soil management and plant nutrition, (4) integrated pest and disease management, (5) water management and (6) marketing.

Among the major results of the project is a database with relevant information on the impact and potential of periurban vegetable production, consumption and marketing in all three cities. Vegetable varieties of the following cultivars were evaluated for production under tropical low elevation conditions: tomato (*Lycopersicon esculentum*), eggplant (*Solanum melongena*), sweet pepper (*Capsicum annuum*), hot pepper (*Capsicum frutescens*), head cabbage (*Brassica oleracea* var. *capitata*), cauliflower (*Brassica oleracea* var. *botrytis*) and broccoli (*Brassica oleracea* var. *italica*), yardlong bean (*Vigna sesquipedalis*), vegetable soybean (*Glycine max*), mungbean (*Vigna radiata*), cowpea (*Vigna unguiculata*) and rice bean (*Vigna umbellata*) and papaya (*Carica papaya*). The effect of aromatic plants as intercrops of cauliflower, the influence of different sticking agents to chemical and bio-pesticides and net covering were tested as alternative strategies for lepidopterous pest control in cauliflower. Further, it was demonstrated that the water amount used by drip irrigation of tomatoes and cauliflwoer was only 72 % compared to the quantity used by hand sprinkler irrigation. Additionally, several ten thousands of Pesos for labor costs per hectare can be saved for water management that can compensate for the cost of equipment.

## 2 RATIONALE

In the 21st century, urban policy as a global, national and local task will assume increasing and crucial significance. The trend seems irreversible: the number of people living in cities will more than double from the actual 3 billion to 5.1 billion in by 2025 or 60 % of the world's population. Urbanization is increasingly located in developing countries. Fifty percent of urban residents lived in such countries in 1970, 66 % in 1994 and the figure is forecast to rise to 79 % by 2025 according to estimates of the UN.

The worldwide urbanization trends are clear and imply fundamental and often rapid changes in socioeconomic, cultural and environmental conditions. This is more dramatic in Asia than elsewhere. Overall forecasts are for 1.5 billion new residents in Asian urban areas over the next 30 years, equivalent to a growth of 137,000 persons per day. Given forecasts of continuing high rates of rural-population increase and limited rural job opportunities, there is every likelihood of continuing inward migration. Efforts to slow down or stop inward migration have had limited success.

By 2015, the UN predicts that there will be 358 cities with one million or more inhabitants, no less than 153 will be in Asia, among them Cagayan de Oro City if its annual growth rate will remain at the actual level of 4.5 %. In the year 1960, Cagayan de Oro had a population of less than 100,000 residents with very rapid growth from thereon reaching an estimated 520,000 people

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today. The population density is typical with more than 3,500 persons per km<sup>2</sup> in urban areas and just over 200 citizens in the periurban or fringe areas surrounding the city.

While cities are likely to become more important to Asia's economic growth, such growth is being achieved in many countries at a high social and environmental cost. City administrations are facing huge challenges: to find and create employment, to provide social services and adequate shelter, to dispose an abundance of wastes from private households, commerce and industry by safe means, as well as to ensure food security for their inhabitants. These huge challenges have to be met locally, nationally and globally, but they also provide a vast range of opportunities.

Based on this background, a research project on periurban vegetable production and marketing systems was conducted from October 1997 to August 2000 in three Southeast Asian cities which represent different levels of urbanization: Ho Chi Minh City (Vietnam), Vientiane (Laos) and Cagayan de Oro (Philippines).

The study was jointly carried out by research institutions from the Philippines, Vietnam, Laos, France and Germany funded by the INCO-DC program of the European Union Commission.

### **3 OBJECTIVES**

The general objective of the project for Xavier University College of Agriculture were:

- to supply the local urban population with year-round healthy vegetable;
- to provide work and additional income to the urban populace;
- to facilitate small- and medium sized farm enterprises access to the market by developing; economically viable, environmental benign and socially accepted vegetable production systems.

The project shall thus contribute

- to strengthen the social and economic livelihood of vegetable farmers, garbage pickers and their families;
- to improve the management, structures and functioning of urban and periurban agro-ecosystems;
- to increase and insure the year-round supply of clean and affordable vegetables;
- to improve quantity and quality of raw materials for the local processing industry;
- to avail baseline data to consider periurban horticulture in local, national and international government policy program and in the curriculum of the academe;
- to stimulate SME development in associated areas of urban agriculture such as organic fertilizer production and the recycling industry.

### **4 ACTIVITIES AND RESULTS**

#### **4.1 Workpackage 1: Economic, sociological and anthropological situation of periurban vegetable production, consumption and marketing in Cagayan de Oro, Ho Chi Minh City and Vientiane**

##### Activities

An initial and important part of the research program was to determine the economic, sociological, and anthropological situation of urban and periurban communities and small and medium-sized farm enterprises (SMEs) in Cagayan de Oro, Ho Chi Minh City and Vientiane by socioeconomic surveys. This has been carried out under the scientific leadership of Xavier University College of Agriculture in all three cities in cooperation with project partners Haddokkeo Horticulture Research Center and Institute for Agricultural Sciences of South Vietnam.

##### Results

A database with relevant information on the impact and potential of periurban vegetable production, consumption and marketing in all three cities is available to farmers, the academe, investors, NGOs and government institutions. Specifically:

- A description of the socio-demographic and economic characteristics of the vegetable growers, vendors and consumers in the project cities, including loans and savings, health status and gender relations;

- An assessment of vegetable consumption patterns and quality criteria for vegetables of private households and institutional users as well as waste disposal practices;
- A classification of different vegetable production practices such as pesticide and fertilizer use including integrated pest management and crop rotation, irrigation practices as well as labor inputs;
- A description of vegetable marketing systems including methods of marketing, type of vegetables sold, sources of supply and possible common problems encountered by vendors.

Results from the surveys have been presented in different national and international conferences as well were published in different journals and books (see section publications, posters and papers).

## 4.2 Work package 2: Crop Improvement

### Activities

XUCA successfully conducted a series of variety trials in cooperation with project partner Bukidnon Seed Corporation (BUSECORP) for evaluation of tomato, sweet and hot pepper, eggplant, several legumes and papaya and with different private seed companies for evaluation of head cabbage and cauliflower. Improved cultivars for each crop can be recommended for commercial production.

### Results

#### *Tomato (Lycopersicon esculentum)*

Busecorp cultivar Hybrid #7 proved to be a reliable variety with stable yield performance throughout the year ranging from 22 t/ha up to 40 t/ha. Compared to the standard variety of local farmers #1403, Hybrid #7 showed yield increases of 200 to 400 % in the experiments conducted. Hybrid # 7 has good hot set properties, is resistant to bacterial wilt (*Ralstonia solanacearum*) and tolerant to prevalent leaf diseases. It has also superior quality attributes such as firmness and long shelf life which makes it highly accepted by local traders since it qualifies for shipping to distant domestic fresh fruit markets. Additionally, it has good internal color and a high soluble solids content, which makes it attractive to the processing industry. Due to its superior performance, Hybrid #7 was released to the Philippine market as cultivar 'Puveporo'.

Other good performing entries with similar characteristics as Hybrid #7 were cultivars Epoch (Sakata Seeds), and Hybrid #9 (Busecorp).

#### *Eggplant (Solanum melongena)*

Based on the results of the varietal trials, cultivars Bingo and Casino (East West Seed Co.) can be recommended for planting in farmers' fields in low elevation areas. They are good yielders with yield potential of about 40 t/ha, are medium-sized (between 75 to 80 g/fruit) and have an external color that is well accepted by the consumers. Also the Busecorp breeding lines EBM 3, EBM 5 and EBM 2 show good potential, particularly in terms of yield and their tolerance to pests and diseases. However, their fruit size is relatively small (around 50 g per fruit) and the fruit color (dark purple) is less attractive to consumers compared to Bingo and Casino. These breeding lines should be further improved by incorporating desired horticultural traits.

#### *Sweet pepper (Capsicum annuum)*

Sweet pepper (locally called atsal) is favored by many growers due to its good marketing potential. Survey results show average farm yields for sweet pepper in Cagayan de Oro of only 1.8 t/ha. These low yields are basically attributed to susceptibility to Tobacco Mosaic Virus (TMV) as well as to bacterial wilt. In the varietal trials conducted at XUCA during wet season, Busecorp selection PBM-13 obtained the highest marketable yield of 13.1 t/ha followed by PBM-5 (10.8 t/ha) and PBM-20 (10.3 t/ha). During dry season, SP 705 (East West Seed Co.) had the highest yield of 21.3 t/ha followed by PBM-6 (20.0 t/ha), PBM-7 (20.0 t/ha), PBM-13 (20.0 t/ha), PBM-4 (19.0 t/ha) and PBM-5 (19.0 t/ha). All these entries showed resistance to bacterial wilt.

These trials got major attention of sweet pepper growers since certified seed material of bacterial resistant lines are hardly available in the Philippines. The Busecorp entries, however showed susceptibility to TMV. Major attention in future breeding programs for sweet pepper should focus on this matter.

#### *Hot pepper (Capsicum frutescens)*

Hot pepper is getting increasingly popular in Philippine diet. Different processors of chili for powder and hot sauces are emerging. However, commercial varieties are basically not available for Cagayan de Oro City farmers. Native, small-fruited hot pepper lines are grown in backyards for family consumption.

In the varietal trials, highest marketable yield was obtained by Busecorp selection HPBM-1 with 20.5 t/ha, followed by Otcay with 15.6 t/ha and HPBM-4 with 11.3 t/ha. The lowest yield was obtained by HPBM-3 with 6.0 t/ha only. HPBM-3 obtained the biggest fruit size with 10.6 g/fruit followed by HPBM 2 with 10.5 g/fruit. The smallest fruit size was recorded by TN 16 with 1.8 g/fruit. These varieties were also processed by XUCA Food Technology Center (FTC) into powder and successfully tested in the market. As an outcome of the project, different bacterial wilt resistant lines are now available for interested growers. However, susceptibility to TMV is still present. Further improvement of these lines is therefore recommended.

#### *Head cabbage (Brassica oleracea var. capitata)*

Based on own survey data, head cabbage is only grown by 1 % of vegetable farmers in Cagayan de Oro indicating production constraints such as high pest pressure as well as lack of varieties, which can form head under the tropical low elevation conditions. In the varietal trials conducted at XUCA, cultivar Southern Treasure (Takii Seed) performed best among all entries in both wet and dry season trials with 23.8 and 7.3 t/ha respectively, with a head forming rate of more than 90%. Marketable head size was 792 g and 257 g during dry season. The low head weight was caused by heavy insect damage during dry season when pest pressure was much higher than during rainy season. Most of the affected outer leaves of the head had to be removed. At an estimated production cost of 60,000 PhP/ha and an average farm gate price of 5 PhP/kg, the break-even yield computes at about 12 t/ha for commercial production.

#### *Cauliflower (Brassica oleracea var. botrytis) and Broccoli (Brassica oleracea var. italica)*

Cauliflower and Broccoli are demanding a high price in the fresh market of up to 80 PhP/kg (farm gate) and are thus attractive crops for vegetable growers. However, heat tolerant varieties were not available/known to Cagayan de Oro city farmers.

Cultivar White Shot (Sakata Seeds) obtained the highest marketable yield in both wet and dry season trials with 12.9 t/ha and 5.1 /ha respectively. It also had the highest percentage of curd forming rate compared to all other entries. White Shot was also used as standard varieties in the fertilization, pest control and water management trials.

As regards Broccoli performed very well under the low elevation conditions of Manresa Farm with an average marketable curd weight of 270 g and a marketable yield potential of about 11.3 t/ha.

At an estimated production cost of 60,000 PhP/kg for both crops and a minimum farm gate price of 15 PhP/kg, the break even yield computes at 4 t/ha for commercial production.

#### *Yardlong bean (Vigna sesquipedalis)*

Cultivars Sandigan and 6001 XL (East West Seed Co.) recorded the highest marketable yield which was significantly different from the other entries with 19.6 and 19.2 t/ha during dry season and 9.5 and 8.3 t/ha during rainy season. These yields are substantially higher compared to the average yield of 5.5 t/ha obtained by Cagayan de Oro as own survey data show. One constraint of these two varieties are their susceptibility to viruses. It was observed, however, that entries from BUSECORP were not affected by viruses. Those lines should be used for further crop improvement by incorporating this trait into higher yielding cultivars.

#### *Vegetable soybean (Glycine max)*

The highest marketable pod yield was recorded by AGS 190 with 4.1 t/ha followed by HDK 510 with 1.3 t/ha and AGS 356 with only 0.9 ton per hectare. Cultivars HDK 510 and AGS 356 were severely affected by virus with subsequent losses in yield. Since AGS 190 did not show virus symptoms, resistance/tolerance to the virus strain is assumed. Though vegetable soybean is not known yet to many Philippine consumers as a palatable vegetable, its potential for a well-established market was recognized by almost everybody who was able to taste it.

#### *Mungbean (Vigna radiata), cowpea (Vigna unguiculata) and Tahore bean/rice bean (Vigna umbellata)*

Cowpea cultivar IPB variety obtained the highest marketable yield of 3.8 tons per hectare compared to variety BUSECORP with 2.1 tons per hectare. Rice bean was identified as a possible substitute for mungbean. It obtained higher yields and pods did not shatter. Problems of cowpea, mungbean and Tahore bean was infestation with different viruses. Tahore bean seemed to be more tolerant to viruses than the to other legumes.

#### *Papaya (Carica papaya)*

Two set of production trials were carried out with three lines of papaya, one small fresh fruit type (Solo 317) as well as two canning types (Cavite, Cavite x PPC), all from BUSECORP

Yields for solo papaya ranged from 50 to 60 t/ha with an average fruit weight of 600 g, while Cavite yielded between 61 to 77 t/ha and Cavite x PPC 81 to 99 t/ha. It took about 7 months from transplanting to 1st harvest, harvesting period was between 358 to 412 days. At a farm gate price of 6 PhP/kg for the canning types and 8 PhP for the solo types, Papaya is an attractive crop for farmers due to the demand from the domestic markets. Due to its low maintenance costs, Papaya was also identified as an ideal crop for school gardens. Seeds were distributed to different schools in Cagayan de Oro City in cooperation with the Department of Education, Culture and Sports (DECS).

### **4.3 Workpackage 3: Soil management and plant nutrition**

#### Activities

In cooperation with the city government of Cagayan de Oro, composting of fruit and vegetable leftovers from the whole sale market were conducted. Based on the research work done by the project, a memorandum of agreement was drafted on a feasibility study on the recovery of municipal waste into organic fertilizer and application for urban agriculture between the Cagayan de Oro city government, a private SME compost company (Agricycle Inc.), a garbage picker association (Mother Ignacia Landfill Organization) and Xavier University College of Agriculture. The objective is household garbage segregation thus providing clean raw materials for composting purposes as well as for recycling through garbage pickers. The organic fertilizer will be part of a technology package for vegetable production which will be developed together with the City Agriculture Office based on the research results of the different workpackages.

Experiments on inorganic and organic fertilization of tomato and cauliflower were conducted by a Ph.D. student of German project partner TUM at the research area of XUCA. The potential use of compost as a standardized, improved seedling media was investigated by a M.Sc. student of TUM.

#### Results

not yet available at time of reporting

### **4.4 Workpackage 4: Integrated Pest & Disease Management**

#### Activities

The following IPM experiments were conducted:

- Effect of aromatic plants as intercrops of cauliflower for the control of lepidopterous pests
- Influence of different sticking agents to chemical and bio-pesticides for the control of lepidopterous pests.
- Net covering as an alternative strategy for lepidopterous pest control in cauliflower.

A German M.Sc. student finished her masteral thesis on IPM strategies for pak choy (*Brassica chinensis* var. *napus*) at XUCA.

#### Results

##### *Effect of aromatic plants as intercrops of cauliflower for the control of lepidopterous pests*

Reduction of lepidopterous pest population of cauliflower by aromatic intercrops such as peppermint and lemon basil was not significant. Through increased plant density and subsequent competition for nutrients and light the curd size of intercropped cauliflower was reduced.

*Influence of different sticking agents to chemical and bio-pesticides for the control of lepidopterous pests.*

The adding of sticker to commercial neem extract and BT (*Bacillus thuringiensis*) products increased significantly their effectivity in controlling lepidopterous pests of cauliflower. In this case, control of lepidopterous pests was more effective compared to synthetic pyrethroids. However, for the control of aphids only the synthetic pyrethroids were effective compared to BT and neem extract.

A disadvantage of commercial neem extract and BT are their higher cost compared to synthetic chemicals. Constraints for homemade neem extracts standardization for the active ingredient as well as the supply of the raw materials.

*Net covering as an alternative strategy for lepidopterous pest control in cauliflower.*

Cauliflower sprayed with synthetic pyrethroids (without net) obtained highest possible marketable yield (16 t/ha), followed by treatments with net (no chemicals, with egg parasitoid *Trichogramma chilonis*) yield of 15 t/ha. However, infestation of cauliflower inside the net may also occur. This may happen through already infested seedlings, through damages in the net or if the net is not properly installed. Egg deposits of Diamondback Moth on top of the net with subsequent hatching of larvae through the holes was also observed. If no parasitoids are present in the net and no chemical control is done, netting can develop into a perfect rearing station for diamond back moth.

Under low elevation conditions, *T. chilonis* is recommended as egg parasite and *Cotesia plutellae* as larvae parasite. *Diadegma semiclausum* as larvae parasite will not survive under the hot temperatures and is only suited for altitudes of 500 m and above.

A major constraint for farmers in Cagayan de Oro is the access to these parasitoids, which are basically not available to them.

#### **4.5 Workpackage 5: Water Management**

##### Activities

Water management trials for eggplant, tomato and cauliflower were conducted. This included use of high bed systems for better drainage during rainy season, drip irrigation, fertigation, aeration and application of living and plastic mulches.

##### Results

Sub-surface drip irrigation with aeration and dry application of fertilizers produced the highest yield for tomatoes with 24.2 t/ha, while the treatment rainfed with hand sprinkler irrigation, dry application of fertilizers resulted in the lowest yield with 19.5 t/ha. However, yield differences between all irrigation treatments were no significantly different from each other at the 5 % level at DMRT. As regards mulching systems, treatments with no mulch produced the highest mean yield with 23.0 t/ha, followed by treatments with rice hull mulch (22.5 t/ha) and those with wild peanut mulch (22.1 t/ha).

In cauliflower, treatment using fertigation as the method of nutrient application (fertilizer was applied continuously during the growing period through the drip irrigation system) yielded higher (9.7 - 10.1 t/ha) than in treatments where the total fertilizer amount was given in two side-dressings (6.6 to 7.9 t/ha)

As regards mulching, highest average yields were obtained in treatments with rice hull mulch (9.2 t/ha), followed by treatments without mulch (8.5 t/ha). Lowest yield was recorded in the treatments with wild peanut mulch (8.0 t/ha) most probably caused by competition of the living mulch with the crop for nutrients.

In terms of water efficiency, the water amount used for drip irrigation was only 72 % compared to the quantity used in the hand sprinkler irrigation. Additionally, several ten thousands of Pesos for labor costs per hectare can be saved for water management that can compensate for the cost of equipment.

It has however to be stated that the drip irrigation is only viable were it could replace less efficient water management systems. A decision has to be made on a case to case basis. Considering

the changing weather pattern in Cagayan de Oro and other parts of the Philippines which make predictions on the occurrence of dry and rainy season less predictable, as manifested by the El Niño and La Niña phenomenon, drip irrigation can serve as kind of an insurance for the farmer. It will make him less dependent on the natural environment and empowers him in a sense that he will be able to decide when to irrigate his crop.

This view is also shared by the city government of Cagayan de Oro who will provide funding for drip irrigation material for 5 ha of demo farms within the city boundaries.

#### **4.6 Workpackage 6: Marketing**

##### *Activities*

A study on purchasing patterns of institutional users of fresh vegetables in Cagayan de Oro City was conducted. One hundred institutional users of fresh vegetables were surveyed to determine their purchasing patterns. Eleven hospitals, twenty schools, fourteen canteens, five government and private institutions each, twenty-five restaurants and twenty hotels were included in the survey.

##### *Results*

Seventy percent of the institutions bought vegetables on a daily basis. These were mostly (67%) bought from Cogon market while another fifteen percent (bought from Carmen market bringing to eighty two percent (82%) the number of institutions sourcing their vegetable requirements mainly from the two wet markets in the city. Only thirteen percent of the institutions buy from supermarkets and this is only some of the time.

On the average, institutions spend 9.5% of their food budget on vegetables. The 100 institutions surveyed buys around PhP 444,000 worth of vegetables monthly. This accounts for 39% of the total expenditures on fruits and vegetables outside the home in Cagayan de Oro City.

Most purchases are paid in cash. It is the hotels, restaurants, and private hospitals which availed of 15 days term credit. All the public hospitals, private and public schools, government and private shelter institutions pay in cash. The five vegetables bought in largest quantities weekly are, squash (6.3 kg), cabbage (6.1 kg) potatoes (5.8 kg) carrots (4.4 kg), and papaya (3.8 kg). Hotels buy more temperate type vegetables than tropical types at a ratio of 1.21. Non hotel-based restaurants on average buy equal amounts of temperate and tropical foods. Government and private shelter institutions buy less temperate than tropical type vegetables at a ratio of 0.28 and 0.13, respectively.

On the average, the respondents find prices which are 2.3 times the minimum price to be prohibitive when buying the cheaper kinds of vegetables (tropical types). For the expensive type of vegetables like asparagus, broccoli, and garlic, prices higher by 1.75 times are already considered prohibitive. For the cheap vegetable varieties like marsh cabbage, malabar spinach (alugbati) and lady's finger (okra), prohibitive prices are when these are 3.25 times higher than the minimum price.

Big sizes are preferred for bitter gourd (ampalaya), eggplant, bulb onion and squash. Medium sized broccoli, bell pepper, cabbage, cauliflower, and cucumber are preferred. Medium and large sized carrots are demanded equally by the institutions. Measurements corresponding to big and small sized overlap for many consumers of fresh vegetables. The range of measurements for what passes as medium overlaps the range of measurements for what passes as big or large. However, there are modes of exact measurements corresponding to what is regarded as medium or large size.

## **5 EQUIPMENT/INFRASTRUCTURE REQUIREMENTS**

### **5.1 Equipment source**

Locally available (in-country)

### **5.2 This technology is recommend for the following size of enterprise:**

small and medium scale

## 6 MINIMUM REQUIREMENTS FOR ADAPTABILITY

### 6.1 Soil

6.1.1 Results of soil analysis at XUCA research area in Manresa Farm:

Chemical soil properties:

	pH	OM <sup>1</sup> (%)	Total N <sup>2</sup> (ppm)	Available P <sup>3</sup> (ppm)	Exchangeable K <sup>4</sup> (ppm)	CEC <sup>5</sup> (meq/100g of DM)
Top Soil (10-20 cm)	6.1	1.82	1000	19	244	16.1

<sup>1</sup>Graham Colorimetric Method; <sup>2</sup>Modified Kjeldahl Method; <sup>3</sup>Olson Method; <sup>4</sup>Cold H<sub>2</sub>SO<sub>4</sub>-Flamephotometer; <sup>5</sup>Ammonium Acetate Method

Physical soil properties:

	Sand %	Silt %	Clay %	Texture
Top Soil (10-20 cm)	36.8	26.0	37.2	Clay Loam
Sub Soil (20-25 cm)	24.8	22.0	53.2	Clay

### 6.2 Climate

Coranas classification: Type 3

6.2.1 Actual Monthly Rainfall Amounts (mm) of Cagayan de Oro (Period 1991 to 2000)

Month	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Ave. by month
January	67	3	33	38	87	72	137	16	185	68	71
February	13	2	157	77	35	137	32	3	257	126	84
March	79	7	31	72	48	20	98	2	110	97	56
April	71	0	24	133	15	189	0	0	118	154	70
May	68	70	32	114	32	103	135	50	188		88
June	172	219	75	448	258	126	185	121	94		189
July	359	266	244	181	253	146	285	190	362		254
August	124	166	201	264	167	122	100	272	153		174
September	113	178	401	175	273	163	307	167	128		212
October	207	207	259	113	168	144	235	104	175		179
November	132	15	119	20	55	187	52	328	195		123
December	11	72	256	87	288	21	48	75	289		127
<b>Average by year</b>	<b>1416</b>	<b>1203</b>	<b>1831</b>	<b>1720</b>	<b>1677</b>	<b>1429</b>	<b>1614</b>	<b>1328</b>	<b>2255</b>		<b>1626</b>

Data station: Lumbia Airport

Data source: Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA)



6.2.2 Actual Monthly Minimum Temperatures (°C) of Cagayan de Oro (Period 1991 to 2000)

Month	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Ave. by month
January	20.9	20.5	20.7	21.0	22.2	22.9	21.1	22.6	23.3	21.3	21.7
February	20.9	20.0	21.1	20.8	22.6	22.3	21.4	21.2	22.7	22.1	21.5
March	21.3	20.9	20.7	22.1	22.9	22.9	20.6	21.6	23.1	22.0	21.8
April	22.1	23.3	22.1	22.6	23.1	23.8	21.8	23.2	23.5	22.3	22.8
May	22.8	24.1	23.3	22.9	24.6	23.7	23.1	25.1	23.6		23.7
June	22.8	22.4	23.2	22.6	24.4	24.0	22.9	23.9	22.5		23.2
July	22.2	22.0	22.7	22.6	23.7	24.0	22.7	23.0	21.9		22.8
August	23.0	22.9	22.0	22.4	23.8	23.5	22.7	22.7	22.2		22.8
September	22.4	22.0	22.1	22.8	23.8	23.9	22.4	22.8	22.1		22.7
October	21.8	22.4	22.0	22.3	24.6	23.0	22.1	22.9	22.3		22.6
November	21.4	21.1	22.3	22.0	23.9	22.7	21.8	22.4	22.1		22.2
December	21.1	20.4	22.4	22.0	23.4	22.7	21.8	22.2	22.6		22.1
<b>Average by year</b>	<b>21.9</b>	<b>21.8</b>	<b>22.1</b>	<b>22.2</b>	<b>23.6</b>	<b>23.3</b>	<b>22.0</b>	<b>22.8</b>	<b>22.7</b>	<b>21.9</b>	<b>22.5</b>

Data station: Lumbia Airport

Data source: Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA)

6.2.3 Actual Monthly Maximum Temperatures (°C) of Cagayan de Oro (Period 1991 to 2000)

Month	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Ave. by month
January	29.3	30.9	30.5	29.5	31.7	30.1	29.3	32.8	31.4	29.8	30.5
February	30.6	31.8	28.9	29.3	32.1	30.1	30.0	32.8	31.8	29.6	30.7
March	30.9	32.9	30.2	29.9	32.7	32.8	30.4	33.4	32.8	30.6	31.7
April	32.0	33.5	31.3	30.6	34.1	33.4	33.0	34.3	32.7	31.8	32.7
May	32.5	34.2	32.3	31.7	34.8	34.1	33.9	35.8	33.6		33.7
June	32.7	32.4	32.6	30.6	34.2	33.6	33.2	33.0	31.1		32.6
July	31.2	31.5	31.4	31.5	33.1	33.3	32.5	32.1	31.5		32.0
August	33.3	32.0	31.0	31.2	33.4	33.5	34.0	32.3	31.3		32.4
September	32.5	32.9	30.9	30.8	31.7	33.4	32.4	32.0	31.7		32.0
October	31.2	31.0	31.2	31.0	33.1	33.1	32.0	31.9	31.3		31.8
November	31.1	30.9	30.7	30.6	33.4	32.0	32.0	30.9	30.3		31.3
December	30.7	30.4	29.8	30.0	31.8	32.1	30.8	31.0	30.0		30.7
<b>Average by year</b>	<b>31.5</b>	<b>32.0</b>	<b>30.9</b>	<b>30.6</b>	<b>33.0</b>	<b>32.6</b>	<b>32.0</b>	<b>32.7</b>	<b>31.6</b>		<b>31.8</b>

Data station: Lumbia Airport

Data source: Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA)

**6.3 Topography**

Level to nearly level (Slope 0-3 %)

**6.4 Ecological/Development Zones**

Lowland rainfed/irrigated

## **7 SUPPORT SYSTEM REQUIREMENTS**

Support systems needed:

- Involvement of LGU in garbage segregation for organic fertilizer production,
- Increase accessibility and availability of predators/parasitoids for farmers,
- Improved marketing strategies and assistance.

## **8 ENVIRONMENTAL IMPACT OF THE TECHNOLOGY**

- improved the management, structures and functioning of urban agro-ecosystems by reduced soil erosion, maintenance of soil fertility, limited pollution of soil and water and increased water use efficiency. In combination with the availability of appropriate plant material this will result in a better and more sustainable utilization of urban and periurban agricultural production resources.
- Improved city environment through promoting household garbage segregation in urban areas of developing countries.

## **9 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY**

### **9.1 Advantages**

It is highly adaptable urban and periurban vegetable farmers nationwide due to the closeness of the market for their produce.

### **9.2 Limitations**

Due to different environmental conditions in other areas, recommended cultivars may perform differently. Also other pests and diseases may prevail in these areas.

## **10 DYSFUNCTIONAL CONSEQUENCE OF THE TECHNOLOGY**

Use of not properly composted organic materials may have negative impacts on crops (phyto-toxicity) or on consumers (pathogens might not be destroyed if composting is not done properly).

## **11 SOURCE OF TECHNOLOGY**

### **11.1 Title of research**

The Periurban Vegetable Project of Xavier University College of Agriculture

### **11.2 Duration**

October 1, 1997 to July 31, 2000.

### **11.3 Agency Address**

Xavier University College of Agriculture  
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### **11.4 Researcher(s)**

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### 11.5 Location

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### 11.6 Cooperating Agencies

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### 11.7 Funding Agency

EUROPEAN COMMISSION  
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Science, Research & Development  
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BELGIUM

Project No. IC18CT97-0184

## 12 HISTORICAL BACKGROUND

### 12.1 Publications, posters and papers of the Periurban Vegetable Project of Xavier University as of August 10, 2000:

#### List of publications

1. GERALD E. POTUTAN, SCHNITZLER, W.H., ARNADO, J.M., JANUBAS, L.G., HOLMER, R.J., 2000. Urban agriculture in Cagayan de Oro: a favourable response of city government and NGOs. In: Bakker, M., Dubbeling, M., Sabel-Koschella, U., Zeeuw, H. (eds). Growing Cities Growing Food; Urban Agriculture on the Policy Agenda. DSE, Feldafing, Germany. ISBN 3-934068-25-10.
2. WILFRIED H. SCHNITZLER & ROBERT J. HOLMER, 1999. Strategies for urban horticulture in developing countries. *Acta Horticulturae* No. 495:331-335.
3. WILFRIED H. SCHNITZLER & ROBERT J. HOLMER, 1999. Project summary of "Urban and Peri-Urban Small and Medium-Sized Enterprise Development for Sustainable Vegetable Production and Marketing Systems (PUVeP)" Project. *Chronica Horticulturae* 39 (3):8-9.
4. WILFRIED H. SCHNITZLER, KHAM SANATEM, POTUTAN, G. E., JANUBAS, L. G., HOLMER, R. J. 1999. City harvests in Vientiane City. *Gate – Technology and Development*. 2:23.
5. WILFRIED H. SCHNITZLER, PHAM VAN BIEN, NGO QUONG VINH, POTUTAN, G. E., JANUBAS, L. G., HOLMER, R. J. 1999. Urban agriculture in Ho Chi Minh City, Vietnam. *Gate – Technology and Development*. 2:26.
6. WILFRIED H. SCHNITZLER, POTUTAN, G. E., ARNADO, J. M., JANUBAS, L. G., HOLMER, R. J. 1999. Urban agriculture in Cagayan de Oro, Philippines. *Gate – Technology and Development*. 2:46-47.
7. WILFRIED H. SCHNITZLER & ROBERT J. HOLMER, 1999. Perspectives of urban and periurban horticulture. *Mediterranean Perspectives and Proposals. Journal of Economics, Agriculture and Environment* 1:34-36.
8. WILFRIED H. SCHNITZLER, HOLMER R. J., HEINRICH V. B., 1998. Urban agriculture – an essential element in feeding the world's cities. *Development & Cooperation (D+C)* 5:26-27.
9. JANET M. ARNADO, HOLMER, R. J., SCHNITZLER, W. H., 1998. Sozio-ökonomische Untersuchungen zu Produktion, Verbrauch und Vermarktung von Gemüse aus periurbanem Anbau in den Philippinen. *Mitteilung der Gesellschaft für Pflanzenbauwissenschaften*. 42. Jahrestagung vom 10. - 12. September 1998 in Freising-Weihenstephan, Band 11: 149-150.
10. WILFRIED H. SCHNITZLER & ROBERT J. HOLMER, 1997. Preliminary results of a European Union financed project on urban vegetable production in South-East Asia. *Kasetsart J. (Nat. Sci.)* 32 (5):21-26 (ISSN 0075-5192).
11. ROBERT J. HOLMER, GABUTIN, L.B., SCHNITZLER, W.H., 1997. Organic fertilizer production from city waste: A model approach in a Southeast Asian urban environment. In: KURDI/AVRDC. *Kasetsart J. (Nat. Sci.)* 32 (5):50-53 (ISSN 0075-5192).
12. JUAN C. ACOSTA, DOMINGO G.C., HOLMER R.J., SCHNITZLER, W.H., 1997. Genetic resources for urban tomato cultivation in the tropics. *Kasetsart J. (Nat. Sci.)* 32 (5):54-55 (ISSN 0075-5192).
13. ROBERT J. HOLMER & WILFRIED H. SCHNITZLER, 1997. Drip irrigation for small-scale tomato production in the tropics. *Kasetsart J. (Nat. Sci.)* 32 (5):56-60 (ISSN 0075-5192).
14. GERALD E. POTUTAN, JANUBAS L. G., ARNADO J. M., HOLMER, R. J., SCHNITZLER, W. H. 2000. Periurban vegetable production, consumption and marketing in Cagayan de Oro, Philippines. *Kasetsart J. (Nat. Sci.)* 32 (5):61-66 (ISSN 0075-5192).
15. ROBERT J. HOLMER & WILFRIED H. SCHNITZLER, 1997. Urban and periurban small and medium-sized enterprise development for sustainable vegetable production and marketing systems. 11./12. Dezember 1997. *Tagungsband Tropentag Universität Hohenheim, - Technischer Fortschritt im Spannungsfeld von Ernährungssicherung un Ressourcenschutz*. p. 343-346.

Accepted for publication (in print):

16. ROBERT J. HOLMER, POTUTAN, G. E., SCHNITZLER, W. H., xxxx. Urban horticulture in the Philippines: Its impact on food security, health, gender and urban environment. Proceedings of the FAO Sub-Regional Workshop on Constraints and Opportunities for the Development of Urban and Peri-Urban Horticulture in South-East Asia, October 16-19, 1999, Kunming, Yunnan, China. Accepted for publication.
17. ROBERT J. HOLMER, MERCADO, A.B., SCHNITZLER, W.H., xxxx. Urban food security and its link to solid waste management, 2000. Annual report of the League of Municipalities of the Philippines (LMP). Accepted for publication.
18. WILFRIED H. SCHNITZLER, ROBERT J. HOLMER, xxxx. Prospective issues and challenges of urban fringe agriculture. Proceedings of the APO Seminar on Urban Fringe Agriculture, May 17-24, 2000, Asian Productivity Organization, Tokyo, Japan. Accepted for publication.
19. TRÜGGELMANN, L., HOLMER, R.J., SCHNITZLER, W.H., xxxx. The use of municipal waste composts in urban and peri-urban vegetable production systems – potentials & constraints. ATSAF Tagungsband, Deutscher Tropentag Berlin, October 13-15, 1999. Accepted for publication.

List of Posters

1. LYNN G. JANUBAS, HOLMER, R.J. SCHNITZLER, W.H., 2000. Alternative strategies for lepidopterous pest control in tropical cauliflower production. Poster presented at the 12th NOMCARRD Regional Symposium on R&D Highlights, Cagayan de Oro City, August 10-11, 2000. Poster presented at the 12th NOMCARRD Regional Symposium on R&D Highlights, Cagayan de Oro City, Philippines, August 10-11, 2000.
2. OSCAR A. CAMANNONG, HOLMER, R.J., ACOSTA, J.C., SCHNITZLER, W.H., 2000. Evaluation of different tomato (*Lycopersicon esculentum*) cultivars under tropical low elevation conditions. Poster presented at the 12th NOMCARRD Regional Symposium on R&D Highlights, Cagayan de Oro City, Philippines, August 10-11, 2000.
3. LYNN G. JANUBAS, HOLMER, R.J., SCHNITZLER, W.H., 2000. Net covering as an alternative strategy for lepidopterous pest control in cauliflower production under tropical lowland conditions. Proceedings of the 31st Anniversary and Annual Scientific Convention of the Pest Management Council of the Philippines. May 3-6, 2000. Baguio City, Philippines.
4. GERALD E. POTUTAN, HOLMER, R. J., SCHNITZLER, W. H., 1999. Cagayan de Oro, Philippines – growing cities growing food. Poster presented at the GTZ/DSE International Conference on Growing Cities Growing Food – Urban Agriculture on the Policy Agenda. October 11-15, 1999, Havana, Cuba.
5. ROBERT J. HOLMER, GABUTIN, L. B., SCHNITZLER, W.H. 1999. Organic fertilizer production from city waste: A model approach in a Southeast Asian urban environment. Poster presented at the 11th NOMCARRD (Northern Mindanao Consortium for Agriculture and Resources Research & Development) Regional Symposium on R&D Highlights, Claveria, Misamis Oriental, July 28-29, 1999 (1st best technical poster award).
6. ROBERT J. HOLMER & WILFRIED H. SCHNITZLER, 1999. Drip irrigation for small-scale tomato production in the tropics. Poster presented at the 11th NOMCARRD Regional Symposium on R&D Highlights, Claveria, Misamis Oriental, July 28-29, 1999.
7. LYNN G. JANUBAS, HOLMER, R. J., SCHNITZLER, W.H., 1999. Effect of intercropping lemon basil (*Ocimum basilicum*) and peppermint (*Mentha piperata*) on the marketable yield of cauliflower (*Brassica oleracea* var. *botrytis*), cultivar 'White Shot' ('S-40'). Poster presented at the 11th NOMCARRD Symposium on R&D Highlights, Claveria, Misamis Oriental, July 28-29, 1999.
8. ROBERT J. HOLMER, GABUTIN, L. B., SCHNITZLER, W.H. 1998. Organic fertilizer production from city waste: A model approach in a Southeast Asian urban environment. In: KURDI/AVRDC. Paper presented at the AVRDC/KURDI International Conference on Periurban Vegetable Production in the Asia-Pacific Region for the 21st Century, Bangkok, September 28 to October 1, 1998. Kasetsart University Research and Development Institute (KURDI) Bangkok, Thailand.

9. JUAN C. ACOSTA, DOMINGO G. C., HOLMER R. J., SCHNITZLER, W. H. 1998. Genetic resources for urban tomato cultivation in the tropics. Poster presented at the 11th NOMCARRD (Northern Mindanao Consortium for Agriculture and Resources Research & Development) Regional Symposium on R&D Highlights, Claveria, Misamis Oriental, July 28-29, 1999 (3rd best technical poster award).
10. JUAN C. ACOSTA, DOMINGO G. C., HOLMER R. J., SCHNITZLER, W. H. 1998. Genetic resources for urban tomato cultivation in the tropics. Poster presented at the AVRDC/KURDI International Conference on Periurban Vegetable Production in the Asia-Pacific Region for the 21st Century, Bangkok, September 28 to October 1, 1998. Kasetsart University Research and Development Institute (KURDI) Bangkok, Thailand.
11. JUAN C. ACOSTA, DOMINGO G. C., HOLMER R. J., SCHNITZLER, W. H. 1998. Genetic resources for urban tomato cultivation in the tropics. Poster presented at the 42. Jahrestagung der Gesellschaft für Pflanzenbauwissenschaften, September 10-12, 1998, Freising-Weihenstephan, Germany.
12. ROBERT J. HOLMER, HEINRICH, V. B., SCHNITZLER, W. H., 1998. Urban and periurban small and medium-sized enterprise development for sustainable vegetable production and marketing systems. Poster presented at the 35. Hochschultagung der Fakultät für Landwirtschaft und Gartenbau, Technische Universität München- Weihenstephan, Germany, February 13, 1998.
13. ROBERT J. HOLMER, HEINRICH, V. B., SCHNITZLER, W. H., 1997. Urban and periurban small and medium-sized enterprise development for sustainable vegetable production and marketing systems. Poster presented at the Tropentag 1997 - Technischer Fortschritt im Spannungsfeld von Ernährungssicherung und Ressourcenschutz, 11./12. Dezember 1997 Stuttgart-Hohenheim.

#### List of presentations

14. ROBERT J. HOLMER, MERCADO, A.B., SCHNITZLER, W.H., 2000. Urban food security and its link to solid waste management. Paper presented at the Luzon Major Island Conference, League of Municipalities of the Philippines (LMP), Clarkfield, Pampanga, Philippines, August 18-19, 2000.
15. ROBERT J. HOLMER & OSCAR A. CAMANNONG, 2000. Review on climate factors affecting vegetable production in Cagayan de Oro. Paper presented at the 12th NOMCARRD Regional Symposium on R&D Highlights, August 10-11, 2000.
16. AMELIA LUZ P. AGBAYANI, HOLMER, R.J., SCHNITZLER, W.H., 2000. Purchasing patterns and requirements of institutional users of fresh vegetables in Cagayan de Oro. Paper presented at the 12th NOMCARRD Regional Symposium on R&D Highlights, August 10-11, 2000.
17. ROBERT J. HOLMER, MERCADO, A.B., SCHNITZLER, W.H., 2000. Urban food security and its link to solid waste management. Paper presented at the Mindanao Major Island Conference, League of Municipalities of the Philippines (LMP), Davao City, Philippines, July 13-14, 2000.
18. WILFRIED H. SCHNITZLER & ROBERT J. HOLMER, 2000. Prospective issues and challenges of urban fringe agriculture. Paper presented at the APO Seminar on Urban Fringe Agriculture, May 17-24, 2000, Asian Productivity Organization, Tokyo, Japan.
19. ROBERT J. HOLMER, 1999. Potential and constraints for micro-enterprise development in urban horticulture. Paper presented at the Xavier University Ateneo de Cagayan Alumni Association Grand Y2K Homecoming, Lecture on Agribusiness, Cagayan de Oro, Philippines, December 11, 1999.
20. ROBERT J. HOLMER, POTUTAN, G. E., SCHNITZLER, W. H., 1999. Urban horticulture in the Philippines: Its impact on food security, health, gender and urban environment. Paper presented at the FAO Sub-Regional Workshop on Constraints and Opportunities for the Development of Urban and Peri-Urban Horticulture in South-East Asia, October 16-19, 1999, Kunming, Yunnan, China.
21. LOTHAR TRÜGGELMANN, HOLMER, R.J., SCHNITZLER, W.H., 1999. The use of municipal waste composts in urban and peri-urban vegetable production systems – potentials & constraints. Paper presented at the ATSAF Deutscher Tropentag Berlin, October 13-15, 1999.

22. GERALD E. POTUTAN, HOLMER, R. J., SCHNITZLER, W. H. 1999. City harvests: The case of Cagayan de Oro, Philippines. Paper presented at the GTZ/DSE International Conference on Growing Cities Growing Food – Urban Agriculture on the Policy Agenda. October 11-15, 1999, Havana, Cuba.
23. GERALD E. POTUTAN, HOLMER, R.J., SCHNITZLER, W.H., 1999. The present status of periurban vegetable production, consumption and marketing in Cagayan de Oro. Paper presented at the 11th NOMCARRD Regional Symposium on R&D Highlights, Claveria, Misamis Oriental, July 28-29, 1999 (2<sup>nd</sup> best paper presentation award).
24. ROBERT J. HOLMER, 1998. Food security for Asian cities in the 21st century: The role of urban horticulture. Paper presented at the Colloquium Series on Food Security, Xavier University College of Agriculture, Cagayan de Oro, Philippines, October 14, 1998.
25. ROBERT J. HOLMER & WILFRIED H. SCHNITZLER, 1998. Drip irrigation for small-scale tomato production in the tropics. Paper presented at the AVRDC/KURDI International Conference on Periurban Vegetable Production in the Asia-Pacific Region for the 21st Century, Bangkok, September 28 to October 1, 1998. Kasetsart University Research and Development Institute (KURDI) Bangkok, Thailand.
26. GERALD E. POTUTAN, JANUBAS L. G., ARNADO J. M., HOLMER, R. J., SCHNITZLER, W. H. 1998. Periurban vegetable production, consumption and marketing in Cagayan de Oro, Philippines. In: KURDI/AVRDC. Paper presented at the AVRDC/KURDI International Conference on Periurban Vegetable Production in the Asia-Pacific Region for the 21st Century, Bangkok, September 28 to October 1, 1998. Kasetsart University Research and Development Institute (KURDI) Bangkok, Thailand.
27. WILFRIED H. SCHNITZLER & ROBERT J. HOLMER, 1998. Preliminary results of a European Union-financed project on urban vegetable production in South-East Asia. Paper presented at the AVRDC/KURDI International Conference on Periurban Vegetable Production in the Asia-Pacific Region for the 21st Century, Bangkok, September 28 to October 1, 1998. Kasetsart University Research and Development Institute (KURDI) Bangkok, Thailand.
28. GERALD E. POTUTAN, 1998. The present status of vegetable production consumption and marketing in Cagayan de Oro City. Paper presented at the Colloquium Series on Food Security, Xavier University College of Agriculture, Cagayan de Oro, Philippines, September 16, 1998.
29. JANET M. ARNADO, HOLMER, R. J., SCHNITZLER, W. H., 1998. Sozio-ökonomische Untersuchungen zu Produktion, Verbrauch und Vermarktung von Gemüse aus periurbanem Anbau in den Philippinen. Paper presented at the 42. Jahrestagung der Gesellschaft für Pflanzenbauwissenschaften, Freising-Weihenstephan, Germany, September 10-12, 1998.
30. ROBERT J. HOLMER, 1998. The periurban vegetable production project of the European Union Commission. Paper presented at the Science and Technology Symposium, Department of Education, Culture & Sports, Division of City Schools, Macabalan Elementary School, Cagayan de Oro City, July, 17, 1998.
31. WILFRIED H. SCHNITZLER & ROBERT J. HOLMER, 1998. Strategies for urban horticulture in developing countries. Paper presented at the World Conference on Horticultural Research (SIHS + ASHS), Rome, Italy, June 17 to 20, 1998.

### **13 RECOMMENDATIONS FOR FUTURE ACTION ON THIS TECHNOLOGY**

Much has still to be considered to make urban and periurban vegetable production a successful economical, ecological and social tool for cities in developed and developing countries. These are:

- Involvement of LGUs, NGOs and POs in organic city waste segregation and recycling;
- Further research efforts in integrated pest and disease management with the possibility of netting for protection; introduction of local predators; intercropping technologies and organic or synthetic soil mulch for weed control.

- Simple but efficient and economic irrigation for higher water productivity and to avoid pollution such as the bucket system with drip irrigation laterals by gravity or mechanized sprinkler irrigation and for advanced technology even drip irrigation and fertigation.
- Community/allotment gardening should be seriously considered by city administrators through allocation and subdividing suitable areas within the city limits to promote urban greening, improving social structures and be part of ready available food supply.
- The same is true for school gardening which can become an efficient way of educating early-on pupils in elementary school to grow fruits and vegetables, improving their eating habits and integrating such school gardening operations into family interactions for educating whole communities for food supply and healthy nutrition.
- Demonstration farms must be established under responsibility either by cooperatives or city governments for education and extension not only to interested farmers but also to consumers and city residents.
- To make urban and periurban vegetable production successful and sustainable, community laws and regulations have to be adopted accordingly, particularly for land allotments, infrastructure, sales outlets, support to cooperative establishments, extension and credits.
- Even if there are established extension services for agriculture in rural areas, such have to be adapted to farming under urban and periurban environments. It is, therefore, necessary to formulate new programs for training of trainers to provide appropriate extension service to farmers.
- Under certain conditions it should be considered to integrate small livestock operations with fish ponds and vegetable growing to make food supply from city agriculture a sustainable process in an urban ecosystem.

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August 10, 2000