PRODUCTION OF ORGANIC FERTILIZER FROM SOLID WASTE AND ITS UTILIZATION IN INTENSIVE ORGANIC-BASED VEGETABLE PRODUCTION AND FOR SUSTAINING SOIL HEALTH AND PRODUCTIVITY[1]

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Abstract

Improper solid waste disposal poses a major threat to the environment and high risks to human health. Most of these wastes are biodegradable and can be converted into a valuable resource that reduces otherwise negative impacts. The Central Luzon State University (CLSU) has devised ways to convert solid wastes into a valuable resource — organic fertilizer — and its subsequent utilization as a source of plant nutrients in intensive small-scale organic-based vegetable production and for sustaining soil health and productivity.

Generally the project aimed to promote proper waste management by the university via organic fertilizer production and demonstrate the feasibility of growing vegetables using organic fertilizer as the major source of plant nutrients. Specifically, it aimed to a) develop and disseminate technology on solid waste composting for the production of organic fertilizer, b) determine the efficacy with which organic fertilizer generates major nutrients for vegetable production and its effect on some soil physical properties.

Shredding the substrate prior to piling shortened the decomposition process by 7 to 10 days depending on the substrate combination. Combined solid waste (buffalo manure: rice hull ash) at a ratio of 2:1:1 proved to be the best combination. When the solid wastes are composed mainly of rice straw and leaf litter, as well as their combination, the decomposition process is prolonged from 30 days to between 60 and 75 days. Economic analysis of producing 100 bags of organic fertilizer for one cycle (27-30 days) revealed a net income of US$102.35.

Pure application of organic fertilizer and/or compost tea showed great potential in intensive small-scale organic-based vegetable production (lettuce, pechay, eggplant, grafted tomato) as a major source of plant nutrients.

Introduction

Waste generation and subsequent accumulation generated by unabating increase in human populations is one of the major problems confronting future generations. This is aggravated by improper waste disposal that often causes greater problems in terms of environmental pollution and disease occurrence — not only to human beings but also to animals. The Central Luzon State University as a leading institution of higher learning is not spared from this scenario particularly as it houses more than 8,000 people notwithstanding the huge area for agricultural production that produces large volumes of farm wastes. Results of our initial survey on waste generation in the campus indicated that an individual generates an average of 500-600 g of waste in one day. The volume of waste collected in one month is approximately 200 m^3. The composition of wastes, collected particularly in the dormitories, is about 40 to 60% biodegradable, the rest

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is non-biodegradable mostly plastic, foils, wrappers, styrofoam, bottles and cans. Considering this huge volume, something has to be done to convert these wastes into a resource. Based on one of the guiding principles of solid waste management, *Waste is a Resource*, waste recycling can alleviate the problem of solid waste management.

On the other hand, the agriculture sector is deemed unsustainable by various studies as the main focus of the current development agenda is feeding the ever-expanding population; it loses sight of the negative environmental consequences it creates, particularly on soil health. Land use is optimized through technologies and management practices that fall short of requirements for sustainability. This is because the current practice in agriculture is basically chemical-based farming that makes a considerable contribution to the degradation of our natural resources, particularly soils. Heavy application of fertilizers has polluted surface and groundwater resources. The high nutrient contents in water body surfaces generate algal blooms and red tide outbreaks as observed in Manila Bay and other parts of the country. Intensive cropping to feed the ever-expanding population coupled with high erosion rates in the uplands has resulted severe soil nutrient depletion. In fact about 13.5 million hectares or 45% of the total arable lands in the Philippines is affected by soil erosion and about 12 million hectares or 40.8% of the total land area is affected by severe low fertility. The most common deficient nutrients are nitrogen, phosphorus, potassium, sulphur and zinc as indicated in the NAST-PCARRD Industry Strategic Plan for Environment Services. With these scenarios, there is an urgent need to find ways and means to alleviate such problems.

Nowadays, organic-based agricultural production is a rapidly emerging technology in the Philippines, which partly solves waste disposal problems through conversion of biodegradable wastes into organic compost; this ensures the availability of organic fertilizer for crop production. In addition, organic-based vegetable production provides unique opportunities for producing high quality vegetables because of reduced chemical application at any given time of the year. It likewise contributes to rehabilitating and sustaining the fertility of our croplands that have been degraded or are in danger of degradation due to intensive crop production and improper soil management practices.

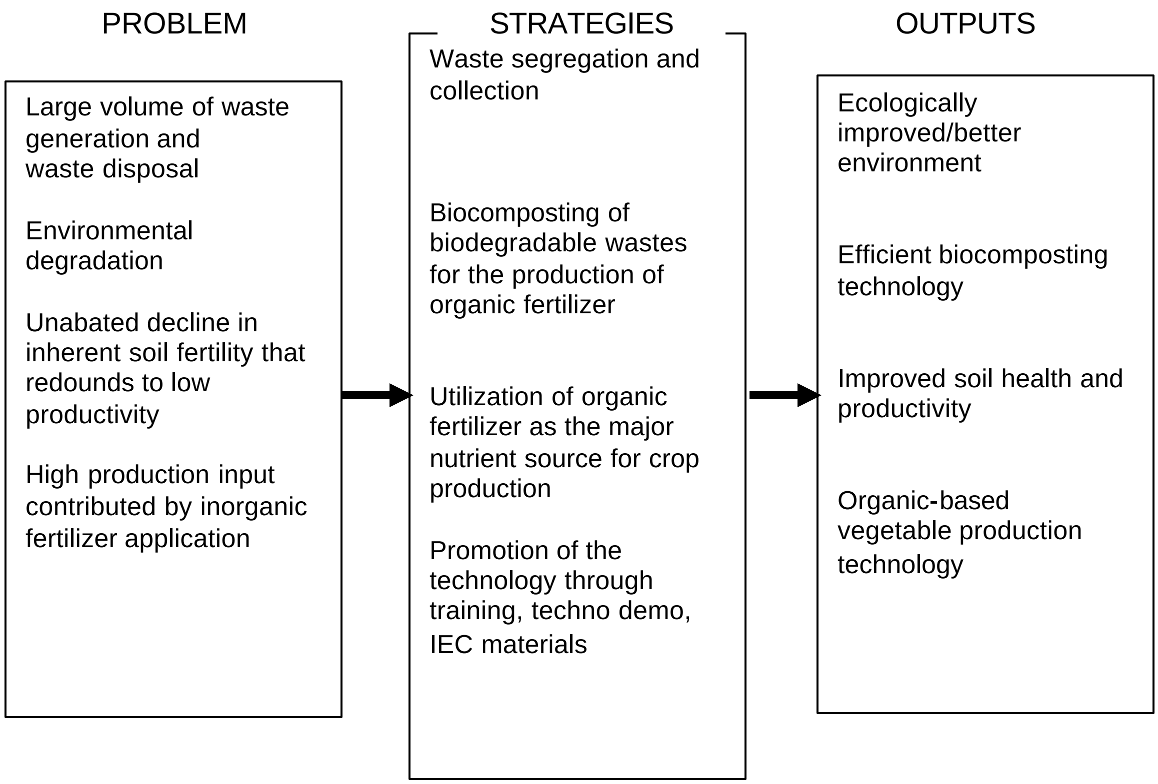
Objectives

The project aimed to promote proper waste management by the university via organic fertilizer production and demonstrating the feasibility of growing vegetables using organic fertilizer as the major source of plant nutrients.

Specifically, it aimed to a) develop and disseminate technology on solid waste composting for the production of organic fertilizer, and b) determine the efficacy with which organic fertilizer generates major nutrients for vegetable production and its effect on some soil physical properties.

Conceptual framework

The project was undertaken following this conceptual framework.



Methodology

The project involved four phases described hereunder:

Phase I. Information dissemination on proper solid waste management

Considering the large volume of wastes generated in the university and the fact that 60% is biodegradable, an information campaign, which included segregation of waste at source, waste classification and waste recycling was intensively carried out through frequent dialogues and group discussion coupled with distribution of IEC.

Phase II. Development/improvement of composting technology

Segregated wastes collected within the CLSU campus were brought to the material recovery facility (MRF) and were used as the substrate for organic fertilizer production. Studies were conducted to identify the best substrate combination and ratio for quality compost that could be harvested in the shortest possible time utilizing natural decomposition processes. Composted products as well as the by-products (compost leachate or compost tea) were analyzed for nutrient composition and possible presence of heavy metals.

Phase III. Evaluation of produced organic fertilizer and compost tea as major sources of plant nutrients for intensive vegetable production

Field studies were conducted to determine the efficacy of the produced organic fertilizer as a nutrient source for selected vegetables with emphasis on leafy vegetables (pechay and lettuce) and fruit vegetables (tomato and eggplant) and the subsequent effect of organic fertilizer application on selected soil properties.

Phase IV. Technology promotion and utilization

To promote the technology, the MRF was converted as a one-stop technology demonstration for the waste processing (segregation, organic fertilizer production) and organic vegetable production farm. Vegetable production involved zero chemical pesticides and no chemical fertilizers. Leaflets and other printed materials were prepared.

At present, the project serves as the hands-on training venue for organic fertilizer production and organic vegetable production not only for outside clients but also for university students.

Results and discussion

The project's accomplishments are described hereunder.

Developed an ecological composting technology

The production of organic fertilizer from solid waste required the MRF (composed of assembly area, composting area, drying area, storage area and drainage or leachate tank system), a multipurpose shredding machine, a hand tractor, a weighing scale, sieves, shovels and containers. Substrates used as compost materials included household and market waste, buffalo, chicken or goat manure as microbial activators and carbonized rice hull as a stabilizer. The details of the production technology are presented in Box 1

Box 1. Guidelines for organic fertilizer production from solid waste

1. Collect raw materials (leaf litter, farm waste, household and market waste, buffalo or goat manure, carbonized rice hull).
2. Mix the materials at a ratio of 2:1:1 (2 solid waste [household, farm, market]: 1 buffalo, chicken or goat manure:1 carbonized rice hull).
3. Moisten the mixed materials and shred to reduce the size and to enhance the decomposition process.
4. Pile the shredded materials at the height of 100-150 cm under shed and cover with plastic to increase the temperature, maintain moisture and minimize escape of gases to the atmosphere.
5. Monitor the temperature of the pile weekly. Maintain 60% moisture in the pile. If the compost pile becomes dry, moisten it using compost leachate or manure tea.
6. After two weeks, open and turn the pile thoroughly to facilitate uniform decomposition.
7. Incubate for another two weeks or more depending on the type of compost material. If most of the compost material is composed of leaf litter and/or rice straw, decomposition is prolonged from 30 days to 60 to 75 days.
8. After another two weeks, the compost is already mature. Matured compost material is compost that does not generating heat, has no smell of decomposing material and looks like soil. Harvest the composted material and spread on a flat floor in the drying area for at least a week or to a moisture level of 30%. Avoid sun drying the harvested composted material.
9. Shred and sieve using a 2-cm mesh prior to bagging.
10. Pack the composted material using polyethylene plastic bags in a sack (50 kg/bag) and store in a cool dry place.

Characteristics of the organic fertilizer produced

The composted product was analyzed for OM, N, P, K, Zn, Cu and Cd, The result is shown in Table 1. The compost leachate was analyzed for nitrate and ammoniacal N, P, K, pH and microbial counts as shown in Table 2. The organic fertilizer produced contained an average of 2.0% N, 2.60% P, 1.75% K and 196 ppm Zn while the leachate contained 100 ppm NO_3-N, 770 ppm NH_4-N, 60 ppm K and P was trace while the pH was 7.4. The microbial population was determined by counting the number of colony-forming units per ml of sample using the serial dilution technique; it showed that the leachate had 4-x10^4 cfu/ml for bacteria and 1.0 x 10^2 cfu/ml for fungi but there were no rhizobia. It was noted that bacteria were more abundant than fungi.

Table 1. Analysis of the organic fertilizer produced

Chemical properties	Reading/analysis
OM (%)	32.00
N (%)	1.72
P (%)	2.60
K (%)	1.75
Zn (ppm)	196.00
Cu (ppm)	45.50
Cd (ppm)	0.00

Table 2. Analysis of compost leachate (HW compost tea)

Constituents	Value
Nitrate N (NO3-N) (ppm)	100
Ammoniacal N (NH_4-N) (ppm)	70
P (ppm)	Trace
K (ppm)	60
pH	7.4

The economics of producing organic fertilizer from solid waste

The economics of organic fertilizer production from solid waste indicate an initial investment of US$4,900. For one cycle (27 to 30 days) with a production of 100 bags, gross sale was US$300 with total expenses of US$113.41. The net income was US$186.59 (Table 3.) The initial investment for the MRF, shredding machine and hand tractor can be recovered within 2.68 years.

Converting solid waste into organic fertilizer will not only increase farm household income but also become a stable source of organic fertilizer for rehabilitating highly nutrient depleted agricultural soils and reduce environmental pollution generated by improper waste disposal.

Table 3. Cost and return analysis of producing organic fertilizer from solid waste

Items	For one cycle (one month)	For ten cycles (one year)
I. GROSS SALE (100 bags per cycle @ US$3)	300	3,000
II. EXPENSES		
? Initial Investment		
a. MRF with a lifespan of 20 years (2,000)	8.33*	100*
b. Shredding machine (1 tonne capacity) with a lifespan of 10 years (1,500)	6.25*	75*
c. Hand tractor for hauling with a lifespan of 10 years (1,400)	5.83*	70*
? Labour (from collection of materials to bagging) @ xxx person days	30	300
? Material Cost		
a. Gasoline and diesel for hauling and shredding	23	230
b. Polyethylyne plastic bags and sacks @ 0.20	20	200
c. Other inputs (shovels, plastic covers and miscellaneous expenses)	20	200
? TOTAL EXPENSES	113.41	1,175.00
? NET INCOME	186.59	1,825.00

* Depreciation cost at 5% per year.

Utilization of organic fertilizer as the major source of plant nutrients in intensive small-scale organic-based vegetable production

As growth media for lettuce production grown in a greenhouse

This study was conducted to compare the efficacy of composted household waste (CHW) with coco coir dust (CCD) and pure soil as growth media for lettuce grown in a greenhouse. Treatments were: a) combined CHW and CCD at the rate of 12 t/ha, b) CHW at 16 t/ha, c) CCD at 8 t/ha, d) soil-less CCD at 37 t/ha, e) soil-less CHW at 74 t/ha and f) combined CHW and CCD with no soil at 56 t/ha.

The incorporation of 16 t/ha CHW into the soil yielded comparably with combined CHW and CCD incorporation as well as soil-less CHW and combined CHW and CCD with no soil. A yield reduction of 61% was noted when lettuce was grown in pure soil compared to the use of CHW (Table 4).

Table 4. Yield/1 m^2 of lettuce grown using different growth media under greenhouse conditions, DS 2005, CLSU, Philippines

Treatments	Yield per plot (kg/m^2)
CCD (8 t/ha)	6.027^{a}
CHW (16 t/ha)	6.103^{a}
Combined CHW + CCD (1:2, 12 t/ha)	4.963^{b}
Soil alone	4.927^{b}
Soil-less CCD (37 t/ha)	3.423^{c}
Soil-less CHW (74 t/ha)	5.693^{ab}
Combined CCD + CHW with no soil (1:2, 56 t/ha)	6.233^{a}

Means with the same superscripts are comparable at the 5% level by Duncan's multiple range test (DMRT).

Residual effect of applied organic fertilizer on grafted tomato

This study was conducted to evaluate the residual effects of CHW, CCD and their combination (CCD+CHW) on the yield of greenhouse-grown grafted Maxima variety tomato and to determine the main effects of organic materials previously used as growth media for lettuce production on the fruit yield of the grafted tomato. Grafted tomato was grown in plots previously used for lettuce production. The layout of the previous cropping with its treatments was used. The experiment was laid out in a split-plot using the Randomized Complete Block Design (RCBD). There were four treatments replicated three times. Each plot was split into two, with inorganic fertilizer (120-60-60 kg N P_20_5 K_2O/ha) and without inorganic fertilizer.

Organic materials previously used as growing media decreased soil bulk density and increased porosity and water holding capacity. Moreover, plots with organic materials previously used as growth media had higher soil OM, total N, exchangeable K and available P compared to the control.

The results indicated the potential of these organic materials as growth media in greenhouse crop production with a short-duration crop (lettuce) as the first crop followed by grafted tomato. The analysis of the soil after harvesting the first crop showed high OM, total N and exchangeable K, notwithstanding the improved physical properties of the soil before planting the second crop (grafted tomato). These findings supported the significant increase in the yield of grafted tomato as influenced mainly by the kind of growth media over the soil alone with yield of only 4.791 t/ha as compared to 9.701, 9.348 and 12.146 t/ha from CHW, CCD, and CCD+CHW, respectively (Table 5).

Table 5. Yield per plot (g) of grafted Maxima tomato as influenced by previously applied organic materials, DS 2005, CLSU

Previously applied organic material	*Inorganic fertilizer*		*A-mean*
	With (120-60-60 kg NPK/ha)	*Without (0-0-0 kg $NP_2O_5K_2O$/ha)*	
Soil alone	*1,522.7 c (7.614)*	*393.4 d (1.967)*	***958.07 C (4.791)***
CHW (16 t/ha)	*2,342.7 b (11.714)*	*1,537.7 c (7.689)*	***1,940.17 B (9.701)***
CCD (9t/ha)	*2,397.73 b (11.989)*	*1,341.2 c (6.706)*	***1,869.47 B (9.348)***
1:2 CHW+CCD (12 t/ha)	*3,126.0 a (15.630)*	*1,732.3 c (8.662)*	***2,429.14 A (12.146)***
B-mean	***2,347.3 X (11.737)***	***1,251.1 Y (6.256)***	

Means followed by a common letter are not significantly different at the 5% level by DMRT. Means in parentheses represent the computed yield per hectare in tonnes.

Application of organic fertilizer on leafy vegetables (lettuce and pechay)

Lettuce. This study was conducted to compare the yield of lettuce and pechay applied with organic fertilizer (26 t/ha) with the recommended inorganic fertilizer (140-90-90 kg NPK/ha) and the combined application of organic and inorganic fertilizers (50% substitution). The effects on yield and on selected soil properties were evaluated for three croppings.

The yields of lettuce were comparable in all the three treatments during the first and the third cropping. In the second cropping, the yields from plots applied with inorganic fertilizer were significantly lower than those applied with pure organic fertilizer and the combined organic and inorganic fertilizer (Table 6). The yield in the third cropping is much lower than from the first and second croppings irrespective of the treatments because of high temperature during this period.

Table 6. Yield of lettuce (kg/6 m^2) as influenced by different fertilizer application, DS 2006, CSLU, Philippines

Treatments	**Cropping**		
	1st (January)	2nd (February)	3rd (March)
T1: Organic fertilizer 26 t/ha	2.270^a	4.447^a	1.957^a
T2: Inorganic fertilizer 140-90-90 kg NPK	3.013^a	2.543^b	1.943^a
T3: ½ organic fertilizer + ½ inorganic fertilizer (13 t/ha + 70-45-45 NPK)	2.803^a	3.827^a	1.450^a

Means followed by a common letter are not significantly different at the 5% level by DMRT.

Pechay. Comparable yields were obtained in the first and second croppings. During the third cropping, significant reduction in yield was noted from the application of pure chemical fertilizer and pure organic fertilizer over the combined application of organic and inorganic fertilizers (Table 7). This is due to the higher number of non-marketable plants in these plots due to higher insect damage.

Generally, analysis of soil N and P using the soil test kit indicates improvement as shown by the initial values of low to medium and high (Table 8). Decreasing trend was noted in the soil bulk density value which indicates improvement in soil porosity (Tables 9 and 10).

Table 7. Yield of pechay (kg/6m^2) as influenced by different fertilizer application

Treatments	Cropping		
	1st (January)	2nd (February)	3rd (March)
T1: Organic fertilizer 26 t/ha	2.077[a]	0.957[a]	2.570[c]
T2: Inorganic fertilizer 140-90-90 kg NPK	3.517[a]	0.453[a]	3.810[b]
T3: ½ organic fertilizer + ½ inorganic fertilizer (13 t/ha + 70-45-45 NPK)	3.143[a]	0.750[a]	5.050[a]

Means followed by a common letter are not significantly different at the 5% level by DMRT.

Table 8. Nitrogen as influenced by different fertilizer application

Treatments	N		
	1st	2nd	3rd
Initial	Low		
T1: Organic fertilizer 26 t/ha	Medium	Medium	Medium
T2: Inorganic fertilizer 140-90-90 kg NPK	Medium	Medium	Medium
T3: ½ organic fertilizer + ½ inorganic fertilizer (13t/ha + 70-45-45 NPK)	Medium	Medium	Medium

Table 9. Phosphorus as influenced by different fertilizer application

Treatments	P		
	1st	2nd	3rd
Initial	Medium		
T1: Organic fertilizer 26 t/ha	Medium	High	High
T2: Inorganic fertilizer 140-90-90 kg NPK	Medium	Medium	High
T3: ½ organic fertilizer + ½ inorganic fertilizer (13 t/ha + 70-45-45 NPK)	High	High	High

Table 10. Bulk density (g/cc) as influenced by different fertilizer application

Treatments	Bulk density (g / cc)	
	2nd	3rd
Initial	1.86	
T1: Organic fertilizer 26 t/ha	1.37	1.46
T2: Inorganic fertilizer 140-90-90 kg NPK	1.54	1.72
T3: ½ organic fertilizer + ½ inorganic fertilizer (13 t/ha + 70-45-45 NPK)	1.67	1.74

Utilization of compost leachate as the nutrient source for eggplant and lettuce

Eggplant. A field study was conducted to analyze the value of leachate from organic fertilizer production as liquid fertilizer alone or in combination with inorganic fertilizer. Five treatments were used: a) recommended fertilizer rate — 120-60-60 kg N, P_2O_5, K_2O/ha (RR); b) ½ RR + ½ l leachate/hill, ½ RR; c) leachate alone (½ l/hill); and d) RR + ½ l leachate/hill. The leachate was applied twice, at 14 and 30 days after transplanting (DAT) whereas inorganic fertilizer was applied thrice; basal, 14 and 30 DAT.

Plant heights at the flowering stage were similar in all inorganic fertilizer and inorganic fertilizer + leachate-treated plots while leachate alone-treated plots had significantly lower plant height than the ½ RR + leachate-treated plots but similar to the height of RR and ½ RR-treated plants. Application of ½ l leachate/hill + ½ RR effected better yield over RR registering a 55.39% increase in yield (Table 11).

Lettuce. This study was conducted to: (a) evaluate the effect of household compost leachate application on the selected soil properties; (b) determine the nutrient composition of household compost leachate; (c) compare the response of lettuce plants to the application of

Table 11. Yield of eggplant as affected by the application of leachate from organic fertilizer (average of eight primings)

Treatments	Yield (kg/plot)	
	Marketable	Non-marketable
T1 RR (120-60-60 kg N, P_2O_5, K_2O/ha)	0.513 [b]	3.637 [a]
T2 ½ RR + ½ l of leachate from organic fertilizer production (LFP)	0.937 [a]	0.593 [a]
T3 ½ RR	0.603 [b]	0.530 [a]
T4 ½ l LFP	0.613 [b]	0.710 [a]
T5 RR + ½ l LFP	1.033 [a]	0.680 [a]

*Means in a column followed by the same letter are not significantly different at the 5% level of significance.

household compost leachate as liquid fertilizer with other commercial liquid fertilizer; and (d) assess the economic importance of household compost leachate in lettuce production.

Household compost leachate was used as liquid fertilizer and was compared with two commercial foliar fertilizers and the commonly used nutrient source, granular fertilizer for lettuce production grown in a screen house. Two croppings were done to determine the possible residual effects of previously applied leachate. There were six treatments: a) 0-0-0 (control); b) 90-30-30 kg N, P_2O_5, K_2O/ha using granular fertilizer (RR); c) commercial foliar fertilizer (6 tbsp./16 li); d); commercial organic liquid-based fertilizer (200 ml/16li); e) household compost leachate (0.50 li/plant); and f) household compost leachate (1 li/plant), each replicated four times. A randomized complete block design was used.

The household compost leachate was analyzed for pH, NO_3-N, NH_4-N, total P and K as well as bacterial and fungal population at the BSWM. Results indicated that the leachate contained 100 ppm of NO_3-N, 60 ppm NH_4-N, total P was trace and K was 70 ppm whereas the pH was 7.4. The presence of bacteria and fungus was noted but there were no rhizobia.

Increases in soil OM and K were noted on the plots applied with household compost leachate after the first harvest but not for soil P and pH (Table12).

The application of 1 li/plant of household compost leachate yielded comparably with the application of (90-30-30) kg N, P_2O_5, K_2O/ha of granular fertilizer but increased by 89% over the control. The residual effect of household compost leachate was noted in the second cropping (Table 13).

A positive net benefit was obtained in all the treatments evaluated. The net benefit from household compost leachate is close to the net benefit obtained from the recommended rate of granular fertilizer. Household compost leachate therefore is a potential plant nutrient source for lettuce production (Table 14).

Table 12. Some chemical properties of the soil applied with compost leachate before and after the study

Treatment	pH	OM	P (ppm)	K (ppm)
Control	6.8	1.25	13.9	43.0
90-30-30 kg N,P_2O_5,K_2O / ha	6.6	1.26	14.1	56.2
RR of commercial foliar fertilizer (6 tbsp/16 li)	6.7	1.88	14.1	69.6
RR of commercial organic liquid-based fertilizer (200 ml/16li)	6.8	1.35	14.2	56.2
Household compost leachate (0.5 li/plant)	6.8	1.62	14.1	74.5
Household compost leachate (1 li/plant)	6.8	2.57	14.2	75.2
Initial analysis (before treatment application)	6.8	1.42	14.3	66.7

Table 13. Response of lettuce (first cropping) to the application of household compost leachate grown in a greenhouse, CLSU, Dec. 2005 to January 2006

Treatment	No. of marketable leaves/plant	Weight of plant (g/plant)	Yield (kg/2.55m^2)
Control	13 c	32.03 c	1.872 c
90-30-30 kg of N,P_2O_5,K_2O)/ha of granular fertilizer	14 ab	53.95 a	3.539 a
Recommended rate of commercial foliar fertilizer (6 tbsp/16 li)	14 b	34.60 c	2.021 bc
Commercial organic liquid-based-fertilizer (200 ml/16 li)	14 b	34.10 c	1.953 bc
Household compost leachate at a rate of 0.5 li/plant	15 ab	38.83 bc	2.243 bc
Household compost leachate at a rate of 1 li/plant	16 a	43.73 b	3.124 a

Means followed by a common letter are not significantly different at the 5% level by DMRT.

Table 13. Residual effect of applied compost leachate on marketable yield (g/plot) of lettuce

Treatment	Mean/SEM
Control	1,615.00 c ? 55.08
90-30-30 kg of N, P_2O_5, K_2O/ha of granular fertilizer	2,523.75 a ? 401.48
Recommended rate of commercial foliar fertilizer (6 tbsp/16 li)	1,766.25 bc ? 362.34
Commercial organic liquid-based fertilizer (200 ml/16 li)	2,195.00 ab ? 314.80
Household compost leachate at a rate of 0.5 li/plant	2,272.50 ab ? 504.27
Household compost leachate at a rate of 1 li/plant	2,357.50 a ? 227.65

Means followed by a common letter are not significantly different at the 5% level by DMRT.

Table 14. Partial budget analysis of lettuce plants over 100 m^2

Treatment	Expense due to fertilizer treatment	Added cost*	Yield** (100 m^2) gross income (kg/US$)	Added benefit*	Net benefit*
Control	0	0	139.40kg/ 167.28	123.72	123.72
90-30-30 kg of N, P_2O_5, K_2O / ha of granular fertilizer	1.04	1.04	242.50 kg/ 291.00	123.72	122.68
Recommended rate of commercial foliar fertilizer (6 tbsp/16 li)	0.03	0.03	151.50 kg/ 181.80	14.52	14.49
Commercial organic liquid-based fertilizer (200 ml/16 li)	0.08	0.08	165.90 kg/ 199.08	31.80	31.72
Household compost leachate at a rate of 0.5 li/plant	0.50	0.05	180.60 kg/ 216.72	49.44	48.94
Household compost leachate at a rate of 1 li/plant	1.00	1.00	219.20 kg/ 263.04	95.76	94.76

* Relative to the control
** Total of first and second croppings

Technology promotion and utilization

The field trial results on the evaluation of organic fertilizer as a major source of plant nutrients for vegetable production were validated on a 1,000 m^2 farm, which also served as the technology demonstration site for organic-based vegetable production. Intensive cultivation was done following the concept of organic farming, which is pesticide- and inorganic fertilizer-free. Two leafy vegetables and two fruit vegetables were used as the test crops. The details of the technologies are presented in Box 2.

Box 2. Guidelines for organic vegetable (lettuce, pechay, tomato and eggplant) production utilizing organizer fertilizer from solid waste

1. Seedling production: Prepare seedling growth media by mixing fine sand, organic fertilizer and CCD at a ratio of 1:1:1 by volume. Put enough of the growth media in each hole of the seedling tray and moisten with water. Sow one to two seeds per hole.

2. Plant the surrounding area with biopesticide plants which serve as insect repellants to minimize insect occurrence and/or a source of biopesticides.

3. Land preparation: Prepare plots (can be permanent or temporary plots) with a width of one metre at desired length for leafy vegetables (pechay and lettuce) and 2.5 metres at desired length for tomato and eggplant. Till the land either by hand hoeing or with small farm implements until good tilth is attained. Incorporate evenly and thoroughly the organic fertilizer (rate should be based on the soil test value). The results of our experiments indicate a high rate of application per unit area because the soil used was a highly depleted one (Table 15).

4. Mulching (optional depending on density of weeds in the area) and transplanting. To minimize growth of weeds mulch the plots using black polyethylene plastic prior to transplanting. Transplant one seedling per hill. The planting distance for pechay and lettuce is 20 x 25 cm between hills and rows respectively and 50 x 100 cm for tomato and eggplant.

5. Insect pest control. With the presence of biopesticidal plants as insect repellant, insect infestation is minimal. In case there is high incidence of insect attack, plant juice from neem tree leaves, jathropa and other pesticidals plant is extracted through fermentation and sprayed on the plants at the rate of 5 cover of knapsak sprayer plant juice extract per 16 liter knapsak sprayer.

6. Weeds. Control weeds via manual weeding or using small farm implements.

7. Irrigation. Irrigate the area using a dripper as the need arises.

8. Harvesting. Harvest the plants manually.

Table 15. Organic fertilizer application rate for vegetable production

Crop	Application		Time and method of application
	Type	Rate	
Lettuce (screen house)	Compost tea	1 l/hill*	At transplanting and two weeks after transplanting/drenching
Lettuce (greenhouse)	Compost	16 t/ha**	Basal/soil incorporation
Lettuce (open field)	Compost	26 t/ha*	Basal/soil incorporation
Pechay (open field)	Compost	26 t/ha*	Basal/soil incorporation
Eggplant (open field)	Compost tea	1 l/ha	Once a week/drenching
Grafted tomato (greenhouse)	Compost	16 t/ha	Basal/soil incorporation
Non-grafted tomato (open field)	Compost	26 t/ha	Basal/soil incorporation

*With residual effect for succeeding two crops (lettuce).

**With residual effect for the succeeding grafted tomato for one cropping.

Summary and conclusion

Project highlights are listed hereunder:

1. A technoguide for organic fertilizer production was developed; it has been given to interested clients and serves as a guide during training courses.
2. The rate of organic fertilizer application for the different test crops used in the field trials was established and formed part of the technology component in organic-based vegetable production.
3. Continuous application of organic fertilizer showed increasing trend in improving soil quality (OM content, bulk density) and generally maintained N, P and K soil contents.
4. Compost leacheates or compost tea can be a promising foliar source of plant nutrients for leafy vegetables and fruit vegetables.
5. The volume of biodegradable wastes brought to the university dumpsite was reduced by almost 60%.
6. Additional income was generated for the operation of the project.

Implications and recommendations

The conversion of solid wastes into a valuable resource such as organic compost or organic fertilizer is a worthwhile strategy for saving the Earth from further degradation generated by improper waste disposal and management. Moreover, the continuous use of organic fertilizer as a source of plant nutrients for vegetable production not only reduces the cost of fertilizer but serves as the ultimate solution for restoring the lost fertility of agricultural soils as well as soil health; this leads to sustained soil productivity.

Production of organic fertilizer from solid wastes and its subsequent utilization in crop production and soil rehabilitation is therefore recommended to reduce the volume of wastes that are brought to dumpsites, minimize environmental pollution and degradation and increase the productivity of agricultural land.

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