EFFICACY OF DIFFERENT GREEN MANURES AND COMMERCIAL ORGANIC FERTILIZERS ON THE GROWTH AND YIELD OF POTTED LETTUCE AND CABBAGE AND THEIR RESIDUES ON LETTUCE AND PECHAY

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ABSTRACT

Two studies were conducted at CPU campus, Iloilo City from October 2009 to April 2010. The first one compared the effects of IMO-5, commercial compost, leaf green manures and inorganic fertilizer. Plants without fertilizer served as basis for comparison. The second study evaluated the growth and yield of pechay and lettuce in pots with residual fertilizer. Pechay was used instead of cabbage because of its shorter growth period than cabbage. The treatments consisted of acacia (*Albizia saman* (Jacq.) *Merr.*) (T1), ipil-ipil (*Leucaena leucocephala* (Lam.) de Wit) (T2), and madre de cacao (*Gliricidia sepium*) (Jacq.) *Walp*.) (T3) leaf manures, IMO-5 (T4), and commercial compost (T5). The inorganic fertilized (T6) and unfertilized (T7) plants served as positive and negative controls, respectively. These were laid out in randomized complete block design with three replications. Results from the first study showed significantly most leaves from fertilized lettuce except those added with madre de cacao. Likewise in cabbage, the fertilized plants were significantly taller and produced significantly more leaves than the unfertilized. Lettuce and cabbage with inorganic fertilizer, however, recorded the highest return on investment (ROI) of 89% and 125%, respectively.

Results from the second study revealed that lettuce grown in soil with residues of green manures and commercial organic fertilizers had more leaves, were taller, and out yielded the unfertilized plants and those previously applied with inorganic fertilizer. Results further showed that pechay with different manures had statistically similar leaf count and height but had significantly outperformed those with inorganic fertilizer (T6) and without fertilizer (T7). However, lettuce and pechay with residues of compost (T5) showed the highest ROI of 411% and 318%, respectively. Based on the results of the first study, it is concluded that it is profitable to use inorganic fertilizer (T_6) in lettuce and cabbage production. However, it was the residue from commercial compost (T_5) that sustained soil productivity and profitability of the second crop.

Keywords*: green manures, organic fertilizers, residual fertility, urban gardening*

INTRODUCTION

People nowadays are more concerned with their health. Nutrition can be in the form of fruits and vegetables. However, with the increasing population, areas allotted to the growing of plants are getting smaller and smaller. This problem can be addressed by urban gardening. Urban gardening is one way of growing vegetables in vacant lots and roof tops and even in cemented areas as long as sufficient containers or even recycled containers are available. Since it is small scale production, it can be managed organically. According to the Department of Agriculture (DA) (Cotthem, 2015) a mixture of urban agricultural production technologies can enable cities to produce their own food, complementing the government's efforts in the countryside to maintain food security in the country.

Cabbage (*Brassica oleracea* L.) and lettuce (*Lactuca sativa* L.) are high value crops with great demand in the market. Crucifers contain phytochemicals which help fight colds and flu, help shrink tumors and malignancies, and with very strong anti-cancer properties (Undan, *et al.*, 2002). For lettuce, this is a good source of dietary fiber, Calcium, magnesium, phosphorus and selenium, and a very good source of Vitamin A, Vitamin C, Vitamin K, Thiamin, Riboflavin, Vitamin B6, Folate, Iron, Potassium and Manganese (Self Nutrition Data; USDA). These benefits can further be enhanced when crops are grown without the use of chemicals which can adversely affect human health. This was further supported by the government through Republic Act No.10068, otherwise known as Organic Agriculture Act

of 2010 that promotes organic agriculture in the Philippines (FAO).

Organic farming takes local soil fertility as the key to successful production. Most fertile and productive soils have a high content of organic matter which is the seat of microorganisms responsible for many biological transformations in soils. Generally, the soil contains 2-5% organic matter and about 5 percent nitrogen (PCAARRD, 2012). Organic manures have low nutrient content and, therefore, need to be applied in larger quantities which can be easily managed when used in container gardens. In contrast, soils which are fertilized with inorganic fertilizers year after have low organic matter content, decreased soil pH and cation exchange capacity (CEC). Physical properties, especially soil water relations, are also greatly affected (Pernes-Debuyser & Tessier, 2004).

Leguminous tress such as ipil-ipil (*Leucaena leucocephala*), acacia *(Albizia saman)* and madre de cacao (*Gliricidia sepium*) are the commonly used green manure crops. Leaf biomass from these trees are good sources of organic matter. A study on alley farming at the International Institute of Tropical Agriculture (IITA) revealed that repeated addition of prunings of Leucaena and *Gliricidia plays* an important role in maintaining high soil organic matter and nutrient status. The study measured the long-term effects of the addition of *Leucaena* and *Gliricidia* prunings on soil properties and crop yield. As compared to a tree-less control plot, the alley farming plots recorded 80% higher soil organic matter after six years of cropping (Kang and Ghuman, 1989). The inputs of organic matter from plant residues and

exudates provide carbon and energy sources for soil organisms. Net increases in soil organic matter improve soil aeration, temperature, moisture, and aggregate stability, and provide a resilient resource base for a wide variety of soil organisms through the maintenance of a rich and varied source of OM (Lehman, R. M. *et al*., 2015).

A study by Seredrica and Patricio (2011) showed that in lettuce, the use of ipil-ipil leaf manure resulted in the highest ROI of 103.71% while those of the unfertilized plants was -70.10%. In cabbage, all treatments with leaf manures gave a negative ROI (-14.45% to 100%). Meanwhile, the result of the study by Detaro (2008) and Antipatia (2009) on the use of IMO-5 (organic fertilizer containing indigenous microorganisms) at one kg/pot in lettuce had an ROI of 39.56% and 5%, respectively, while that of Catalan (2009) showed that the application of organic fertilizer at one kg/pot recorded an ROI of 10%.

Seredrica and Patricio (2011) recommended that to increase yield of potted cabbage, the amount of ipil-ipil and madre de cacao as leaf manures should be increased along with an increasing amount of soil in order to support the growth and yield. For this reason, this study was conducted to verify the above results.

Objectives of the Study

The general objective of study I was to compare the effect of IMO- 5, organic compost and leaf green manures on the growth and yield of potted leaf lettuce and cabbage.

Specifically, this aimed to determine the:

1) horticultural characteristics of lettuce and cabbage; and,

2) productivity and profitability of growing lettuce and cabbage using leaf green manures and composts.

As to study II, the general objective was to determine if lettuce and pechay can still grow on residual fertility of the different organic manures.

Specifically, this study was conducted to determine and compare the:

1) horticultural characteristics of lettuce and pechay; and,

2) productivity and profitability of lettuce and pechay.

Time and Place of the Studies

These studies were conducted from October 2009 to April 2010 at the vacant lot at the back of the LEB building, Central Philippine University, Jaro, Iloilo City.

METHODOLOGY

The experimental treatments consisted of acacia (*Albizia saman* (Jacq.) Merr.) (T1), ipil-ipil (*Leucaena leucocephala* (Lam.) de Wit) (T2) and madre de cacao (*Gliricidia sepium* (Jacq.) Walp.) (T3) leaf green manures, IMO-5 (T4), commercial compost (T5), inorganic fertilizer (T6) and the control (T7). These were laid out in a randomized complete block design (RCBD) with three replications.

Seven pots were used for every treatment. Big-sized plastic pots (30 cm dia) ($0.07m^2$/pot) for cabbage were added with 14 kg of 2:1 part garden soil and sand incorporated with two kg of the designated leaf manures allowed to decompose for a month. Medium- sized pots (25.4 cm dia) ($0.05m^2$/pot) for lettuce were placed with 7 kg of 2:1 soil medium plus a kg of each of leaf manures which were mixed separately. For treatments with IMO-5 and organic compost, the potted media were mixed with two kg and one kg of each material a day prior to transplanting for big-sized and medium-sized pots, respectively. The amount of inorganic fertilizers was based on the recommendation of 240-60-60 N,P_2 O_5 and K_2O using T-14 and Urea for cabbage and 200-60-60 N,P_2 O_5 and K_2O for lettuce.

Seeds were sown in a mixture of 1:1:1 garden soil, sand and humus. Cabbage was transplanted at one seedling/pot while lettuce was transplanted at four seedlings/pot. Plants were watered daily and protected from spittle bugs, cabbage worms and aphids using neem extract while alternaria blight was controlled using moringa and coleus extracts.

One month old seedlings of cabbage and lettuce and leaf samples after harvest were processed for plant tissue analysis. Soil analysis was also done before planting and after harvest. One kg soil sample from each treatment was set aside for analysis of residual fertility.

For the study on fertilizer residues, pechay and lettuce were used after cabbage and lettuce, respectively. Pechay was used after cabbage and not cabbage after cabbage because it takes three months to harvest cabbage while pechay can be harvested in one month only. There were four seedlings transplanted per pot.

The data collected were plant height, number of functional leaves, days to head formation, head diameter, and yield. The ROI was calculated by dividing the net income by production cost. All data collected except for plant tissue, soil analysis and ROI were statistically analyzed using ANOVA for RCBD. Significant treatment mean differences were determined using the DMRT at the 5% level of significance.

RESULTS AND DISCUSSION

Study I

Lettuce

Plant height, leaf count and weight/m^2. Results from the first study (Table 1) showed that lettuce height was not significantly influenced by the kind of fertilizers used. However, leaf production was affected

with significantly more leaves in all fertilized pots than other treatments except from pots added with madre de cacao whose leaf count was comparable to the unfertilized plants. Furthermore, the highest yield was obtained from plants fertilized with acacia at 1.25 kg/ m^2. This was significantly higher than the yields of other fertilized plants which ranged from 0.85 to 1.00 kg. The soil analysis in Table 2 showed a high percentage of organic matter (OM) in soil incorporated with acacia and consequently high nutrient N (5.58%) in tissue analysis of lettuce.

Cost and return analysis. The highest ROI of 83% (Table 3) was obtained from lettuce fertilized with inorganic fertilizer which are 9%, 45%, 46%, 48%, 51% and 64% higher than those plants in pots incorporated with acacia, commercial compost, IMO-5, ipil-ipil, and the control treatments, respectively. The lowest ROI (19%) was obtained from plants applied with madre de cacao which could be explained by the lowest leaf count. These results showed that acacia leaf green manure can be a good substitute for inorganic fertilizer.

Table 1. Final Height, Leaf Count and Yield of Lettuce.

Treatment	Height	Leaf Count	Yield/m^2
	-cm-		-kg-
Acacia	22.49 [ns]	6.26 [a]	1.25[a]
Ipil-ipil	21.57	5.90[ab]	0.97[b]
Madre de cacao	22.09	5.43[bc]	0.85[b]
IMO-5	22.43	6.06[ab]	1.00[b]
Commercial compost	21.13	5.96[ab]	0.88[b]
Inorganic fertilizer	21.45	6.13[ab]	0.90[b]
Control (unfertilized)	19.91	5.06[c]	0.58[c]

[ns] not significant at the 5% level of probability

[abc] Treatment means followed by the same letter superscript are not significantly different at the 5% level of significance.

Table 2. Soil Analysis of Growing Medium before First Planting and Tissue Analysis of Organic Fertilizer Sources, Lettuce and Cabbage as First Crop

Treatment	% OM	% N		
	Growing Media	Green Manures/ Organic Fertilizers	Lettuce	Cabbage
Acacia	4.62	4.43	5.58	3.07
Ipil-ipil	3.12	4.78	4.83	3.09
Madre de cacao	4.38	3.62	4.56	2.80
IMO-5	3.18	0.26	4.18	2.68
Commercial compost	3.21	0.90	4.10	2.58
Inorganic fertilizer*			4.63	3.04
Control (unfertilized)	0.47		3.48	1.56

* T6 – no soil analysis was done because inorganic fertilizers have to be applied during planting and during the growth period of the crop

Note: Lettuce seedlings, 2.53% N; Cabbage seedlings, 1.66% N dry basis

Table 3. Cost and Return Analysis for Lettuce

Treatment	Yield kg/m^2	Gross Income	Production Cost	Net Income	% ROI
Acacia	1.25	P275.00	P 157.53	P 117.47	74
Ipil-ipil	0.97	213.30	157.53	55.47	35
Madre de cacao	0.85	187.00	157.53	29.47	19
IMO-5	1.00	220.00	160.27	59.73	37
Commercial compost	0.88	193.60	139.72	53.88	38
Inorganic*	0.90	198.00	108.21	89.79	83
Control	0.58	127.60	96.63	30.97	32

Price = P220/kg

Cabbage

Leaf count and final height. Leaf count (Table 4) for cabbage did not significantly differ among treatments while plant height was highly significantly affected by the fertilizer used. The tallest plant were those applied with inorganic fertilizer but were as tall as those added with ipil-ipil and IMO-5 while the shortest were the plants without fertilizer.

Table 4. Leaf Count and Final Height (cm) of Cabbage

Treatment	Leaf Count	Height
		-cm-
Acacia	15.66[a]	25.79[d]
Ipil-ipil	17.33[a]	30.33[ab]
Madre de cacao	16.46[a]	27.45[cd]
IMO-5	15.66[a]	29.30[abc]
Commercial compost	16.86[a]	28.34[bcd]
Inorganic fertilizer*	17.26[a]	31.46[a]
Control (unfertilized)	12.80[b]	21.47[e]

[ns] not significant at the 5% level of probability

[abcde] Treatment means followed by the same letter superscripts are not significantly different over each other at the 5% level of significance.

Days to heading, head diameter and yield of cabbage. Plants with IMO-5, commercial compost and inorganic fertilizer had significantly earlier head formation (Table 5) than the other treatments. On the other hand, the significantly widest head and heaviest heads were obtained from plants fertilized with acacia and ipil-ipil. In Table 2, the higher N content from acacia and ipil-ipil leaf tissues had supplied the N needed for three months growing period of cabbage that yielded 2.75 kg and 2.68 kg/m^2, respectively. The results of the study of Hara and Sonoda (1981) revealed that the contribution of 10 ppm S was important in increasing cabbage-head formation. As presented in Table 6, soil analysis showed that acacia and ipi-ipil contain 22.58 to 41.76

ppm S in SO_4^{2-} form that were absent in the inorganic fertilizer used. Cabbage from the control treatments were stunted and formed no heads (unproductive) due to lack of nutrients to support its growth.

The return on investment was quite good with cabbage added with inorganic fertilizer that recorded a lower cost of production and a higher yield that gave the highest ROI of 125% (Table 6). Although, plants fertilized with acacia and ipil-ipil leaf green manures had the highest yield, these had the highest cost of production resulting in ROI of 66 to 70%. A negative ROI was obtained from the unfertilized cabbage because there was no head produced.

Table 5. Days to Heading, Head Diameter and Yield of Cabbage/m^2

Treatment	Heading	Head Diameter	Yield
	-days-	-cm-	-kg/m^2-
Acacia	40.30^{b}	11.96^{a}	2.75^{a}
Ipil-ipil	37.40^{cd}	11.74^{a}	2.68^{a}
Madre de cacao	38.46^{bc}	9.79^{c}	1.80^{c}
IMO-5	34.66^{e}	10.65^{b}	1.82^{c}
Commercial compost	35.53^{de}	8.92^{d}	1.40^{d}
Inorganic fertilizer*	35.80^{de}	11.04^{b}	2.18^{b}
Control (unfertilized)	58.20 ^{a}	0.00^{e}	0.00^{e}

^{abcde} Treatment means followed by the same letter superscript are not significantly different over each other at the 5% level of significance.

Table 6. Soil Analysis before First Crop and Pure IMO-5 and Commercial Compost Analysis.

Treatment	pH	P	SO_4^{2-}	Fe	OM
		_____ ppm _____			%
Acacia	7.27	42.06	22.58	1.93	4.62
Ipil-ipil	7.23	14.61	41.76	1.88	3.12
Madre de cacao	7.01	40.65	35.08	1.68	4.38
IMO-5	6.97	60.98	122.76	1.63	3.18
Commercial compost	6.98	51.45	140.86	1.65	3.21
Control (unfertilized)	7.45	22.35	81.07	61.14	0.47
Pure Commercial Com	7.64	34.74	192.54	423.28	2.10
Pure IMO 5	7.71	26.75	151.56	192.45	1.72

Table 7. Cost and Return Analysis for Cabbage

Treatment	Yield kg/m^2	Gross Income	Production Cost	Net Income	% ROI
Acacia	2.75	P330.28	P194.28	P136.00	70
Ipil-ipil	2.68	321.60	194.28	127.00	66
Madre de cacao	1.80	217.14	194.28	22.86	12
IMO-5	1.82	219.04	184.76	45.64	23
Commercial compost	1.40	169.14	152.38	16.76	11
Inorganic	2.18	261.71	116.19	145.52	125
Control	0.00	0.00	96.19	-96.19	-100

Cabbage = P120/kg

Study II

Lettuce after Lettuce

Height, leaf count and yield of lettuce after lettuce. Results from the second study showed that at 4 WAT, lettuce with madre de cacao leaf manure had significantly the most leaves (Table 7) but were comparatively similar to plants applied with IMO-5, commercial compost, acacia and ipil-ipil. The least leaves were recorded from unfertilized plants and those previously applied with inorganic fertilizer.

The final heights at 4 WAT showed lettuce with IMO-5 residue as tallest but the mean height was comparable to those with commercial compost and ipil-ipil residue. Plants grown in pots previously added with inorganic fertilizer were the shortest.

Significantly highest yields of lettuce/m^2 were obtained from soils with residues of organic fertilizers. This means that the use of organic fertilizers had improved soil health and sustained biological productivity. This is further supported by the results of the soil analysis after planting lettuce and tissue analysis of lettuce as second crop (Table 8).

Table 7. Final Height, Average Leaf Count and Yield of Lettuce after Lettuce Four Weeks after Transplanting

Treatment	Height	Leaf Count	Yield
	-cm-		-kg/m^2-
Acacia	17.90^{cd}	7.80^{ab}	2.18^{a}
Ipil-ipil	19.29^{abc}	7.73^{ab}	2.26^{a}
Madre de cacao	18.56^{bcd}	8.03^{a}	2.16^{a}
IMO-5	20.83^{a}	7.96^{ab}	2.61^{a}
Commercial compost	19.86^{ab}	7.96^{ab}	2.53^{a}
Inorganic fertilizer	12.89^{e}	6.76^{b}	0.90^{c}
Control (unfertilized)	17.10^{d}	7.40^{b}	1.49^{b}

^{ns} not significant at the 5% level of probability

^{abc}Treatment means followed by the same letter superscript are not significantly different over each other at the 5% level of significance.

Table 8. Soil Analysis of Growing Medium before and after First Crop and Plant Tissue Analysis of Lettuce and Pechay as Second Crop

Treatment	% OM on Growing Medium			% N	
	Before Planting	After First Crop		Second Crop	
		Lettuce	Cabbage	Lettuce	Pechay
Acacia	4.62	2.84	3.78	3.45	4.99
Ipil-ipil	3.12	3.82	2.68	3.19	5.09
Madre de cacao	4.38	3.95	2.52	3.21	4.45
IMO-5	3.18	1.49	3.63	3.03	4.03
Commercial compost	3.21	3.06	2.87	2.52	4.42
Control (unfertilized)		1.68	2.02	3.26	4.21
Pure Commercial Com	0.47	1.59	0.09	2.68	3.87

Lettuce with IMO-5 realized the highest gross income (Table 9) followed by those grown with commercial compost. However, the highest net income was obtained from plants with commercial compost residue that resulted in the highest ROI of 411%. Plants with inorganic fertilizers had the lowest gross and net incomes. This could be due to the destructive effect of inorganic fertilizer on the soil structure. Potted lettuce fertilized with organic fertilizers and those without fertilizer had ROI that ranged from 244 to 411%.

Table 9. Cost and Return Analysis for Lettuce after Lettuce

Treatment	Yield Kg/m^2	Gross Income	Production Cost	Net Income	% ROI
Acacia	2.18	P479.60	P140.00	P339.60	242
Ipil-ipil	2.26	497.29	140.00	357.20	255
Madre de cacao	2.16	475.20	140.00	335.20	239
IMO-5	2.61	574.93	141.33	432.87	306
Commercial compost	2.53	556.60	112.00	444.60	397
Inorganic	0.90	198.00	88.00	110.00	125
Control	1.49	327.80	78.66	249.14	317

Price = P220/kg

Pechay after Cabbage

The tallest pechay ($p < 0.05$) were grown from pots with residues of organic fertilizers (Table 10) while the shortest were from pots previously fertilized with inorganic fertilizer and the unfertilized plants.

Furthermore, pechay grown in soil with residues from ipil-ipil leaf green manure, IMO-5 and commercial compost had significantly the most leaves but were comparable with those grown from residues of acacia and madre de cacao.

Table 10. Final Height, Leaf Count and Yield of Pechay after Cabbage/m^2 Three Weeks after Transplanting

Treatment	Height	Leaf Count	Yield
	-cm-		-kg-
Acacia	18.45[a]	7.43[ab]	2.39[a]
Ipil-ipil	18.30[a]	8.13[a]	2.31[ab]
Madre de cacao	18.80[a]	7.43[ab]	2.02[bc]
IMO-5	18.51[a]	7.93[a]	1.95[a]
Commercial compost	18.55[a]	7.66[a]	2.32[ab]
Inorganic fertilizer	15.17[b]	6.73[b]	0.95[d]
Control (unfertilized)	15.62 [b]	6.63[b]	1.16[d]

[ns] not significant at the 5% level of probability

[abc]Treatment means followed by the same letter superscripts are not significantly different over each other at the 5% level of significance.

Although the cabbage plants in Study 1 were grown for almost three months, data in Table 8 show that the residues of organic matter were sufficient to significantly increase the yield of pechay. These organic sources had provided carbon and energy sources for soil organisms in carrying out their biological activities in the soil and improved soil properties conducive to crop production (Lehman, *et*

al., 2015). The highest ROI of 318% (Table 11) was recorded from pechay grown with commercial compost and is much better than the ROI of cabbage (11%) in the first crop. This was followed by those from the control treatments (128% ROI) and acacia at 102% ROI.

Based on the results of the first study, it can be concluded that it is profitable to use inorganic fertilizer (T_6) in lettuce and cabbage production. However, it was the residue from commercial compost (T_5) that favourably sustained soil productivity and profitability of the following crop.

Table 11. Cost and Return Analysis for Pechay after Cabbage

Treatment	Computed Yield (kg/ m^2)	Gross Income	Production Cost	Net Income	% ROI
Acacia	2.39	P286.80	P141.90	P144.90	102
Ipil-ipil	2.31	277.20	141.90	135.30	95
Madre de cacao	2.02	242.40	141.90	100.50	71
IMO-5	1.95	234.00	127.61	106.39	83
Commercial compost	2.32	278.40	66.66	211.74	318
Inorganic	0.95	114.00	62.85	51.15	81
Control	1.16	139.20	60.95	78.25	128

Price /kg = P120

CONCLUSIONS AND RECOMMENDATIONS

Based on the foregoing results, it can be concluded that lettuce and cabbage respond favorably to the use of IMO 5, commercial compost, and leaf green manures from acacia, ipil-ipil, and madre de cacao as substantiated by their highly positive agronomic performances and yields. Although lettuce with acacia can result in significantly highest yield, the use of inorganic fertilizer, can give the highest ROI. Improved height, more leaves, bigger heads, and higher yields are attainable in cabbage with the application of organic fertilizers. However, the use of inorganic fertilizer can offset the advantages of organic fertilizer with its higher ROI. Furthermore, continues application of inorganic fertilizers year after year resulted in negative effects on soil properties like decreased soil pH and cation exchange capacity (CEC), low organic matter and also affecting soil water relations (Pernes-Debuyser & Tessier, 2004).

Results from the second study, however, contradicted the superior advantage of inorganic vis-à-vis organic fertilizers. Lettuce and pechay with residues of green leaf manures and commercial compost produced more leaves, taller plants, higher yield, and greater ROI than the unfertilized and those previously applied with inorganic fertilizer.

It is recommended that organic fertilizers which include commercial compost, IMO-5 and green leaf manures from ipil-ipil, acacia, and madre de cacao should be used as organic fertilizers when growing lettuce, cabbage, and pechay. For optimum yields

and ROI, however, commercial compost and IMO-5, respectively, are recommended.

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